PROJECT

ON

"To study the effect of NPK provided by Greenland Agri Marketing India Pvt. Ltd. On the yield & yield contributing factors of paddy in Muzaffarnagar District"

SUBMITTED BY:

Dr. Suhal Sardar
Assistant Professor

Session - 2023-24

DEPARTMENT OF AGRICULTURE

SHRI RAM COLLEGE, MUZAFFARNAGAR

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

CIN -U36912UR2010PTC033059

PAN AADCG7571Q

Green Land

GREEN LAND AGRI MARKETING INDIA PVT LTD.

Khasra No. 457, Village- Begrajpur, Meerut Road, Muzaffarnagar (U.P.)

To
The Principal,
Shri Ram College, Muzaffarnagar

Date: 24.06.2023

Respected Madam

Greetings

Green Land Agri Marketing India Pvt. Ltd. Muzaffarnagaris an apex representative body of manufacturing the agro chemical which are very beneficial for increasing the crop production in India. Green Land Agri Marketing India Pvt. Ltd. Muzaffarnagar chapter is a renowned and important Agro industry of Muzaffarnagar In several meetings held in the past under the aegis of this organization, impact of agro chemical Like NPK fertilizer in Muzaffarnagar have been discussed in details. There is no data available on the impact of agro chemical Like NPK fertilizer on growth and yield of paddy in Muzaffarnagar, due to which no plan could be implemented in the past to mitigate these effects. In this context, the Green Land Agri Marketing India Pvt. Ltd Muzaffarnagar wants to conduct research through Shri Ram College which can show the direct impact of NPK on performance of paddy in Muzaffarnagar. Green Land Agri Marketing India Pvt. Ltd. Muzaffarnagar requests to Shri Ram College to take a step forward in fulfilling its social responsibilities by helping in this work. The Green Land Agri Marketing India Pvt. Ltd. Muzaffarnagar will always be ready to bear all the expenses incurred in this research.

Awaiting your reply on the above.

Vineet Kumar Baliyan
(Vineet Kumar Baliyan)
Secretary
Green Land Agri Marketing India Pvt. Ltd. Muzaffarnagar

Managing Director

Green Land Agri Marketing India Pvt. Ltd.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Contact - 9258263333, E-mail. - greenlandmzn@gmail.com

Shri Ram College
Approved by UGC, NCTE and Affiliated to MS University, Saharanpur
Muzaffarnagar - 251001, NCR (U.P.)
A++ Grade Accredited by NAAC

Date:02-07-2023

To

The Secretary

Green Land Agri Marketing India Pvt. Ltd.

Muzaffarnagar

Respected Sir

With reference to your letter, it gives me immense pleasure to informed you that Shri Ram College will be grateful to participate in social contribution with Green Land Agri Marketing India Pvt. Ltd. Muzaffarnagar through the conduct of this research. We nominate **Dr. Suhal Sardar** Assistant Professor in the Department of Agriculture, as the Principal Researcher& Co- Researcher for the research.

Dr. Suhal Sardar is a distinguished academician with extensive experience in teaching and research. His expertise in "Soil Fertility mgt. and Production and economic feasibility of paddy, perfectly with the objectives of this project. Dr. Suhal Sardar has consistently demonstrated his ability to lead and deliver high-quality research outcomes.As the Principal Investigator, he will be responsible for overseeing the project, ensuring adherence to the proposed timeline and objectives, and contributing to the advancement of knowledge in the field. You are also requested to discuss regarding project expenses duration and total expected budget with him.

I am confident that Dr. Suhal Sardar is expertise and commitment will make this project a success and bring significant recognition to our institution.

We extend our best wishes to him for the successful execution of this research endeavour.

Regards,

(Dr Prerna Mittal)

Principal, SRC

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Website : www.srgcmzn.com E-Mail : src_mzn@rediffmail.com
Contact @ 9927028908, 9927011422

CIN -U36912UR2010PTC033059

PAN AADCG7571Q

GREEN LAND AGRI MARKETING INDIA PVT LTD.

Khasra No. 457, Village- Begrajpur, Meerut Road, Muzaffarnagar (U.P.)

Green Land

Date: 05-07-2023

To
The Principal
Shri Ram College, Muzaffarnagar

Subject: Sponsorship for Research Project and Requirement for Fund Utilization Report

Honourable Madam

The **Green Land Agri Marketing India Pvt. Ltd. Muzaffarnagar,** is pleased to sponsor funds amounting to **1,50,000/-** for the research project titled **" To Study the effect of NPK provided Green Land Agri Marketing India Pvt. Ltd. on the yield and yield contributing factors of paddy in Muzaffarnagar district"** undertaken by your esteemed college. This initiative aligns with our vision of fostering innovation and contributing to the advancement of knowledge in areas critical to economical and societal development.

We request that these funds be utilized strictly for the purpose outlined in the approved project proposal, including but not limited to (mention broad categories such as research materials, data collection, analysis, and reporting).

To ensure transparency and proper accountability, we kindly ask you to provide a detailed utilization report upon the project's completion. This report should include:

1. A summary of activities and outcomes achieved.
2. A financial statement detailing the allocation and expenditure of funds.
3. Copies of invoices, receipts, and any supporting documentation.

We value this collaboration and trust that the institution will make the most effective use of this sponsorship to achieve the desired outcomes. Should you require any additional assistance or clarification, please do not hesitate to reach out to us.

We look forward to receiving the utilization report and wish your institution great success in this research endeavour.

Yours sincerely,

(Veenit Kumar Baliyan)
Secretary,
Green Land Agri Marketing India Pvt. Ltd. Muzaffarnagar

Managing Director

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Contact - 9258263333, E-mail. - greenlandmzn@gmail.com

Project Fund Detail

Date: 31-03-2024

1. Title of Project: **" To study the effect of NPK provided Green Land Agri Markating India Pvt Ltd on the yield and yield contributing factors of paddy in Muzaffarnagar district"**
2. Principal Investigator and Co-Investigator: **Dr Suhal Sardar& Dr, Department of Agriculture, Shri Ram College, Muzaffarnagar.**
3. Implementing College and Sponsored Body: **Department of Agriculture, Shri Ram College &Green Land Agri Markating India Pvt Ltd Muzaffarnagar.**
4. Sanctioned Project Amount by **Green Land Agri Markating India Pvt Ltd Muzaffarnagar. Rs. 150,000/-**
5. Project Duration: **July 2023 to March 2024(Nine Months)**
6. Project Completion Date: **March 31th 2024**

Statement of Expenditure

Amount Received **Rs.150,000/-**

Less Expenditure:

1.	Total common cost of cultivation	61492.24/-
2.	Equipments	20000/-
3.	Books and Journal	3500/-
4.	Reagent for soil chemical analysis	11000/-
5.	Glass ware	4000/-
6.	Local Travelling	17,150/-
7.	Refreshments	14,955/-
8.	Printing& Typing	7,725/-
9.	Miscellaneous expenses	10,178/-
		150,000/-

(Dr Suhal Sardar)
Research Project Coordinator

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

(Dr Prerna Mittal)
Principal Shri Ram College

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Utilization Certificate

S.N.	Detail of sanction of Fund with Project name and Duration	Amount
1.	9 months project on To study the Effect of NPK provided By Greenland Agri Marketing India Pvt Limited on the yield And yield contributing Factors of paddy in Muzaffarnagar District Date of Sanction of Fund- 05-07-2023 as per Sanction Letter	150000.00 /-
	TOTAL	150000.00/-

It is Certified that out of Rs. 150000.00/- (One Lacs fifty Thousands only) of grants sanctioned by **Jai Hind Agriculture Industries, Muzaffarnagar** during the year 2023-2024 in favor of **Shri Ram College, Muzaffarnagar,** a sum of Rs. 150000.00 has been utilized for the purpose of the project for which it was sanctioned and that the balance of Rs. **Nil** remaining unutilized at the end of the year has been surrendered. The Extra amount (If any) is met out by Shri Ram College.

2. Certified that we have satisfied our self that the conditions on which the grant was sanctioned have been duly fulfilled/are being fulfilled and that we have exercised the following checks to see that the money was actually utilized for the purpose for which it was sanctioned.

Kinds of checks exercise-

1 Checking of cash book
2 Checking of payment vouchers.
3 Checking of salary register.
4 Checking of expense bill.

For Shri Ram College

Secretary
Date: 07-04-2024
Place: Muzaffarnagar

For Goel Rakesh & Co.
Chartered Accountants

GOEL RAKESH & CO. CHARTERED ACCOUNTANTS Muzaffar-Nagar (U.P.)

Rakesh Kumar Goel
Proprietor

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

PROJECT

Shri Ram College, Muzaffarnagar

Identification

PROJECT TITLE: "To study the effect of NPK provided by Green Land Agri Markating India Pvt Ltd on the yield and yield contributing factors of paddy in Muzaffarnagar district."

INTRODUCTION:

Rice (*Oryza sativa* L.)is one of the most important field crops after wheat inthe world providing staple food to the millions. It is an indispensable source ofcalories for almost half of the population with in Asia. More than 90% of the worldrice is produced and consumed in Asia, which is a native for 60% of the earth' spopulation. Rice is the first most important crop in India where it is grown in an areaof 43.9 million ha^{-1} with a total production of 106.77 million tonnes and an average productivity of 24.32 q ha^{-1} (Anonymous, 2015). Uttar Pradesh ranks second afterWest Bengal where the total production is 14.41million tonnes with a share of13.80%to total rice productionin thecountry(Anonymous, 2014).

The green revolution played a major role in India in terms of food grain production and productivity. Now, India has become self-sufficient in food grainproduction but with the time it has started to show the signs of adverse effects likedeclineinyield,deteriorationinsoilfertilityanddecliningfactorproductivity.Replacement of organicmanureswhich were used prior to green revolution andexcessiveuseofchemicalfertilizersresultedindeteriorationofsoilphysical,chemical and biological health in rice growing areas. This has altered the ideal NPKratio which should be 4:2:1. Soil fertility restoration is one of the major constraintswith regard to targeted increase in crop production. Increasing land use intensitywithout adequate and balanced use of chemical fertilizers with little or no use oforganic manure have caused severe fertility deterioration of our soils resulting instagnatingorevendecliningcropproductivity(Shormy*etal.*,2013).Thereisgrowing concern about sustainability of the rice production system due to stagnationand decline in yield of rice in some of the states like Punjab, Haryana, eastern UttarPradesh, Madhya Pradesh, Bihar, Himachal Pradesh and Jammu and Kashmir (Chandand Haque, 1998; Ladha *et al.*, 2000; Mahajan *et al.*, 2002 and 2008; and Paroda,1996). thepresentinvestigationentitled"**To study the effect of NPK provided by Green Land Agri Markating India Pvt Ltd on the yield and yield**

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

contributing factors of paddy in Muzaffarnagar district

Objective:

1. To study the effect of NPK on growth parameter of rice.
2. To study the effect of NPK on yields attributing characters and yield of rice.
3. To study the effect of NPK on pH, EC, organic carbon and available NPK in soil.
4. To study the effect of NPK treatments on economics of rice crop.

REVIEW OF LITERATURE

Slaton *et al* (2002) observed that the four Zn fertilizers with a range of WS-Zn contents were applied at five Zn rates (2, 4, 8, 12, and 16 lb Zn/acre) and compared to an untreated control. In general, rice yields increased as Zn rate increased from 2 to 8 lb Zn/acre and then plateaued from 8 to 16 lb Zn/acre at each location. Small numerical yield differences were observed among Zn sources with the highest yields generally produced by Zn sources high in WS-Zn. Zinc application rate, rather than Zn source, was the most important factor affecting rice growth, uptake of Zn, and grain yield. When the recommended rate of granular Zn fertilizer is applied to the soil before rice emergence, all four of the Zn fertilizers evaluated are adequate to optimize rice yields.

Lora *et al.*(2002) observed that the on a Typic Tropaquept with low Zn content located in Villanueva, Casanare, Colombia, a study was conducted to determine the effect of Zn application (at 0, 8, 16, 24 and 32 kg ZnO/ha) on yield and quality of 3 rice cultivars. Observations were recorded for yield, tiller number per plant, plant height, number of grain per panicle, 1000-seed weight and milling quality. Foliar, soil and benefit:cost analyses were also performed. The best effect on yield was observed at 16 kg Zn/ha for R-I, Selecta and Tailandia III. A significant effect on number of grain per panicle and seed weight was also observed. The best income recorded was $25.8, $17.8 and $18.3 for R-I, Selecta and Tailandia III, respectively.

Jadhav et al. (2003) also noted that the highest grain yield (57.7 q/ha), straw (53.8 mg/kg) and grain (44.5 mg/kg) Zn contents, and total Zn uptake (575.7 g/ha) were obtained with NPK + FYM + Zn at 45 kg/ha. Straw yield was generally higher with the combination of Zn, FYM and NPK compared to NPK only. The N, P and K contents of grain, and P and K contents of straw were not significantly affected by Zn and FYM. The application of NPK + FYM + Zn at 30 kg/ha resulted in the highest total N (97.10 kg/ha) and P uptake (12.0 kg/ha), whereas NPK + Zn at 15 kg/ha gave the highest total K uptake (128.2 kg/ha). Straw (39.6-44.1 mg/kg) and grain (40.1-42.5 mg/kg) Zn contents did not significantly vary among plots

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

treated with NPK + Zn at 30 or 45 kg/ha, and NPK + FYM + Zn at 15 or 30 kg/ha, suggesting that Zn fertilizer rate can be reduced by the incorporation of FYM.

Mythili et al. (2003) observed that the NPK at 100:50:50 kg/ha, Zn as ZnSO4 and S as gypsum coupled with green manuring resulted in the highest grain yield for both clay loam and sandy loam soils (46.8 and 39.4 g/pot, respectively). The uptake of Zn and S significantly increased with green manure application in addition to improved soil fertility.

Patil and Meisheri (2003) observed that theapplication of Zn forms with and without FYM resulted in significant increases in grain and straw yields of subsequent rice crop. The Zn uptake and available Zn in the soil increased significantly when Zn was applied for the first crop. The treatments comprising application of 25 kg ZnSO4 and 10 kg chelated Zn/ha were at par.

Gurmani et al. (2003) exhibited that the highest significant paddy yield of 6087 kg ha-1 was achieved from Zn + Cu + Fe + Mn compared to the yield of 4703 kg ha-1 from the control (NPK). By separating the yield means for individual treatments, Zn, Cu, Fe, and Mn gave an increase of 15.7, 14.5, 11.8, and 10.6% over NPK, respectively. The dry matter and straw yields were also significantly affected and produced the highest yield of 14 818 and 8732 kg ha-1, respectively from NPK + Zn + Cu + Fe + Mn. The significantly highest number (500) of panicles/m2 was produced by the same treatment.

Kulandaivel *et al.* (2003) observed thatthe successive increase in the rates of ZnSO4 and FeSO4 had a positive effect on the grain and straw yields of rice. However, it was significant only up to 30 kg ZnSO4/ha. On an average, a 15% increase in grain yield (62.12 q/ha), due to 30 kg ZnSO4, was recorded compared to the control (54.23 q/ha). FeSO4 at 5 and 10 kg/ha did not affect the growth, yield and yield attributes of rice.

Singh *et al* (2003) advocated that Significantly lower weed population and weed dry matter were recorded at 3.0 kg Zn/ha compared to 6.0 kg Zn/ha. Zinc application up to 6.0 kg/ha increased the grain and straw yields over 3.0 kg/ha. HW twice recorded the lowest weed population and weed dry matter accumulation among all treatments. HW twice, anilofos + 2,4-DEE, and anilofos + 2,4-DEE + HW treatments were at par with each other in terms of weed growth. Twice HW produced significantly higher grain (4.18 t/ha) and straw yields (5.43 t/ha) over the weedy control.

Bandara *et al.* (2003) also noted that Soil analysis revealed that the soil was deficient in Zn and application of Zn at 2.5 kg/ha increased N use efficiency from 15.6 to 19.4 kg grain yield/kg of applied N, and N recovery from 31 to 41%, and increased rice yield. A combination of 100 kg N/ha and 2.5 kg Zn/ha gave the same yield as that of 125 kg N/ha

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

alone. The interaction between N and Zn for grain yield was synergistic. The residual effect of Zn on grain yield was also observed in the second crop of rice.

Khan *et.al* (2003) observed that the methods were used, i.e., nursery root dipping in 1.0% ZnSO4, 0.20% ZnSO4 solution spray after transplanting, and 10 kg Zn ha-1 by field broadcast method. Zinc content of soil before flowering and after harvest was significantly increased for all the methods. The yield and yield parameters also increased significantly by the application of Zn by any method. Among the methods used the effect of Zn was insignificant on yield components like tillers m-2, spikelets panicle-1, % filled grains, 1000-grain weight and straw yield. However, soil application of Zn at 10 kg ha-1 was rated superior because it produced significantly higher paddy yield.

Gurmani *et al.* (2003) observed that The effects of Zn, Cu, Fe and Mn, applied alone or in combination with NPK on the yield of rice cv. Gomal 6 were determined in a field experiment conducted in Pakistan during the kharif season of 2000. Crop yield was highest (6087 kg/ha) with the application of NPK + Zn + Cu + Fe + Mn. Zn, Cu, Fe and Mn concentrations in the soil were highest with the application of NPK + Zn + Cu, NPK + CU, Fe and NPK + Cu, respectively. Application of NPK + Zn + Cu + Fe + Mn resulted in the highest Zn concentration, whereas application of NPK + Cu resulted in the highest Cu concentration in the leaves. Fe and Mn concentrations in the leaves were highest with the application of NPK Cu + Mn and NPK + Zn + Cu + Fe + Mn, respectively.

Patil and Meisheri (2003) also noted that the Zn uptake by straw and grain and its content in the soil were increased when Zn was applied; the increases were significantly higher when Zn was combined with FYM. Application of Zn forms with and without FYM resulted in significant increases in grain and straw yields of subsequent rice crop. The Zn uptake and available Zn in the soil increased significantly when Zn was applied for the first crop. The treatments comprising application of 25 kg ZnSO4 and 10 kg chelated Zn/ha were at par.

Ummed *et al.* (2003) advocated that the treatment with 120:60:60 kg NPK/ha significantly increased the grain and straw yields over 60:30:30 kg NPK/ha. However, the highest grain and straw yields were recorded with 180:90:90 kg NPK/ha (4.16 and 5.32 t/ha, respectively). Significantly lower weed population and weed dry matter were recorded at 3.0 kg Zn/ha compared to 6.0 kg Zn/ha. Zinc application up to 6.0 kg/ha increased the grain and straw yields over 3.0 kg/ha. HW twice recorded the lowest weed population and weed dry matter accumulation among all treatments.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College
Muzaffarnagar

Adhikri and Mishra (2004) exhibited that the treatments comprised: 0 kg N/ha (T1); 60 kg prilled urea (PU)/ha (T2); 120 kg PU/ha (T3); 80 kg PU + 40 kg farmyard manure/ha (T4); 60 kg PU + 60 kg farmyard manure/ha (T5); 80 kg PU + 40 kg vermicompost/ha (T6); 60 kg PU + 60 kg vermicompost (T7); 80 kg PU + 20 kg farmyard manure + blue green algae (BGA)/ha (T8); and 80 kg PU + 40 kg farmyard manure + BGA/ha (T9). Basmati 370 and Pusa Sugandh-3 gave the highest yields with T7 and T9, respectively. Wheat yield was highest with T5 regardless of the preceding rice cultivar.

Singh and Singh (2004) reported that the soil application of 10 kg Zn/ha was adequate in partially reclaimed alkali soil with initial pH 10.3, exchangeable sodium percentage of 85 and electrical conductivity of soil solution (1:2) 2.1 dS/m. Zinc sulfate was the superior source of zinc compared to zinc frits. Zinc application increased chlorophyll and increased the tissue concentration of Zn, Ca, Mg, K and P, whereas Na content decreased. Zinc modified the elemental composition of plant tissues favourably and thereby accelerated plant growth and yield.

Yokoyama et al. (2004) advocated that the effect of zinc on the auxin-induced rooting of rice was investigated. There was no significant effect of zinc (2 vs. 36 mg litre-1) on the shoot and root weight of rice without application of auxin. When auxin was applied at 0.1 mg litre-1, the rooting of rice was increased by 36 mg Zn litre-1. Application of 0.3 mg litre-1 auxin induced callus formation rather than rooting of rice. It is suggested that the increased rooting of rice could be attributed to the interaction effect of auxin and zinc, and not due to other indole compounds and counter ions of zinc.

Haq et al. (2005) The results revealed that the treatment 90 kg N + Azospirillum showed significantly higher values of plant height (109.16 cm) and dry matter production (89.75 g), followed by vermicompost + Azospirillum + 60 kg N/ha. Also a number of panicles/m2 (335.66), grain yield (49.66 q/ha) and straw yield (91.40 q/ha) were significantly higher as compared to other treatments.

Slaton *et.al* (2005) also noted that the Zinc rate had the greatest influence on grain yields with near maximum yield produced when >9 kg Zn ha-1 was applied. During the second year, tissue Zn concentration and yield increased linearly or nonlinearly, depending on location, as Zn rate increased and were not affected by Zn source. During the first year, Zn source and rate influenced early season growth and Zn concentrations, but grain yield, Mehlich-3 soil Zn, and the residual benefits of Zn fertilization were affected only by application rate.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Khan *et al.* (2005) observed that the ZnSO4 was applied at 0, 0.5, 1.0 and 1.5% solution by root dipping along with the basal doses of 120 kg N, 90 kg P2O5 and 60 kg K2O/ha. Four 30-day-old rice (cv. IRRI-6) seedlings were grown. A significant increase in yield and yield components was recorded for increasing levels of Zn ($P<0.05$). The application of 1.0% Zn solution appeared to be an optimum level for rice crops in these soil series. Tikken soil series gave the highest paddy and straw yield, while the Ramak series gave the lowest. The interaction between the soil series and Zn levels was significant for all parameters.

Ghatak *et al.* (2005) reported that zinc fertilizer application significantly increased the plant height, effective tillers, panicle length, grains per panicle, grain and straw yields, uptake of Zn, N and K by plant. Application of 30 kg ZnSO4/ha recorded the highest values of yield attributes, yield, uptake of Zn, N and K by plant. Similarly, the net return was also maximum (Rs. 4832/ha) upon treatment with 30 kg ZnSO4/ha.

Poongothai et al. (2005) reported that seed treatment with 130% Zn-P formulation significantly enhanced the yield with 29.2% over control, besides increasing the growth and yield attributes of rice. Though this treatment maintained its superiority, it was on par with soil application of 5.5 kg Zn ha-1. The treatments exerted a non-significant influence on P and Zn availability in post-harvest soil.

Hosseini et al. (2005) observed that theZn fertilizer application increased the number of tillers, dry matter yield, and Zn, Cu, B, and K concentrations in leaves. Concentrations of Mn and P decreased with application of Zn, but that of Fe was not affected. Soil B application increased B, Cu, P, and K concentrations, but reduced the concentration of Fe. When Zn was not supplied, the application of 2.5 mg B kg-1 significantly increased the dry matter yields. In the presence of optimum amounts of Zn from either source, the increase in dry matter continued up to 5 mg B kg-1. The results also showed that in soils with high levels of B, Zn application may reduce the adverse effects of B toxicity and increase rice yield.

E ShengZhe *et al.* (2005) observed thatThe effects of N,P and K fertilizers on the Fe, Zn, Cu, Mn and Mg content and yield of rice cultivars Diantu 502 and Hexi 39 were determined in a field experiment conducted in Sichuan, China. Fe, Zn, Cu, Mn and Mg content increased with increasing N rates. For Diantu 502, the mineral contents and crop yield reached their highest with the application of 90 and 270 kg N/hm2. For Hexi 39, the highest mineral contents and crop yield were recorded with the application of 180 and 270 kg N/hm2. P fertilizer reduced the Fe, Mn, Cu and Ca content in rice. K at 90 kg/hm2 increased the Fe, Zn, Cu and mn content in rice.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Slaton *et.al* (2005) observed that Zn fertilizer source, averaged across application times, significantly affected grain yield at all sites, with Zn fertilizer application increasing yields by 12-180% compared with the untreated control. Zn application time, averaged across Zn sources, significantly affected grain yield at only one site, which had severe Zn deficiency. Zn applied PPI (6915 kg grain ha-1) and DPRE (7456 kg grain ha-1) produced similar yields that were greater than Zn applied POST (5526 kg grain ha-1). Zn solutions sprayed at 1.1-2.2 kg Zn ha^{-1} generally produced yields that were comparable with yields from granular fertilizers applied at 11.2 kg Zn ha^{-1}.

Singh and Tripathi (2005) observed that The 15 treatment combinations with one absolute control. Significantly the highest grain and straw yields (48.36 and 87.19 q/ha) and yield attributing characters were recorded with M3, whereas the lowest grain and straw yields (18.55 and 31.05 q/ha) and yield attributing characters were noticed with the absolute control. Amongst the methods of Zn application, Zn4 recorded significantly higher grain and straw yields (45.84 and 81.82 q/ha) and related characters compared to Zn1. Zn3 was found to be superior to Zn2, but it did not cross the level of significance. The highest amount of Zn acquisition by grain+straw was recorded with M3 (135.55 g/ha) and Zn4 (127.15 g/ha). However, the interaction effects were not significant.

Singh and Tripathi, (2005) reprted that theamongst the methods of Zn application, Zn4 recorded significantly higher grain and straw yields (45.84 and 81.82 q/ha) and related characters compared to Zn1. Zn3 was found to be superior to Zn2, but it did not cross the level of significance. The highest amount of Zn acquisition by grain+straw was recorded with M3 (135.55 g/ha) and Zn4 (127.15 g/ha). However, the interaction effects were not significant.

Cheema *et.al* (2006) advocated that the final plant height, number of tillers/hill, panicle bearing tillers, number of primary and secondary spikelets; panicle size, 1000-grain weight, paddy and straw yield and harvest index showed positive correlation with the increase in ZnSO4 levels from 2.5 to 10 kg/ha. However, sterility percentage decreased as the level of ZnSO4 increased. All the yield components exhibited significant increase, except harvest index, though, had increased but not significantly indicating that a still higher level of zinc may be required to obtain a significant difference or otherwise. It is concluded that not only Basmati rice, but the coarse rice like IR-6 is also affected by various levels of zinc for growth and yield of rice.

Ruan *et al.* (2006) observed that the effect of Zn fertilizer on rice yield and yield characters was studied in salinized soil in China. The result showed that Zn fertilizer

Co-ordinator
IQAC, Shri Ram College,
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

significantly affected rice growth, yield and yield characters more at the late growth phase than at the early growth phase. Under the test conditions, the highest yield comes from treatment B (0.4 g Zn/dish), which was 23.0% higher than that of the control, and 17.2% higher than that of treatment D (0.8 g Zn/dish). Yields of treatments A and C (0.2 and 0.6 g/dish) were also higher than that in the control, and the difference is extremely significant. In treatment D (0.8 g Zn/dish), the available ear, seed number and yield decreased.

Tanmoy *et.al* (2006) also noted that the Zn content in rice dry matter increased (9.42 mg/kg) with the application of chelated Zn (Zn-EDTA) in 2 splits compared to split application of ZnSO4 (8.56 mg/kg). The Zn content and uptake by grain and straw were highest (87.97 and 122.48 g/ha) in the treatment where chelated Zn (Zn-EDTA) was applied as splits. The yield of rice grain was highest (4.56 tonnes/ha) in the treatment receiving split application of chelated Zn. The yields of grain and straw were significantly positively correlated with their corresponding Zn content.

Singaravel *et al* (2006) studied that the effects of foliar application of micronutrients on the yield and micronutrient uptake by rice (cv. ADT 43). The experimental soil was clay loam with a pH of 7.84 and electrical conductivity of 0.56 dS m-1. The treatments consisted of the control (recommended NPK) and foliar spraying of Kiecite (a micronutrient mixture containing Fe, Mn, Zn, Cu, B and Mo) at various rates (0.5, 1.0, 1.5 and 2.0%). NPK + spraying of 1.0% Kiecite significantly increased grain and straw yields, and uptake of Fe, Mn, Zn, Cu and B.

Jin LingNa *et al* (2006) studying the upland rice cultivars Handao 502 and Baxi Ludao in greenhouse, to study the effects of different Zn application levels (0, 0.1, 0.5, 2.5, 5.0 and 10.0 mg Zn/kg) on Zn distribution and dry matter accumulation. The above-ground dry matter in the 2 cultivars tended to increase with increasing Zn level in a range of 0-5.0 mg/kg. The highest above-ground dry matter in Handao 502 and Baxi Ludao was noted with application of 5.0 mg Zn/kg, being 5.73 and 42.46% higher than that no application. The Zn absorption amount tended to increase with increasing Zn level, and the Zn absorption capability of Baxi Ludao was higher than that of Handao 502. In addition, the Zn contents in root and sheath were markedly higher than in leaf. The Zn contents in root and sheath increased markedly with increasing Zn level, whereas that in leaf increased steadily.

J. Mirzavand (2007) also noted that The ANOVA of the two-year data showed that the effect of ZnSO4.7H2O on grain yield, number of grain per spike, N and P was significant (5%) and highly significant (1%) on the protein content of grain. The effect of zinc oxide on 1000 kernel weight and protein content were significant at 5 and 1% level, respectively. It

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

was concluded that the application of Zn in paddy fields of Pars province is essential, but with regards to the fertilizer source and amounts, further study is needed.

Khan *et al.* (2007) reported that Zn as ZnSO4 7 H2O (21%) was applied @ 0, 5, 10 and 15 kg ha-1 along with the basal doses of 120 kg N, 90 kg P2O5 and 60 kg K2O ha-1. Thirty days old four seedlings of rice cv. IRRI-6 were grown. The increasing levels of Zn in these soil series significantly influenced yield and yield components of the crop. Application of 10 kg Zn ha-1 appeared to be an optimum dose for rice crop in these soil series. Tikken soil series gave the highest paddy and straw yield while the Ramak gave the lowest. The interaction between soil series was also found significant for all these series.

Khan *et.al* (2007) exhibited that Zn application also affected significantly to the yield parameters of rice like the number of spike m-2, number of spike/plant, spike length, plant height and 1000 grain weight over control from the above said treatment of 10 kg Zn ha-1. The direct application of 5 and 10 kg Zn ha-1 gave an increase of 39 and 45% while residual effect 30.0 and 43.0%, cumulative effect of 38 and 50% over control, respectively. The residual application of 10 kg Zn ha-1 can be recommended for economical production in wheat rice system.

J. Mirzavand, (2007) reported that the effect of immersing the seedlings in zinc oxide in the first year had a significant affect (5%) on the zinc and protein content of the grain, and highly significant effect (1%) on N content of grain. In the second year, the effect of zinc oxide on grain yield, N, K and protein content of grain was significant (5%). The ANOV of the two-year data showed that the effect of ZnSO4.7H2O on grain yield, number of grain per spike, N and P was significant (5%) and highly significant (1%) on the protein content of grain.

Jiang *et al.* (2007) advocated that the low-Zn tolerance index for grain yield was effective in screening for high stability and high potential of grain yield, and the low-Zn tolerance index for grain-Zn mass concentration was effective for grain-Zn mass concentration under low and high soil-Zn conditions. Genotypic differences in yield and grain-Zn mass concentration were shown to be unrelated and therefore deserve separate attention in breeding programmes. Combining the low-Zn tolerance index for grain yield and the low-Zn tolerance index for grain-Zn mass concentration in a single low-Zn tolerance index was considered but did not appear to be superior to using the two indices separately.

Wei YiChang *et al.* (2007) exhibited that the number of panicles per square meter, grain number per panicle, 1000-grain weight, and yield of rice increased significantly with the application of zinc. They were at their best at the recommended zinc application rate of 15

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

kg/hm2, with the yield showing an increase of 16.9%. In addition, Zn concentration in rice plants and grains increased with rising Zn application rate, but the duration to maturity decreased. Soil residual available Zn and NH4+ concentrations increased significantly, but soil residual available P, K, Ca, Mg concentrations decreased and other soil available nutrient (S, B, Cu, Fe, Mn) concentrations and soil organic matter content and pH remained unchanged with the increase of zinc application rate, and the residual available Zn concentration was 1.83 mg/L at the recommended zinc application rate, which was nontoxic to rice growth. Therefore, zinc application rate on the basis of soil ASI testing not only improve the rice yield components, but also cause no zinc pollution.

Rahmatullah *et al.* (2007) reported that the paddy yield was also significantly affected by Zn levels ranged from 3.9 to 5.9 t ha-1. The highest yield was obtained from 10 kg Zn ha-1 each applied to both crops. Similarly Zn application also affected significantly to the yield parameters of rice like the number of spike m-2, number of spike/plant, spike length, plant height and 1000 grain weight over control from the above said treatment of 10 kg Zn ha-1.

Khan *et al.* (2007) reported that the Highest yield for paddy and straw was recorded by the combined application of NPK+GM+Zn (soil application) (T7), which was statistically different from all other treatments except T6 and T10. The combined application of NPK and organic manures (GM or FYM) and Zn significantly increased the paddy and straw yields of rice crop.

Ramkala *et al.* (2008) observed that the Zinc was applied @ 1.8 and 5.0 kg ha-1 through ZnSO4 and NPZn in kharif and rabi. Grain and straw yields of rice and wheat were maximum in 3.2 kg Zn through ZnSO4+1.8 kg Zn through NPZn. Both crops responded significantly in terms of yield attributes, number of tillers/hill and panicle weight. Phosphorus and zinc uptake in rice and wheat were found highest and significantly higher over control when Zn was applied through NPZn complex fertilizer and zinc sulphate combined. The effect of all the treatments was found non significant on N and K content but significant on their uptake. Agronomic efficiency of zinc for total biomass and grain yield of rice and wheat was found maximum where 5 kg Zn ha-1 was applied through both 1.8 kg through NPZn and 3.2 kg through ZnSO4. Post harvest build-up of available N, P, K and Zn was also observed.

Tripathi and Verma (2008) also noted that the treatments having nutrition through farmyard manure and vermicompost, respectively, recorded 29.0 and 30.6% reduction in grain yield compared to the control. Vermicompost-treated plots had comparatively high

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

number of filled grains per panicle (80.3) and low percentage of floret sterility (20.7), however, it recorded the lowest grain yield due to their low number of ear-bearing shoots.

Das *et al.* (2008) also noted that the results of the field experiment show that the grain yield of continuous flooding (4.84 t/ha) and intermittent flooding up to 40 days after transplanting followed by continuous flooding (4.83 t/ha) with the application of ZnSO4 at the rate of 25 kg/ha did not vary significantly. The lowest grain yield (3.65 t/ha) was recorded in the treatment where the intermittent flooding was maintained throughout the growth period without the application of zinc. The amount of arsenic was, however, much lower in the treatment where intermittent flooding was maintained throughout the growing period combined with zinc sulphate application.

Prado *et al.* (2008) also noted that the treatments comprised 5 Zn concentrations (0, 1.0, 2.0, 4.0 and 8.0 g/kg of seed) and 2 Zn sources (zinc sulfate and zinc oxide). At 30 days after sowing, the root and aerial dry matter and Zn content and accumulation were evaluated. Zinc sulfate provided greater production of total dry matter in rice seedlings in relation to zinc oxide.

Das *et al.* (2008) The results of the field experiment show that the grain yield of continuous flooding (4.84 t/ha) and intermittent flooding up to 40 days after transplanting followed by continuous flooding (4.83 t/ha) with the application of ZnSO4 at the rate of 25 kg/ha did not vary significantly. The lowest grain yield (3.65 t/ha) was recorded in the treatment where the intermittent flooding was maintained throughout the growth period without the application of zinc. The amount of arsenic was, however, much lower in the treatment where intermittent flooding was maintained throughout the growing period combined with zinc sulphate application.

Kumar *et al.* (2008) studied that the stubbles+ZnSO4/Zn EDTA, Stubbles+FYM, Stubbles+ZnSO4/Zn EDTA+FYM and Stubbles were the four different situations in the farmer fields identified for the study. Soils of surveyed area were neutral to alkaline in reaction (7.4 to 8.6), low in salt content (0.18 to 0.21 dsm-1), low to high in organic matter content (2.4 to 8.5 gkg-1) and high in CaCO3 content (4.6 to 12.1%). Residual Zinc fraction was the dominant Zn fraction among different Zn fractions, while the values of water soluble exchangeable Zn were the least (0.18 to 0.13 mg kg-1) which were below the critical limit. Application of stubbles+ZnSO4/Zn EDTA+FYM resulted in higher grain and straw yield of paddy (61.1 & 81.0 q ha-1, respectively).

Vivek *et al* (2008) reported that the Zn application at different nutrient levels increased the rice yield significantly, while in the case of Fe, no significant effect was

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

observed with 75% NPK, although yield increased significantly when Fe was applied at 100 and 125% NPK during both years. A significant variation was observed between the effect of Zn or Fe application with nutrient levels, and application of Zn recorded significantly higher yield than Fe at the same fertilizer rate. Grain yield of rice in the control plot (34.98 and 34.15 q/ha) increased significantly up to 53.39 and 55.81 q/ha upon the application of 125% NPK+Zn+Fe in 2003 and 2004, respectively. Yield attributes also significantly increased upon treatment with Zn and Fe at different levels.

Chakeralhossein *et al.* (2009) results showed that in first year, zinc application increased yield significantly at 5% probability level. The highest yield was 7508 kg/ha with application of 40 kg Zn sulfate/ha in addition to foliar spraying ZnSo4 with 0.003 concentrations. In the second year, fertilizer application increased yield significantly at 1% probability level. Grain yield was 3988 kg/ha in control, which increased to 6366 kg/ha with application of 40 kg Zn/ha soil application in addition to foliar spraying of znso4. Results showed that soil application of 40 kg znso4/ha plus foliar spraying of 3/1000 znso4 increases the rice yield.

Chakeralhossein *et al.*(2009) studied that Soil application and foliar spraying of ZnSo4 and root exposure to 2% Zno suspension. Design was in a completely randomized block (RCBD) with tree replication. The results showed that in first year, zinc application increased yield significantly at 5% probability level. The highest yield was 7508 kg/ha with application of 40 kg Zn sulfate/ha in addition to foliar spraying ZnSo4 with 0.003 concentrations. In the second year, fertilizer application increased yield significantly at 1% probability level. Grain yield was 3988 kg/ha in control, which increased to 6366 kg/ha with application of 40 kg Zn/ha soil application in addition to foliar spraying of znso4. Results showed that soil application of 40 kg znso4/ha plus foliar spraying of 3/1000 znso4 increases the rice yield.

Jana *et al.* (2009) working on a field experiment conducted to study the effect of zinc application on transplanted rice grown on farmer's field of red and laterite soil indicated that zinc application produced significantly greater yield attributes, higher grain and straw yields of rice. Application of 30 to 40 kg ZnSO4/ha gave significantly higher values of plant height, number of effective tillers, panicle length, grain number per panicle, grain and straw yields and higher uptake of N, P, K and Zn in grain and straw of rice. Also 30 to 40 kg ZnSO4 gave greater yield response (10 to 13 q/ha) and higher net return (Rs. 4836 to Rs. 6371/ha).

Hao HuLin *et al.* (2009) reported that under the condition of pot cultivation with silty loam soil, due to P fertilizer application, the amounts of Fe,Mn, Cu and Zn accumulated

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

in the shoot of IR68144 increased significantly, compared with the control without fertilizer, and their distribution in brown rice of the two varieties increased significantly. Moreover, the amounts of Fe,Mn, Cu and Zn accumulated in the shoot of IR68144 were higher than those of IR64 at different P fertilizer application levels, which suggested that the transportation ability of Fe, Mn, Cu and Zn from the root to the shoot of IR68144 was stronger than that of IR64. Besides, P fertilizer promoted the accumulation of protein in brown rice of IR68144, decreased the accumulation of amylose, and enhanced gel consistency of brown rice, and had scarcely any effect on brown rice quality of IR64. Those results indicated that appropriate P fertilizer management can increase micronutrients in rice grain and improve the nutrition quality of rice.

Srivastava *et al.*(2009) Observed that a new Zn source (ZEMB) contained most of the Zn (98.4% of total Zn) in citrate-soluble form as compared to ZSH which had all Zn in water-soluble form. Chemical speciation of Zn in the aqueous solution of both fertilizers revealed that 85.8% of water-soluble Zn present in ZEMB existed as complexes of dissolved organic matter. In the field experiment, application of ZEMB at 5 kg Zn ha-1 to I-year rice increased the grain yields of rice and wheat in both years significantly over the control while application of ZSH at 5 kg Zn ha-1 to I-year rice increased only grain yields of I- and II-year rice (first year and second year, respectively). The magnitude of increase in grain yields was also higher with ZEMB than with ZSH.

Kumar amd Kumar (2009) studying the effect of rates and methods of zinc (Zn) fertilizer application in rice under flood prone conditions. There was a significant increase in the yield and yield attributes of rice up to 45 kg ZnSO4/ha. The content and uptake of Zn also increased significantly with increasing levels of zinc sulfate. Soil applied Zn was superior compared to its foliar application. Soil application of 45 kg ZnSO4/ha was the best, which recorded the highest net monetary return of Rs. 8111/ha with a B:C ratio of 1.63.

Chakeralhossein *et al.* (2009) observed thatthe soil application and foliar spraying of ZnSo4 and root exposure to 2% Zno suspension. Design was in a completely randomized block (RCBD) with tree replication. The results showed that in first year, zinc application increased yield significantly at 5% probability level. The highest yield was 7508 kg/ha with application of 40 kg Zn sulfate/ha in addition to foliar spraying ZnSo4 with 0.003 concentration. In the second year, fertilizer application increased yield significantly at 1% probability level. Grain yield was 3988 kg/ha in control, which increased to 6366 kg/ha with application of 40 kg Zn/ha soil application in addition to foliar spraying of znso4. Results

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

showed that soil application of 40 kg znso4/ha plus foliar spraying of 3/1000 znso4 increases the rice yield.

Jana et al. (2009) studying on the application of 30 to 40 kg ZnSO4/ha gave significantly higher values of plant height, number of effective tillers, panicle length, grain number per panicle, grain and straw yields and higher uptake of N, P, K and Zn in grain and straw of rice. Also 30 to 40 kg ZnSO4 gave greater yield response (10 to 13 q/ha) and higher net return (Rs. 4836 to Rs. 6371/ha).

Singh et al. (2009) observed that in rice and wheat, 25-50% NPK could be substituted by farmyard manure, vermicompost or farmyard manure + vermicompost. Percent yield reduction in rice following the substitution of 25% NPK with farmyard manure, vermicompost or pressmud, and substitution of 50% NPK with farmyard manure + vermicompost over 100% NPK were 2.5, 1.46, 6.3 and 7.31%, respectively, during 2005-06 (corresponding yield reductions during 2006-07 were 5.02, 4.79, 9.59 and 11.18%). Greater removal of plant nutrients was recorded for plots treated with chemical fertilizers under a similar yield level. Vermicompost and farmyard manure were better organic sources than pressmud.

Sing et al. (2009) also concluded that three modes of zinc nutrition, i.e. basal application of ZnSO4 at 15 and 25 kg/ha and seed soaking with 1.5% aqueous ZnO solution in addition to the control plot receiving no zinc, were compared. Being at par with the higher dose of ZnSO4 (25 kg/ha), the application of ZnSO4 at 15 kg/ha registered significantly higher values of growth characters, yield attributes and yield of the genotypes. USAR group performed better than CSR group. The application of 15 kg ZnSO4/ha to USAR group gave almost similar yield as that of 25 kg ZnSO4/ha. However, CSR group responded more to 25 kg ZnSO4/ha than to 15 kg ZnSO4/ha.

Jana *et al.* (2009) studying on the application of 30 to 40 kg ZnSO4/ha gave significantly higher values of plant height, number of effective tillers, panicle length, grain number per panicle, grain and straw yields and higher uptake of N, P, K and Zn in grain and straw of rice. Also 30 to 40 kg ZnSO4 gave greater yield response (10 to 13 q/ha) and higher net return (Rs. 4836 to Rs. 6371/ha).

Kumar and Kumar (2009) studying There was a significant increase in the yield and yield attributes of rice up to 45 kg ZnSO4/ha. The content and uptake of Zn also increased significantly with increasing levels of zinc sulfate. Soil applied Zn was superior compared to its foliar application. Soil application of 45 kg ZnSO4/ha was the best, which recorded the highest net monetary return of Rs. 8111/ha with a B:C ratio of 1.63.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Fu LiCheng *et al.* (2010) also noted that when the concentration of zinc sulfate was increased from 0 to 0.2%, the zinc contents in brown rice of Liangyoupeijiu were increased, while that in grain hull was increased and much higher than that in brown rice, and for Jiahua1, the zinc content in grain hull was higher too. With the increase of fertilization, more zinc and iron distributed in grain hull and panicle structures.

Ram *et al.*(2011) also noted that M7 (Zn as foliar application through Zn-EDTA 1.00 kg/ha+Fe as foliar application through Fe-EDTA 0.5 kg/ha), M8 (Fe as soil application through Fe-EDTA 1.00 kg/ha+Zn as foliar application through Zn-EDTA 0.5 kg/ha) arranged in split plot design and replicated three times. Among varieties and fertilizer level V1 treatment recorded significantly higher NPK uptake, grain and harvest index than V2 while in fertilizer levels F2 treatment recorded significantly higher N, P, K, Zn and Fe uptake, grain and harvest index than F1. Among the different micronutrient treatments M7 recorded significantly higher N, P, K, Zn and Fe uptake, grain yield and harvest index over other treatments.

Pooniya and Shivay (2011) also noted that the application of 2.0% zinc-enriched urea (ZEU) 'ZnSO4.H2O' recorded the highest grain yield (3.79 t/ha) of Basmati rice as compared to remaining treatments closely followed by 2.0% ZEU (ZnO). The highest N (159.7 kg/ha) and Zn (3085.3 g/ha) uptake in Basmati rice was recorded with 2.0% ZEU (ZnSO4.H2O) followed by 2.0% ZEU (ZnO) and 0.2% foliar spray of ZnSO4.H2O.

Dixit et al.(2012) studying the effect of sulphur and zinc on yield, quality and nutrient uptake by hybrid rice grown in sodic soil. Application of 40 kg S ha−1 recorded significantly high grain and straw yield, protein content and sulphur uptake. Similarly, positive response of hybrid rice to zinc application was also noticed significantly up to the zinc dose @ 10 kg ha−1. Increasing doses of sulphur and zinc enhanced significantly their uptake by hybrid rice crop. The interaction effect of sulphur and zinc was found non-significant and the highest grain and straw yields were recorded with application of 40 kg S and 10 kg Zn ha−1. Nitrogen, phosphorus and potassium uptake in crop increased significantly with sulphur and zinc application.

Shivay and Prasad (2012) observed that the 2% Zn-coating with zinc sulfate (ZnSO4.7H2O) was found to be the best but a 2% Zn-coating with zinc oxide (ZnO) was very close to it in terms of grain and straw yield and Zn concentrations in basmati rice grain and straw under Zn stress conditions. Partial factor productivity (PFP) of applied Zn varied from 984-3,387 kg grain kg Zn-1, agronomic efficiency (AE) varied from 212-311 kg grain kg-1 Zn (applied) and physiological efficiency (PE) of Zn varied from 6,384-17,077 kg grain

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

kg-1 Zn (absorbed). Thus, adequate Zn fertilization of basmati rice can lead to higher grain yield and Zn-denser grains with improved cooking quality in basmati rices under Zn stress soil conditions.

Tripathi and Kumar (2013) studied that the application of gypsum @ 50 and 100% of gypsum requirement (GR) significantly enhanced nutrient uptake, yield components and grain yield over the control during both the cropping seasons. The response was more pronounced when gypsum 50% of GR was applied in conjunction with green manure (GM) at 10 t ha-1 or ZnSO4 (60 kg ha-1). The response of gypsum 50% of GR+GM @ 10 t ha-1 on the yield and yield attributes was at par with the treatment receiving gypsum 50% of GR+ZnSO4 (60 kg ha-1) in both the rice cultivars.

Mabesa et.al (2013)reported that thbe foliar Zn application at the two tested growth stages failed to overcome agronomic Zn deficiency. Three of the biofortification breeding lines (IR68144, IR85800, and IR83668) had high grain Zn content that was independent of grain yield. In a separate experiment to test a wider range of spraying times at the severely deficient site with IR64, the spraying at the early milk stage emerged as the most effective stage for increasing brown rice Zn concentration. Our results show that agronomic Zn biofortification through foliar Zn application is likely to be much more effective at increasing grain Zn concentration of genotypes with strong Zn-remobilization capacity than those with weak remobilization capacity.

Impa et. Al (2013) observed that the Zn deficiency is a widespread problem in rice (Oryza sativa L.) grown under flooded conditions, limiting growth and grain Zn accumulation. Genotypes with Zn deficiency tolerance or high grain Zn have been identified in breeding programmes, but little is known about the physiological mechanisms conferring these traits. A protocol was developed for growing rice to maturity in agar nutrient solution (ANS), with optimum Zn-sufficient growth achieved at 1.5 micro M $ZnSO_4.7H_2O$. The redox potential in ANS showed a decrease from +350 mV to -200 mV, mimicking the reduced conditions of flooded paddy soils. In subsequent experiments, rice genotypes contrasting for Zn deficiency tolerance and grain Zn were grown in ANS with sufficient and deficient Zn to assess differences in root uptake of Zn, root-to-shoot Zn translocation, and in the predominant sources of Zn accumulation in the grain.

Somayanda *et al.*(2013) studied that Zn efficiency of a genotype was highly influenced by root-to-shoot translocation of Zn and total Zn uptake. Translocation of Zn from root to shoot was more limiting at later growth stages than at the vegetative stage. Under Zn-

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

sufficient conditions, continued root uptake during the grain-filling stage was the predominant source of grain Zn loading in rice, whereas, under Zn-deficient conditions, some genotypes demonstrated remobilization of Zn from shoot and root to grain in addition to root uptake. Understanding the mechanisms of grain Zn loading in rice is crucial in selecting high grain Zn donors for target-specific breeding and also to establish fertilizer and water management strategies for achieving high grain Zn.

Naik, and Das (2010) studying the among the various extractants, the performance of 0.1 N HCl in extracting Zn was better than the other two extractants and followed the trend 0.1 N HCl >0.005 M DTPA >0.05 N HCl. The greatest increase in grain and straw yield of rice was 37.8 and 20.4%, respectively, over the control in the treatment T7 (1 kg Zn ha-1 as Zn-EDTA at basal).

Patnaik *et al* .(2010) advocated that the Zinc application (as Zinc sulphte) up to 50 kg/ha had significantly increased the yield of direct crop of hybrid rice and first residual crop i.e., soybean in the system. Application of Zn at highest dose i.e., 100 kg/ha resulted in the residual effects up to fourth crop of soybean. If an additional dose of 25 kg is applied to the third crop of hybrid rice to the initially applied 50 kg/ha to hybrid rice, significant response in fourth crop (soybean) was observed. There was a built up in the available Zn status up to 20.5% at 0-15 cm depth. Application of Zn significantly increased the available Zn in soil. Available Zn was reduced in the control plots to an extent of 12.1 and 22.4% after direct and fourth crops in the system.

Naik, and Das (2010) advocated that the diethylenetriaminepentaacetic acid (DTPA), 0.1 N hydrochloric acid (HCl), and 0.05 N HCl-extractable Zn concentrations in soil increased initially up to the Z29 stage of crop growth when Zn was applied as a single basal source, being greater with Zn ethylenediaminetetraacetic acid (Zn-EDTA) compared to zinc sulfate (ZnSO4) application. Among the various extractants, the performance of 0.1 N HCl in extracting Zn was better than the other two extractants and followed the trend 0.1 N HCl >0.005 M DTPA >0.05 N HCl. The greatest increase in grain and straw yield of rice was 37.8 and 20.4%, respectively, over the control in the treatment T7 (1 kg Zn ha-1 as Zn-EDTA at basal).

Vijay Pooniya Shivay, Y. S. (2011) exhibited that the application of 2.0% zinc-enriched urea (ZEU) 'ZnSO4.H2O' recorded the highest grain yield (3.79 t/ha) of Basmati rice as compared to remaining treatments closely followed by 2.0% ZEU (ZnO). The highest

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

N (159.7 kg/ha) and Zn (3085.3 g/ha) uptake in Basmati rice was recorded with 2.0% ZEU (ZnSO4.H2O) followed by 2.0% ZEU (ZnO) and 0.2% foliar spray of ZnSO4.H2O.

Zayed et al.(2011) reported that the rice grain yield, straw yield, harvest index and yield components; panicle numbers, panicle weight, filled grains/panicle and 1000-grain weight were significantly increased by application of micronutrients application. The combination of Zn+2+Fe+2+Mn+2 gave the highest values of most studied traits without any significant differences with those produced by foliar spray twice. It could be concluded that micronutrient application especially through foliage under saline soil conditions is beneficial for rice growth and yield under such circumstances.

Ishimaru *et al.* (2011) observed that the Zinc (Zn) is an essential micronutrient with numerous cellular functions in plants, and its deficiency represents one of the most serious problems in human nutrition worldwide. Zn deficiency causes a decrease in plant growth and yield. On the other hand, Zn could be toxic if excess amounts are accumulated. Therefore, the uptake and transport of Zn must be strictly regulated. In this review, the dominant fluxes of Zn in soil-root-shoot translocation in rice plants (Oryza sativa) are described, including Zn uptake from soils in the form of Zn2+ and Zn-DMA at the root surface, and Zn translocation to shoots. Knowledge of these fluxes could be helpful to formulate genetic and physiologic strategies to address the widespread problem of Zn-limited crop growth.

Mustafa *et al.* (2011) observed that Zinc application methods and timing had significantly pronounced effect on paddy yield. Maximum paddy yield (5.21 t ha-1) was achieved in treatment Zn2 (Basal application at the rate of 25 kg ha^{-1} 21% ZnSO4) and minimum paddy yield (4.17 t ha-1) was noted in Zn7 (foliar application at 75 DAT @ 0.5% Zn solution). Zinc application increases the crop growth rate of rice.

Reddy *et al* (2011) reported that the It was found that significantly higher yield attributes, grain yield (7312 and 7042 kg/ha, respectively) and net returns (Rs.51, 212 and 62,344/ha, respectively) were recorded with basal application of Biozinc or ZnS04 @ 50 kg/ha+foliar spray @ 3 g/l at 30 DAT. Even foliar spray of ZnS04 or Biozinc @ 3 g/l at 30 and 45 DAT recorded significantly higher yield attributes, grain yield and net returns over control but inferior to basal application of Zn during both the years of study.

Sarwar (2011) reported that the average yield per hectare was increased at all doses of Zn and by applying it at the rates of 20, 25 and 30 kg/ha, the differences in grain yield were not significant, but production increased significantly over the untreated crop due to varying pest prevalence. With respect to borers incidence, higher dose 30 kg Zn/ha markedly

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

decreased infestation, while, applications at 20 and 25 kg permitted slightly more dead hearts and whiteheads incidence, but differed significantly from unfertilized control.

Reddy *et al.* (2011) It was found that significantly higher yield attributes, grain yield (7312 and 7042 kg/ha, respectively) and net returns (Rs.51, 212 and 62,344/ha, respectively) were recorded with basal application of Biozinc or ZnS04 @ 50 kg/ha+foliar spray @ 3 g/l at 30 DAT. Even foliar spray of ZnS04 or Biozinc @ 3 g/l at 30 and 45 DAT recorded significantly higher yield attributes, grain yield and net returns over control but inferior to basal application of Zn during both the years of study.

Ram *et al.* (2011) also noted that among varieties and fertilizer level V1 treatment recorded significantly higher NPK uptake, grain and harvest index than V2 while in fertilizer levels F2 treatment recorded significantly higher N, P, K, Zn and Fe uptake, grain and harvest index than F1. Among the different micronutrient treatments M7 recorded significantly higher N, P, K, Zn and Fe uptake, grain yield and harvest index over other treatments.

Zayedet al.(2011) studied that dry matter production, leaf area index and chlorophyll content (SPAD value) as well as plant height and panicle length were significantly higher when rice plant received the micronutrient rather compared to the control. Rice grain yield, straw yield, harvest index and yield components; panicle numbers, panicle weight, filled grains/panicle and 1000-grain weight were significantly increased by application of micronutrients application.

Mustafa et al. (2011) studied the experiment was comprised of eight treatments viz., control, rice nursery root dipping in 0.5 % Zn solution, ZnSO4 application at the rate of 25 kg ha-1 as basal dose, foliar application of 0.5 % Zn solution at 15, 30, 45, 60 and 75 days after transplanting. Super Basmati, a promising variety of rice was used as a test crop. Remarkable effects were noted on yield components such as number of productive tillers per hill, kernel per panicle, 1000-kernel weight, biological yield, kernel yield and harvest index. Maximum productive tillers per m2 (249.80) were noted with basal application at the rate 25 kg ha-1 21 % ZnSO4 and minimum (220.28) were recorded with foliar application at 60 DAT @ 0.5 % Zn solution. Zinc application methods and timing had significantly pronounced effect on paddy yield.

Mahajan et al. (2012) it was concluded that GLM (10 tonnes/ha) or GLM (5 tonnes/ha)+VC (2.5 tonnes/ha) or neem cake (2.5 tonnes/ha) are an ideal organic nutrition module/dose to meet the nutritional requirement of basmati crop and is best alternative to inorganic fertilizer without significant loss in grain yield.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Sridhara *et al.* (2012) The results revealed that among the genotypes, BI-43 recorded significantly higher grain yield (49.5 q ha-1) and higher number of tillers (23.5 plant-1) as compared to other genotypes. Among the method of micronutrient application, soil application of zinc and iron recorded significantly higher grain yield (49.5 q ha-1) as compared to other methods.

Rengel et al. (2012) observed that the results indicated that foliar application with 350 g ha-1 of zinc significantly increased plant height (14.4%) and nutrient use efficiency (11.99 kg grain/g Zn), while with 700 g ha-1, yield and 1000 grain weight were significantly increased in 63.0 and 2.76%, respectively. The aspersion of boron in dose of 225 g ha-1 significantly increased plant height in 7.9% over the absolute control, while the application of smallest dose (150 g ha-1), the biggest partial productivity of factor was obtained (28.9 kg grain/g B).

Vijay Pooniya and Y. S Shivay (2012) advocated that as regards to the economics of Basmati rice, SGMI and 2.0% ZEU (ZnSO4.H2O) Zn fertilization treatments gave the highest gross (SGMI, 85,985 and 91,582 INR ha-1; 2.0% ZEU, 89,837 and 59,851 INR ha-1) and net (SGMI, 56,997 and 61,445 INR ha-1; 2.0% ZEU, 59,851 and 64,442 INR ha-1) returns, respectively, compared with incorporation of the remaining summer green manuring residue and Zn fertilization treatments in 2008 and 2009. A significantly higher benefit:cost ratio was recorded with SGMI and 2.0% ZEU (ZnSO4.H2O). Overall, Sesbania aculeata green manuring and 2.0% ZEU (ZnSO4.H2O) are excellent sources of N and Zn for improved productivity of Basmati rice.

Raghuvir et al (2012) reported thatthe treatments comprised vermicompost at 4.0 t/ha (T1), CPP [cow pat pit] at 2 kg/ha (T2), farmyard manure (FYM) at 10 t/ha (T3), 50% NPK+vermicompost (VC) at 0.5 t/ha (T4), 50% NPK+CPP at 2 kg/ha (T5), 50% NPK+FYM at 5 t/ha (T6), 50% NPK+VC at 0.5 t/ha+CPP at 2 kg/ha (T7), 50% NPK+VC at 0.5 t/ha+FYM at 5 t/ha (T8), 50% NPK+VC at 0.5 t/ha+FYM at 5 t/ha+CPP at 2 kg/ha (T9), and 100% NPK (T10). The greatest plant height (89.9 cm) was recorded with T10, which was at par with all the treatments, except T2 and T3. The maximum plant stand/m2 was recorded with T10 (350), followed by T8 (345). The greatest grain weight (3.52 g) was recorded with T9, followed by T7 (3.48 g) and T1 (3.41 g). T10 recorded the highest grain yield of 47.42 and 39.29 q/ha during both years, respectively, which was at par with T9 (45.76 and 36.44 q/ha) and T8 (42.42 and 35.91 q/ha). The highest straw yield (60.12 and 53.36 q/ha) was recorded in T10, followed by T9 (58.32 and 52.43 q/ha).

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Shivay et al. (2012) also noted that the application of 2.0% ZEU as ZnSO4.H2O recorded the highest Basmati rice grain yield, i.e. 3.79 t ha-1 and the increase was registered to the tune of 12.78%, 2.43%, 3.26%, 5.71%, 7.05% and 5.27% over control (only N), 2.0% ZEU as ZnO, 5 kg Zn ha-1 as ZnSO4.H2O, 5 kg Zn ha-1 as ZnO, 0.5 kg Zn as ZnO slurry and 1.0 kg Zn through 0.2% foliar spray, respectively. Our results clearly indicated that incorporation of S. aculeata SGMC residue in conjunction with 2% ZEU as ZnSO4.H2O significantly enhanced soil microbial activities, which are vital for the nutrient turnover and long-term productivity of soil, leading to enhanced productivity of Basmati rice.

Asadi, et al. (2012) also noted thatHydroponically studies were conducted in rice seedlings (Oryza sativa L, cv. Tarom Hashemi) under different Zn levels. The nutrient solution treatments were prepared of three 4 zinc levels (0.5, 5, 50 and 100 micro M ZnSO4). Zn decreased Zn-TF, increased Zn accumulation in roots. Addition of Zn from 0.5 to 5 micro M in nutrient solution increased shoot length, plant dry weight, Superoxide dismutase (SOD) and decreased ascorbate peroxidase (APX) and guaiacol peroxidase (GPX) while addition of Zn from 5 to 100 micro M had the reverse effects.

Muthukumararaja *et al.* (2012) observe that the Zinc deficiency in flooded soil is impediment to obtain higher rice yield. Zinc deficiency is corrected by application of suitable zinc fertilizer. The results revealed that rice responded significantly to graded dose of zinc applied. The highest grain (37.53 g pot-1) and straw yield (48.54 g pot-1) was noticed at 5 mg Zn kg-1 which was about 100 % and 86% greater than control (no zinc) respectively.

Abbas *et al.* (2013)The results showed that soils were heavy in texture, non-saline, moderately alkaline in reaction and low in organic matter. Micronutrients B, Zn, Cu, Fe and Mn found in the soils were low in at 0-15 and 15-30 cm soil depth. Higher TGM: 25.7 g, 24.3 g, 24.3 g, 25.4 g and 25.8 g; paddy yield:12.6, 11.3, 10.9, 12.3 and 11.5 tons per hectare; protein 11.1, 10.7, 10.4, 10.5 and 10.9%; fat 2.5, 2.6, 2.6, 2.7 and 2.5% was found at T2 (N+P+Zn+B) in the varieties IR6, IR8, DR92, DR83 and Shahkaar respectively. Yield, TGM and protein significantly ($p<0.05$) increased within varieties at each treatment whereas fat contents in all varieties were found to be non-significant ($p>0.05$).

Niru et al. (2013) reported that the productivity of rice-wheat was 21.4% higher than rice-lentil system (3.09 REY t/ha). All combinations of organic manuring were equally effective in increasing productivity of system, decreased the bulk density and increased water holding capacity, microbial population, soil fertility than the initial values as compared to control treatment over a period of four years study.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Vijay Pooniya and Y. S.(Shivay, 2013) also noted that the agronomic efficiency (AE) of applied Zn to rice crop was significantly higher with mungbean (Vigna radiata) GM and ZnO slurry Zn fertilization treatment, however, 0.2% foliar spray of ZnSO4.H2O recorded the highest Zn crop recovery efficiency (Zn CRE) viz. 57.6 and 61.6%, respectively. Overall, application of Zn fertilizer (ferti-fortification) to basmati rice through ZEU and foliar spray of 0.2% (ZnSO4.H2O) increased Zn concentration in grain and straw, resulting in greater bio-availability of grain Zn. Therefore, this would be a very important and useful strategy in solving the Zn deficiency related problems in Indo-Gangetic plains of India.

Singh *et al.* (2013) studied the higher levels of nitrogen and zinc sulfate enhanced significantly plant height, number of tillers/plant and grain and straw yield of rice. Nitrogen application at 120 kg/ha increased grain yield to the extent of 23.57 and 26.94% during first and second years over 60 kg/ha level of nitrogen while zinc sulfate at 50 kg/ha increased grain yield by 44.20 and 40.93% during first and second year over control, respectively.

Boonchuay*et al.*(2013) studying the largest increases of up to ten-fold were in the husk, and smaller increases in brown rice Zn. In the first few days of germination, seedlings from seeds with 42 to 67 Zn $mgkg^{-1}$ had longer roots and coleoptiles than those from seeds with 18 mg Zn kg_1, but this effect disappeared later. Zinc in rice grains can be effectively raised by foliar Zn application after flowering, with a potential benefit of this to rice eaters indicated by up to 55% increases of brown rice Zn, and agronomically in more rapid early growth and establishment.

Tripathi and Kumar (2013) observed that the application of gypsum @ 50 and 100% of gypsum requirement (GR) significantly enhanced nutrient uptake, yield components and grain yield over the control during both the cropping seasons. The response was more pronounced when gypsum 50% of GR was applied in conjunction with green manure (GM) at 10 t ha-1 or ZnSO4 (60 kg ha-1). The response of gypsum 50% of GR+GM @ 10 t ha-1 on the yield and yield attributes was at par with the treatment receiving gypsum 50% of GR+ZnSO4 (60 kg ha-1) in both the rice cultivars.

Ghasemi *et al* (2013) observed that Zn application had significant increased on 1000-grain weight and also there was a significant interaction effect with other fertilizers. Therefore, grain yield and harvest index had similarly increased with K application and without or with Zn application. Generally, it seem that there was relationship replacement between Zn and K fertilizer in rice because grain yield had severe decreased without K and Zn application.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Singh *et al.* (2013) exhibited that the Interaction effect between EC and nitrogen and EC and zinc showed that increasing levels of N and Zn increased grain and straw yield significantly under each level of water salinity indicating that adverse effect of water salinity can be reduced by N and Zn application.

Hafeez *et al.* (2013) observed that the direct and residual response of Zn on rice genotypes at the rates of 0 and 15 kg Zn ha-1 in low-Zn-content acidic submerged soil. The genotypes differed significantly in grain yield and its components. Single application of Zn significantly increased the growth and yield of the crop for two seasons. Based on the grain yield efficiency index, the most Zn-efficient genotypes were MR 106 and Seri Malaysia Dua. Two genotypes, MR 220 and MR 219, were moderately efficient, but MR 211 and Bahagia were classified as inefficient.

Srivastava *et al.* (2014) advocated that thefoliar applications of Zn increased the P concentration in grain and straw and the total P uptake by basmati rice and the P concentration in flag leaves of wheat significantly, while soil or foliar application of Zn increased the total P uptake of wheat. Phosphorus application increased the Zn concentration in flag leaves, grain and straw of basmati rice and in grain and straw of wheat and the total Zn uptake of both crops. Phosphorus levels up to 17.5 kg P ha-1 increased utilization efficiency of soil or foliar application of Zn. Zinc application increased the P utilization efficiency of basmati rice and wheat up to 17.5 kg P ha-1 level; foliar Zn application was more effective in a wheat crop than a rice crop.

Singh *et.al* (2014) observed that It recorded the highest Basmati rice grain (5.46 t ha-1) and straw yields (9.89 t ha-1), and the increase was registered to the tune of 23.5% and 12.9%, 5.6% and 2.9%, 8.98% and 5.1%, 17.4% and 9.8%, 12.67% and 7.2% over control (no Zn application), ZnSO4.7H2O, ZnSO4.H2O, ZnO and ZnSO4.7H2O+ZnO (50%+50%), respectively.

Guo JiuXin *et.al (2014)* studied that compared with control Zn fertilizer application could significantly improve the rice grain yield by about 0.3%-13.0%, with the yield increasing by rising Zn fertilizer rate, and the yield-improving efficiency of Zn fertilizer application in the borderline Zn deficient soil was higher than that in low Zn soil. In addition, application methods of Zn fertilizer also significantly affected grain yield and Zn content in individual rice organ. The yield-improving efficiency of soil application was higher than that of foliars spray, but the foliar spray of Zn fertilizer evidently increased Zn content in individual rice organ relative to the soil application of Zn fertilizer, and the effect of

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College
Muzaffarnagar

application method on Zn content followed a general trend as soil application+foliar spray > foliar spray > soil application > control.

Srivastava *et.al* (2014) reported that theFoliar applications of Zn increased the P concentration in grain and straw and the total P uptake by basmati rice and the P concentration in flag leaves of wheat significantly, while soil or foliar application of Zn increased the total P uptake of wheat. Phosphorus application increased the Zn concentration in flag leaves, grain and straw of basmati rice and in grain and straw of wheat and the total Zn uptake of both crops. Phosphorus levels up to 17.5 kg P ha-1 increased utilization efficiency of soil or foliar application of Zn. Zinc application increased the P utilization efficiency of basmati rice and wheat up to 17.5 kg P ha-1 level; foliar Zn application was more effective in a wheat crop than a rice crop.

2.2 Effect of Zinc sources and application modes on residual soil fertility in basmati rice field

Dwivedi and Srivastava (2008) recorded on application of 0, 6.25, 12.5 and 25.0 kg zinc sulphate ha-1 to first year rice crop with or without cyclic incorporation of 1.5, 3.0 and 6.0 t ha-1 wheat straw for rice and rice straw for wheat crop for two years influenced organic carbon content, available N, available P and available K significantly. EC and pH of soil were not affected. In general, after rice harvest the content of soil organic C was higher than after wheat harvest. Incorporation of straw @ 6.0 t ha-1 with Zn application helped accumulation of available soil N. After two crop cycles, available P content of soil increased significantly with the incorporation of straw @ 3.0 t ha-1. Available K content in soil increased significantly with the conjunctive use of straw and ZnSO4.

Naik and Das (2010) advocated that the diethylenetriaminepentaacetic acid (DTPA), 0.1 N hydrochloric acid (HCl), and 0.05 N HCl-extractable Zn concentrations in soil increased initially up to the Z29 stage of crop growth when Zn was applied as a single basal source, being greater with Zn ethylenediaminetetraacetic acid (Zn-EDTA) compared to zinc sulfate (ZnSO4) application. Among the various extractants, the performance of 0.1 N HCl in extracting Zn was better than the other two extractants and followed the trend 0.1 N HCl >0.005 M DTPA >0.05 N HCl. The greatest increase in grain and straw yield of rice was 37.8 and 20.4%, respectively, over the control in the treatment T7 (1 kg Zn ha-1 as Zn-EDTA at basal).

Patnaiket *et.al* (2010) opined that Zinc application (as Zinc sulphte) up to 50 kg/ha had significantly increased the yield of direct crop of hybrid rice and first residual crop i.e., soybean in the system. Application of Zn at highest dose i.e., 100 kg/ha resulted in the

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

residual effects up to fourth crop of soybean. If an additional dose of 25 kg is applied to the third crop of hybrid rice to the initially applied 50 kg/ha to hybrid rice, significant response in fourth crop (soybean) was observed. There was a built up in the available Zn status up to 20.5% at 0-15 cm depth. Application of Zn significantly increased the available Zn in soil. Available Zn was reduced in the control plots to an extent of 12.1 and 22.4% after direct and fourth crops in the system.

Pooniya and Shivay (2012) advocated that as regards to the economics of Basmati rice, SGMI and 2.0% ZEU (ZnSO4.H2O) Zn fertilization treatments gave the highest gross (SGMI, 85,985 and 91,582 INR ha-1; 2.0% ZEU, 89,837 and 59,851 INR ha-1) and net (SGMI, 56,997 and 61,445 INR ha-1; 2.0% ZEU, 59,851 and 64,442 INR ha-1) returns, respectively, compared with incorporation of the remaining summer green manuring residue and Zn fertilization treatments in 2008 and 2009. A significantly higher benefit:cost ratio was recorded with SGMI and 2.0% ZEU (ZnSO4.H2O). Overall, Sesbania aculeata green manuring and 2.0% ZEU (ZnSO4.H2O) are excellent sources of N and Zn for improved productivity of Basmati rice.

Shivay *et al.* (2012) also noted that the application of 2.0% ZEU as ZnSO4.H2O recorded the highest Basmati rice grain yield, i.e. 3.79 t ha-1 and the increase was registered to the tune of 12.78%, 2.43%, 3.26%, 5.71%, 7.05% and 5.27% over control (only N), 2.0% ZEU as ZnO, 5 kg Zn ha-1 as ZnSO4.H2O, 5 kg Zn ha-1 as ZnO, 0.5 kg Zn as ZnO slurry and 1.0 kg Zn through 0.2% foliar spray, respectively. Our results clearly indicated that incorporation of S. aculeata SGMC residue in conjunction with 2% ZEU as ZnSO4.H2O significantly enhanced soil microbial activities, which are vital for the nutrient turnover and long-term productivity of soil, leading to enhanced productivity of Basmati rice.

Abbas *et al.* (2013) The results showed that soils were heavy in texture, non-saline, moderately alkaline in reaction and low in organic matter. Micronutrients B, Zn, Cu, Fe and Mn found in the soils were low in at 0-15 and 15-30 cm soil depth. Higher TGM: 25.7 g, 24.3 g, 24.3 g, 25.4 g and 25.8 g; paddy yield:12.6, 11.3, 10.9, 12.3 and 11.5 tons per hectare; protein 11.1, 10.7, 10.4, 10.5 and 10.9%; fat 2.5, 2.6, 2.6, 2.7 and 2.5% was found at T2 (N+P+Zn+B) in the varieties IR6, IR8, DR92, DR83 and Shahkaar respectively. Yield, TGM and protein significantly ($p<0.05$) increased within varieties at each treatment where as fat contents in all varieties were found to be non-significant ($p>0.05$).

Niru et al. (2013) reported that the productivity of rice-wheat was 21.4% higher than rice-lentil system (3.09 REY t/ha). All combinations of organic manuring were equally effective in increasing productivity of system, decreased the bulk density and increased water

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

holding capacity, microbial population, soil fertility than the initial values as compared to control treatment over a period of four years study.

Singh *et.al* (2013) reported that the Interaction effect between EC and nitrogen and EC and zinc showed that increasing levels of N and Zn increased grain and straw yield significantly under each level of water salinity indicating that adverse effect of water salinity can be reduced by N and Zn application. The ECe of experimental soil increased remarkably with increasing water salinity levels indicating reasonable accumulation of soluble salts in the soil. The pH value of the soil could not affect with water salinity. Application of nitrogen and zinc sulfate could not produce any remarkably variation in ECe and pH of the soil.

Materials and Methods

Details of layout plan

S. No.	Particulars		Remarks
1	Design of Experiment	:	Randomized Block Design
2	Number of Treatments	:	10
3	Number of replications	:	03
4	Total number of Plots	:	30
5	Plot gross size	:	5 x 4m = 20 m^2
6	Block Border	:	0.75 m wide
7	Irrigation channel	:	1.5 m wide
8	Spacing	:	20 cm x 15 cm
9	Rice variety	:	Pusa Basmati-1121

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Treatments Description:

S. No.	Treatments	Symbol
1	Control (without NPK)	T_1
2	100 % RDF (NPK @ 120: 60:60)	T_2
3	50 % RDF (NPK @ 120: 60:60) + 10Kg Zn through $ZnSO_4.7H_2O$	T_3
4	75 % RDF (NPK @ 120: 60:60) + 10 Kg Zn through $ZnSO_4.7H_2O$	T_4
5	100 % RDF (NPK @ 120: 60:60) + 10 Kg Zn through $ZnSO_4.7H_2O$	T_5
6	50 % RDF (NPK @ 120: 60:60) + 10 Kg Zn through Mono $ZnSO_4.7H_2O$	T_6
7	75 % RDF (NPK @ 120 : 60:60) + 10 Kg Zn through Mono $ZnSO_4.7H_2O$	T_7
8	100 % RDF (NPK @ 120 : 60:60) + 10 Kg Zn through Mono $ZnSO_4.7H_2O$	T_8
9	100 % RDF (NPK @ 120 : 60:60) + Micronutrient mixture @50kg ha^{-1}	T9
10	100 % RDF (NPK @ 120: 60:60) + Vermicompost @ 6 tones ha^{-1}	T_{10}

3.1 Experimental site and location

The experiment was conducted at the Crop Research Center, Shri Ram College Muzaffarnagar (U.P.) which is located at a latitude of 29^0 40′ North and longitude of 77^0 42′ East and at an altitude of 287 meter above mean sea level (MSL). Muzaffarnagar lies in western Uttar Pradesh and has semi arid to sub-tropical climate.

3.2 Climate and weather

The region enjoys semi-arid and subtropical climate with extremes of hot weather in summer and cold in winter season. The area does have 3 distinct seasons viz- kharif, rabi and spring. There is gradual decrease in mean daily temperature from October reaching as low as 2-4 ^{0}C in January and further a gradual increase is registered from February reaching as high as 43-45 ^{0}C in May. The rains are predominantly caused by south-west monsoon which sets in the last week of June, reaches its peak in July-August and withdraws by the end of September. The area receives 862 mm of rains annually on an average, of which 90% is confined to rainy season (July - September).

The meteorological data recorded at the observatory of the University and the Project Directorate for Farming System Research, Modipuram is given in Appendix-I & II

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

and depicted in Fig 1 a and 1 b. Perusal of the data revealed that mean weekly maximum temperature varied from 36.1 ^{0}C in 31th week (Aug.1-7) to 27.3 ^{0}C in 47th week (Nov. 22-30), and the mean weekly minimum temperature ranged from 26.2 ^{0}C in 35th week (Sep.1-7) to 12.0 ^{0}C in 47rd week (Nov. 22-30) during 2011. During next season i.e. 2012, mean weekly maximum temperature varied from 33.79 ^{0}C in 40th week (Oct 1-7) to 26.29 ^{0}C in 45rd week (Nov. 8-14), and the mean weekly minimum temperature ranged from 30.57 ^{0}C in 33th week (Aug15-21) to 13.36 ^{0}C in 45th week Mean weekly relative humidity fluctuated from 88.35% in 33st week (Aug. 15-21) to 67.88% in 47th week (Nov. 22-30) during 2011, whereas it ranged from 76.47% in 34nd week (Aug. 22-31) to 53.17% in 43th week (Oct. 22-31) during 2012 in the consecutive *kharif* season. The total rainfall of 286.88 mm was received by the crop in 62 rainy days during 2011 and 614.7 mm in 79 rainy days during 2012.

3.3 Soil of the experiment field

Soil samples from a depth of 0-15 cm were collected from each plot of the experiment prior to transplanting and a composite sample was drawn for determining its physico-chemical properties (Table. 1)

3.4 Sequence of the crops grown on the experimental field

The production potential of the experimental field can be judged from the cropping history. The details of the cropping history of the experimental field are presented in the Table.2 Perusal of the table showed that the field was cropped with the general rotation of rice-wheat in preceding four years and having normal fertility.

Table 1: Physico-chemical properties of the experimental field soil

SN	Characteristics	Values	Method followed	Reference
A	Particle size	Percent	Hydrometer method	Bouyoucons (1965)
1	Sand	53.54		
2	Silt	27.6		
3	Clay	18.86		
4	Textural class	Sandy loam	USDA triangular diagram	Brady (1996)
B	Physical Characteristics			
1	Bulk density (g/cc)	1.57	Core method	Black, 1965
2	Particle density (g/cc)	2.38	Pichnometer Method	Danienlson&Sutherl, (1986)
3	Porosity (%)	35	1-BD/PD	

Co-ordinator
IQAC, Shri Ram College,
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

4	Soil aggregate stability (%)	54	Wet sieving method	
5	Infiltration rate (cm/hr)	3.37 to 0.25	Double ring Infiltometer method	
6	Hydraulic conductivity (cm/hr)	1.89 to 0.82	Constant Head Method	
C	Chemical characteristics			
1	pH (1:2.5 Soil : water)	8.35	Glass electrode pH meter	Richard (1954)
2	EC (dSm $^{-1}$ at 25C^{o}) (1:2.5 Soil: Water)	0.189	Solubridge	Richard (1954)
3	Organic Carbon (percent)	0.42	Rapid titration method	Walkley and Block (1965)
4	Available nitrogen (N kg ha^{-1})	206.30	Alkaline potassium permanganate method	Subbiah and Asija (1956)
5	Available phosphorus (P kg ha^{-1})	18.60	Extraction by 0.5 M $NaHco_3$ Solution at pH 8.5 (Olsen's method)	Olsen *et al.*, (1954)
6	Available potassium (K kg ha^{-1})	278.70	Extraction with Neutral 1 N ammonium acetate and estimated by flame photometer	Hanway and Heidel (1952)
9	DTPA extractable Zinc (ppm)	1.23	DTPA extractant and estimated on atomic absorption spectrophotometer	Lindsay and Norvell (1978)
10	DTPA extractable Iron (ppm)	14.85	DTPA extractant and estimated on atomic absorption spectrophotometer	Lindsayand Norvell (1978)
11	DTPA extra ctable Copper (ppm)	2.43	DTPA extractant and estimated on atomic absorption spectrophotometer	Lindsayand Norvell (1978)
12	DTPA extractable Manganese (ppm)	10.91	DTPA extractant and estimated on AAS	Lindsayand Norvell (1978)

The experimental field was ploughed immediately after the harvest of previous wheat crop by a tractor drawn harrow in summer to expose weeds and the eggs of harmful insects. The field was prepared by practicing two cross disc harrowing and two cross tiller operations and finally the field was leveled and planked.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

3.6.2 Seed

Seed of basmati rice variety Pusa basmati -1121 purchased from Basmati Export Development Foundation; Meerut (U.P.) was used for experiment.

3.6.3 Nursery raising

The seedling of rice variety Pusa basmati-1121 raised in nursery plot by "Wet bed method". A seed bed of 8 x 1.25 m size was prepared in dry condition. On sowing date, the beds were flooded with water and puddle manually. After leveling, a mixture of 135 g urea (60 kg ha^{-1}), 187.5 g single super phosphate (30 kg ha^{-1}) and 25 g zinc sulphate per bed was broadcasted and incorporated in to the soil. Sprouted seed were sown then beds kept saturated initially up to a week and then submerged with a thin layer of water throughout the nursery period. These beds were irrigated on alternate days during rainless period.

3.6.4 Application of fertilizers

A uniform dose of NPK and MOP , Zinc Sulphate , Mono Zinc suphate, Chelated Zinc, micronutrient mixture and Vermicompost were used to provide N, P, K, Zn, Cu, Fe, Mn as per treatments in T_2-T_{12} Whereas in T_1 no fertilizers were used.

3.6.5 Uprooting of seedlings, transplanting and gap filling

The nursery beds were irrigated one day before seedling uprooting to make the soil soft and about 29 days old seedlings were uprooted by holding at the base and pulling them up one by one and their roots were washed to remove the soil. Transplanting was done manually as per treatments keeping two seedlings $hill^{-1}$. One week after transplanting, gap filling was done from the same nursery for maintaining the optimum plant population.

3.6.6. Water management

A thin layer of water (approximately 3.0 cm) was maintained during the initial stage of crop growth for better establishment of seedlings and maximum 5.0 cm at tillering stage and later an intermittent irrigation at the time of panicle initiation, flowering and grain formation stage were applied. Water was drained out from the field at least one week before the harvesting of crop.

3.6.7 Plant protection measures

In order to control stem borer, leaf hopper, gundhy bug and other insect, the recommended insecticide as Cartap hydro chloride 4G and to control the disease recommended fungicide as Carbendazim @ 0.1% etc were applied on the basis of economic threshold level (ETL).

3.6.9 Harvesting and threshing

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Harvesting was done manually when the crop reached at full physiological maturity stage. First of all, the border rows were harvested and separated. Later, the crop from net plot area was harvested and sun dried. The harvested material from each plot was carefully bundled, tagged and brought to threshing floor. Threshing was done plot wise and grains were cleaned, dried and weighed separately for each net plot and computed to qha^{-1} at 14% moisture level. The straw yield was also recorded plot wise after sun drying and computed to $q\ ha^{-1}$.

3.7 Observation recorded and sampling procedures

The various observations recorded during the course of investigation to study the effectiveness of different treatments are described in this section.

3.7.1 Observations on crop

3.7.1.1 Growth studies

3.7.1.1.1 Plant height

Ten plants were selected and tagged to measure the plant height. The plant height was measured from the base of plant to tip of the fully opened leaf till panicle emergence and at harvest (after panicle emergence) the height was measured from the base of the plant to the tip of the upper most spikelet and expressed as average plant height in cm.

3.7.1.1.2 Number of tillers ($No.m^{-2}$)

Number of tillers was recorded by using a quadrate of one square meter from three places in each plot at 30 and 60 DAT and at harvest stage; average of three places was taken for analyses.

3.7.1.1.3 Dry matter accumulation ($kg\ ha^{-1}$)

Dry matter accumulation was recorded by selecting five hills randomly from observation row of each plot. Selected hills were cut carefully closed to the ground surface at 30 and 60 DAT and at harvest stage. After sun drying these samples were collected in paper bags by cutting in small pieces and were put in a electric oven at $60\pm1\ ^0C$ till constant weight. After this the weight was recorded on electronic balance and expressed as dry matter accumulation in $g\ m^{-2}$.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

3.7.2. Yield and yield attributes

3.7.2.1 Panicle length (cm)

Twenty panicles were selected from five marked plants from each plot and recorded the panicle length in cm on average basis.

3.7.2.2 Test weight (g)

A handful of seeds were taken without any bias from the total seeds of the plot, after threshing and cleaning. One thousand filled grains from each plot samples were counted and weighed on electronic balance and their weight was expressed in grams.

3.7.2.3 Grains yield (qha^{-1})

After cleaning and drying the grains, the grain yield was recorded in kg per plot. The moisture percentage in 100 g samples drawn from each treatment was determined with the help of moisture meter and grains yield per plot was adjusted to 14 percent moisture. The yield of net plot, thus converted to qha^{-1}.

3.7.2.4 Straw yield (qha^{-1})

Dry weight of straw collected from net plot was recorded after sun drying for 5-6 days and expressed in qha^{-1}.

3.7.2.5 Biological yield (qha^{-1})

The total above ground produce (grain + straw) was recorded on dry basis after sun drying from net plots and expressed in (qha^{-1}).

3.7.2.6 Harvest index (%)

The harvest index of rice was obtained by dividing the economical yield (grains yield) with the biological yield (grains + straw) and represented in percentage.

$$Harvest\ \ Index = \frac{Economic\ yield(q/ha)}{Biological\ yield(q/ha)} x100$$

3.8 Chemical analysis

3.9 Soil analysis

3.9.1 Collection of soil samples

Soil samples were collected from 0 -15 cm. depth from each plot. These samples were processed and analyzed for various physico-chemical and biological properties in the laboratory of department of soil science, in Shiri Ram College Muzaffarnagar (U.P.).

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

3.9.2 Available soil N

Available nitrogen in soil was determined by the procedure outlined by Subbiah and Assija,(1956.)

3.9.3 Available soil P

Available phosphorus in the soil was extracted by 0.5 M Sodium bicarbonate ($NaHCO_3$) adjusted to pH 8.5 and P in the aliquot was determined by Ascorbic acid method (Olsen et al; 1954).

3.9.4 Available soil K

Available K in the soil was extracted by 1N neutral ammonium acetate as an extractant, (Hanway and Heidel, 1952) and K in the extract was estimated by Flame photometer.

3.9.5 DTPA extractable micro nutrients

Available Zn, Fe, Mn , and Cu in the soil was extracted by DTPA and nutrient concentration in extract was determined by Atomic Absorption Spectrophotometer .

3.9.6 EC measurement

The EC was determined with the help of glass electrode of EC meter in 1:2.5 soils: water suspension (Jackson, 1973).

3.9.7 pH measurement

The pH was determined with the help of glass electrode of a pH meter in 1:2.5 soils: water suspension (Jackson, 1973).

3.10 Statistical studies

The data recorded during the course of investigation were subjected to statistical analysis using analysis of variance technique (ANOVA) for randomized block designed as prescribed by Cochran and Cox (1959). Standard error of mean in each case and critical difference only for significance cases were computed at 5% levels of significance as under

3.10.1 Critical difference

The data obtained were subjected to statistical analysis as outlined by Gomez and Gomez (1984). The treatment means were compared by using the transformed values. The

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

treatment differences were tested by least significant difference at 5 per cent of probability and calculated by the following formula:

$$CD = \sqrt{\frac{2 \times \text{Error mean square}}{r}} \times t_{0.05}$$

Where,

CD = Critical difference

r = Number of replications of the factor for which C.D. is to be calculated.

Result and Discussion

4.1.1 Plant height

The data regarding the application effect of various sources of zinc in different mode and vermicompost along with RDF on plant height of rice at 30, 60 DAT and harvesting during experimental yearare shown in TableIt is clear from the table that measured plant height was affected significantly by different treatments at all the observation interval during experimental year. Plant height increased at faster rate till 60 DAT while after that the increment in plant height was slower. The plant height measured at 30 DAT ranged from 72.30 to 90.94 cm during experimental yearunder different treatments and affected significantly by different treatments. Plant height of rice during experimental yeardid not varied significantly with the application of zinc through different sources. Plant height recorded in T_{10} (RDF+VC) was significantly higher than the rest of the treatments during experimental year. At 60 DAT stage plant height ranged from 87.35 to 109.78 cm during experimental yearunder different treatments and varied significantly. Plant height increased by 20.71 to 20.82 per cent from the height recorded at 30 DAT under different treatments during experimental year.At this stage the maximum plant height (109.78) was recorded in T_{10} where vermicompost was applied with recommended NPK in experimental yearfollowed by T_9(106.64) where micronutrient mixture was applied with recommended NPK.At this stage increment of 4.31 per cent in plant height was found during experimental year. At harvesting stage maximum plant height (111.52 cm) was recorded in T_{10}(vermicompost with recommended NPK) followed by T_9 (108.93) where micronutrient mixture with recommended NPK was applied. At all growth stages highest plant height was recorded in $T_{10}$where vermicompost with RDF was applied.Plant height of rice at different stage was

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

affected significantly by different treatments. Similar results were also reported by **Jana, *et al.* (2009).** Theyreported that the application of 30 to 40 kg ZnSO4/ha gave significantly higher plant height. **Khan *et.al* (2007)** also found the similar results.

T able : Effect of NPK and zinc sources on plant height (cm) of rice at different stages

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Treatments	30 DAT	60 DAT	At harvest
T_1	72.30	87.35	89.34
T_2	75.75	99.37	101.88
T_3	85.94	105.65	108.37
T_4	84.54	105.12	107.42
T_5	82.23	104.54	107.23
T_6	82.23	104.47	107.10
T_7	81.96	104.20	106.97
T_8	80.82	101.57	105.31
T_9	87.87	106.64	108.93
T_{10}	90.94	109.78	111.52
SE (m)	*1.63*	*1.95*	*1.58*
CD(p=0 .05)	*4.81*	*5.76*	*4.66*

4.1.1.2 Number of tillers per meter row length at different day interval

The data regarding application effect of various sources of zinc in different mode and vermicompost along with RDF on number of tillers per meter row length of rice at 30, 60 DAT and harvesting during experimental year are shown in TableIt is clear from the table that measured number of tillers per meter row length were affected significantly by different treatments at all observation interval during experimental year. Number of tillers increased at faster rate till 60 DAT and there after a slight decline in number of tillers per meter row

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

length was noticed. The number of tillers per meter row length counted at 30 DAT varied from 22 to 49 during experimental year. Maximum number of tillers 49 during experimental yearin T_{10} were found statistically at par to T_3, T_{11} and significantly higher than the rest of the treatments. Result reveals that application ZnSO4@ 25kg $ha^{-1}$was equally good to the application of micronutrient mixture or VC. Foliar application of zinc through either source was found significantly inferior to the application of zinc sulphate @ 25kg ha^{-1}. With one exception the foliar application effect of zinc was more or less similar in respect of number of tillers per meter row length. The number of tillers per meter row length did not responded to the foliar application of either source of zinc. Number of tillers per meter row length were slightly lower in the treatments receiving zinc nutrition through foliar than soil application with every source. At 60 DAT, number of tillers per meter row length varied from 32 to 69 and 36 to 73 during 2011 and 2012, respectively. Number of tillers per meter row length increased by 46.80 to 68.48 and 48.97 to 61.22 per cent from the tillers number recorded at previous stage under different treatments during experimental year. At this stage the highest number of tillers per meter row length (69 and 73) counted in T_{12} were statistically at par with T_{11} (64 and 69) and T_3 (61 and 64) and significantly higher over rest of the treatments during both the years. At this stage also comparatively lower number of tillers per meter row length were recorded with foliar than soil application. The effect of treatments consisting foliar application of zinc on tillers per meter row length was more or less similar. At harvesting number of tillers per meter row length varied from 29 to 68 and 33 to 71 during both the years and reductions of 1.45 to 9.37 and 2.74 to 8.33 per cent in tillers number was noticed during experimental year respectively. At harvesting stage, highest number of tillers per meter row length (68 and 71) recorded in T_{12} (3t ha^{-1}vermicompost was applied with RDF) were found statistically similar to T_{11} and T_3 and significantly higher than the rest of the treatments. The effect of foliar application of zinc with higher to lower concentration on number of tillers m^{-1} was non-significant and it was also found statistically at par with T_2 during both the years.

Number of tillers of rice at different stage was affected significantly by different treatments. At 30 DAT with exception of T_9 (micronutrient mixture +RDF), the number of tillers recorded in T_{10} (RDF+VC) were significantly higher than the rest of the treatments during both the years in this treatment vermicompostwas applied over 100% NPK. The nutrient released from the additionally added VC may respond the plant growth and tillers may be higher on the decomposition of vermicompost many organic acid are produce and these organic acid have ability to bind the micronutrients and their by availability may be

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

higher. Number of tillers per meter row length increasedsignificantly due to basal application of different zinc sources with recommended NPK which may be due to better utilization of applied zinc owing to developed root system. Similar results were also recorded by **Cheema *et.al* (2006)** who advocated that the final plant height, number of tillers/hill, panicle bearing tillers, number of primary and secondary spikelet's panicle size, 1000-grain weight, paddy and straw yield and harvest index showed positive correlation with the increase in ZnSO4 levels from 2.5 to 10 kg/ha.

Table : Effect of NPK and zinc sources on number of tillers per meter row length of rice at different stages

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Treatments	30 DAT	60 DAT	At harvest
T_1	22	36	33
T_2	25	41	38
T_3	44.	64	62
T_4	38	58	55
T_5	35	54	51
T_6	33	51	48
T_7	32	48	45
T_8	30	46	43
T_9	46	69	65
T_{10}	49	73	71
SE (m)	*2.24*	*3.96*	*3.62*
CD(p=0.05)	*6.62*	*11.69*	*10.70*

Dry Matter Accumulation

The data regarding application effect of various sources of zinc in different mode and vermicompost along with RDF on dry matter accumulation of rice at 30, 60 DAT and harvesting during experimental year are shown in TableIt is clear from the table that dry matter accumulation was affected significantly by different treatments at all observation interval during experimental year. Maximum dry matter accumulation 33.58 and 36.48 qha^{-1}during experimental year in T_{10} was found statistically at par to T5, T_9 and significantly higher than the rest of the treatments. Results reveal that application of ZnSO4was equally

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

good to the application of micronutrient mixture or VC. The dry matter accumulation did not responded to the foliar application of either source of zinc. Dry matter accumulation was slightly lower in the treatments receiving zinc nutrition through foliar than soil application with every source. At this stage highest dry matter accumulation (66.02 qha^{-1}) was recorded in T_{10} where 3t/ha vermicompost was applied with recommended NPK and found statistically at par with T9 (62.81 qha^{-1}) and T_5 (58.71 qha^{-1}) during experimental year, whereas value received in T_9 and T5 during experimental year was slightly lower with the at par of T_{10} and significantly higher than the rest of the treatments during both the years. At this stage also comparatively lower dry matter accumulation was recorded with foliar than soil application. The effect of treatments consisting foliar application of zinc on dry matter accumulation was more or less similar.

It is clear from the table that measured dry matter accumulation were affected significantly by different treatments at all observation intervals during both the years. Maximum dry matter accumulation during experimental year in T_{10} was found statistically at par to T_5, T_9 and significantly higher than the rest of the treatments. Results reveal that application ZnSO4was equally good to the application of micronutrient mixture or VC. Foliar application of zinc through either source was found significantly inferior to the application of zinc sulphate as basal. Taller plants and profuse tillering with the application of NPK + vermicompost clearly explain the significantly higher dry matter accumulation in T_{10}, T_5 and T_9.

At this stage highest dry matter accumulation recorded in T_{10} (vermicompost was applied with recommended NPK) was statistically at par with T_9 and T_5during experimental year. At this stage also comparatively lower dry matter accumulation was recorded with foliar than soil application. The effect of treatments consisting foliar application of zinc on dry matter accumulation was more or less similar. This finding may attributed more growth attributing characters with the sufficient nutrient supply in the said treatments. Dry matter accumulation at harvesting was also found higher in said treatments owing to described explanation. Similar results was also reported by **Prado *et al.* (2008)** whonoted zinc sulphate provided greater production of total dry matter in rice seedlings in relation to zinc oxide. The application of 3.92 g Zn/kg of seed, using the zinc sulphate source provided the greatest increment in dry matter with values 48% higher than the control.

Table :Effect of NPK and zinc sources on dry matter accumulation (q ha^{-1})of rice at different stages

Treatment	30 DAT	60DAT

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

T_1	19.83	39.47
T_2	22.10	44.16
T_3	31.35	58.71
T_4	28.95	57.85
T_5	26.90	55.60
T_6	26.40	53.41
T_7	25.06	52.10
T_8	24.37	50.55
T_9	33.78	62.81
T_{10}	36.48	66.02
SE (m)	*2.41*	*2.34*
CD(p=0.05)	*7.11*	*6.93*

4.2.1 Panicle length

The data regarding application effect of various sources of zinc in different mode and vermicompost along with RDF on panicle length (cm) of rice during experimental yearare shown in Table. and depicted graphically by figure.6 It is clear from the table that measured panicle length was affected significantly by different treatments during both the years. Panicle length varied from 23.99 to 28.47 cm and increment in panicle length from 18.67 per cent in comparison to control was noticed during experimental year. Maximum panicle length (28.47 cm) during experimental year respectively recorded in T_{10} were found statistically at par to T_9, T_5 and significantly higher than the rest of treatments. Result reveals that application of ZnSO4was equally good to the application of micronutrient mixture (T_9)or vermicompost (T_{10}). Foliar application of zinc through either source was found significantly inferior to the application of zinc sulphate.With one exception of T_5, the foliar application of zinc was more or less similar in respect of panicle length during both the years. The panicle length did not responded to the foliar application of either source of zinc except T_5. Panicle length was slightly lower in the treatments receiving zinc nutrition through foliar than soil application with every sources during experimental year.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

This effect may be supposed due to better nutrition of crop plant with the application of micronutrient zinc or vermicompost which may also improve the availability of native zinc. Panicle length was slightly lower in the treatments receiving zinc nutrition through foliar than soil application with every source which may be due to lower zinc assimilation under foliar application treatments. Similar results was also recorded by **Channabasavanna *et al.* (2001)** who reported that the application of 25 kg ZnSO4/ha resulted in the highest seed yield and panicles per hill. Interaction effect indicate that an application of poultry manure or farmyard manure with 25 kg ZnSO4/ha was optimum. **Gurmani et al. (2003)** also reported significantly affected and produced the highest yield of 14 818 and 8732 kg ha-1, respectively from NPK + Zn + Cu + Fe + Mn. The significantly highest number (500) of panicles/m2 were produced with the application of Zn + Cu +Fe +Mn.

4.2.2 Number of grain per panicle

The data regarding application effect of various sources of zinc in different mode and vermicompost along with RDF on number of grain per panicle of rice during experimental yearare shown in Table It is clear from the table that counted number of grains per panicle was affected significantly by different treatments during both the years. Number of grain per panicle varied from 94.01 to 128.59 and 104.70 to 135.40 during both the years 24.33 to 36.78 per cent higher grain were recorded in comparison to control during experimental year. The highest number of grains per panicle (128.59 and 135.4) counted in T_{10}were statistically at par with T_9 (125.35 and 132.10) during both the years. Number of grains per panicle recorded in T_5 (123.83 and 130.18) varied significantly from T_{12} and found statistically at par with T_{11} during experimental year. Number of grains per panicle recorded in T_{10} was significantly higher than rest of the treatments. Application of zinc sulphate was found equally good to the application of micronutrient mixture (T_9) but significantly lower with VC (T_{10}) during experimental year. Foliar application of zinc through either source was found significantly inferior to the application of zinc sulphate @ 25kg ha^{-1}. Foliar application effect of zinc was more or less similar in respect of number of grains per panicle. The number of grains per panicle did not responded to the foliar application of either source of zinc. Number of grains per panicle were slightly lower in the treatments receiving zinc nutrition through foliar than soil application with every sources during both the years.

It is clear from the table that counted numbers of grains per panicle were affected significantly by different treatments during both the years. The highest numbers of grains per panicle counted in T_{10} were statistically at par with T_9 and significantly higher than the rest of the treatments during both the years. This effect may be explained due to better leaf area

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

index and leaf area duration with the adequate and balanced plant nutrition. Better leaf area index and duration will affect the photosynthetic activity and transformation of photosynthates to grain. The number of grains per panicle were slightly lower in the treatments receiving zinc nutrition through foliar than soil application with every source which may be due to comparatively lower growth in said treatments which will affected photosynthasis. Similar results were also recorded by **Kulandaivel *et.al* (2003)** that the yieldattributes of rice, namely number of panicles/m2, and number and weight of grains per panicle were higher due to the incubated mode of application of ZnSO4.

4.2.4 Test weight (g)

The data regarding application effect of various sources of zinc in different mode and vermicompost along with RDF on test weight of rice during experimental year are shown in TableIt is clear from the table that measured test weight was affected non significantly by different treatments during both the years. Test weight varied from 18.95 to 24.55 and 19.35 to 26.38 g during experimental year. Test weight during both the years was comparatively lower in the treatments receiving zinc nutrition through foliar than soil application with every source. The highest test weight (24.55 and 26.38g during experimental year) was recorded in T_{10} where vermicompost was applied with RDF while lowest test weight (18.95 and 19.35 in experimental year) was found in T_1.

It is clear from the table that measured test weight were affected non significantly by different treatments during both the years. The highest test weight was recorded in T_{10} where vermicompost was applied with RDF while lowest test weight was found in T_1.This effect may be due to better photosynthetic activity with increased leaf area index and leaf area duration and there by more translocation of photosynthates to grain. Similar results were also recorded by **Kulandaivel *et.al* (2003)** that the yield attributes of rice, namely number of panicles/m2, and number and weight of grains per panicle were higher due to the incubated mode of application of ZnSO4. **Haq et al. (2005)** reported that with the application of vermicompost + Azospirillum + 60 kg N/ha the number of panicles/m2 (335.66), grain yield (49.66 q/ha) and straw yield (91.40 q/ha) were significantly higher as compared to other treatments.

Table: Effect of NPK and zinc sources on yield attributing characters of rice.

Treatments	Panicle length (cm)	Grains panicle^{-1}	Test weight (g)

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

T_1	23.99	104.70	19.35
T_2	25.13	112.38	20.24
T_3	27.06	130.18	23.28
T_4	26.44	128.75	22.36
T_5	26.44	124.26	21.49
T_6	26.18	122.87	21.35
T_7	26.01	121.95	21.26
T_8	25.98	120.30	20.78
T_9	27.73	132.10	24.56
T_{10}	28.47	135.40	26.38
SE (m)	*.52*	*.69*	*1.72*
CD(p=0.05)	*1.55*	*2.03*	*N.S.*

4.2.4 Grain yield (qh^{-1})

The data regarding application effect of different sourcesof zinc in different mode and vermicompost along with RDF on grain yield of rice during experimental yearare shown in Table and depicted graphically by figure.7 During 2011 grain yield recorded in T_2 to T_{10} did not varied significantly with the application of zinc through different source, grain yield did not responded to the foliar application of either source of zinc while differ significantly from T_1. Whereas during experimental year with exception of $T_9$and T5 the rice grain yield recorded in T_{10} (RDF+ VC) was significantly higher than the rest of the treatments. Grain yield increased by 31.52 to 52.07 and 23.99 to 62.31per cent in rest of the treatments comparison to control during experimental year. Rice grain yield was slightly lower in the treatments receiving zinc nutrition through foliar than soil application with every source. Maximum grain yield 43.50q/ha during experimental year recorded in T_{10} was found statistically at par to T_5, T_9 and significantly higher than the rest of the treatments. Result reveal that application of $ZnSo_4$was equally good to the application of micronutrient mixture or vermicompost. Foliar application of zinc through either source or mono $ZnSo_4$[1] was found

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

significantly inferior to the application of zinc sulphate. With exception of T_5 and T_6 the foliar application effect of zinc was more or less similar in respect of grain yield in experimental year. The effect of foliar application of zinc with higher to lower concentration on rice grain yield was non-significant and it was also found statistically at par with T_2 during experimental year. With one exception of T_1, treatment receiving any application mode of either source of zinc and vermicompost with RDF was non significant and it was also found statistically at par with T_2 in respect of grain yield during both the years.

Grain yield which depends on growth parameter and yield attributing character was affected significantly by different treatments in rice crop. During experimental year with exception of $T_9$and T_5 the rice grain yield recorded in T_{10} (RDF+ VC) was significantly higher than the rest of the treatments. It may be due to adequate and balanced availability of plant nutrient. Organic matter is reported to increase the micronutrient availability. In the present study zinc was applied with different sources in different mode. Results revealed that with soil application of zinc the crop growth is better. Therefore higher grain yield with the soil application of zinc sulphate or micronutrien mixture is well expected as most of the applied zinc will be exploited by developed rice rooting system. Native zinc availability will also increase with the application of vermicompost. The result clearly indicates that zinc nutrition in adequate amount is most important for rice not only for higher yield but also for better quality. Rice grain yield was slightly lower in the treatments receiving zinc nutrition through foliar than soil application with every source. It may be due to unfavourable climate condition which will affect the uptake of nutrients and transformation of the vermicompost, NPK and zinc in rice plant from which lower zinc assimilation under foliar application treatments. Similar results were also reported by **Khan *et.al* (2007)** that Zn application significantly affected the yield parameters of rice like the number of spike m^{-2}, number of spike/plant, spike length, plant height and 1000 grain weight over control from the above said treatment of 10 kg Zn ha^{-1}. **Jana *et al.* (2009)** reported thatzinc application produced significantly greater yield attributes, higher grain and straw yields of rice. Application of 30 to 40 kg ZnSO4/ha gave significantly higher values of plant height, number of effective tillers, panicle length, grain number per panicle, grain and straw yields and higher uptake of N, P, K and Zn in grain and straw of rice. **Chakeralhossein *et al.* (2009)** observed thatthe grain yield was 3988 kg/ha in control, which increased to 6366 kg/ha with application of 40 kg Zn/ha soil application in addition to foliar spraying of znso4.

4.2.5 Biological yield (qha^{-1})

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

The data regarding application effect of various sources of zinc in different mode and vermicompost along with RDF on biological yield of rice during experimental year are shown in table. It is clear from the table that measured biological yield was affected significantly by different treatments during both the years. The biological yield of rice varied from 65.17 to 92.20 and 67.82 to 109.79q ha^{-1} during experimental year under the different treatments and was affected significantly by different treatments. Maximum biological yield was recorded in T_{10} where vermicompost was applied with recommended NPK. With exception of T_1 rest of the fertilized treatment were non significant in respect of biological yield. Biological yield was slightly lower in the treatments receiving zinc through foliar than soil application with every source. The biological yield differ significantly under different treatments during experimental year. Maximum biological yield (109.79 q ha^{-1}) significantly higher than rest was recorded in T_{10} where vermicompost was applied with recommended NPK. The effect of any application mode of zinc through different sources on biological yield of rice was non significant and it was also found statistically at par with T_2 during experimental year.

4.2.6 Straw yield (qha^{-1})

The data regarding application effect of various sources of zinc in different mode and vermicompost along with RDF on straw yield during experimental yearare shown in table It is clear from the table that measured straw yield was affected significantly by different treatments during experimental year. The straw yield of rice varied from 40.80 to 57.03 and 40.99 to 60.29 q ha^{-1} during both the years. Straw yield increased by 26.54 to 39.77 and 31.32 to 61.72 per cent in rest of the treatments comparison to control during experimental year. Maximum straw yield (57.03 and 60.29qha-^{1}) during experimental yearrespectively recorded in T_{10} was found statistically at par to rest of the treatments with exception of T_1.

Maximum straw yield during experimental year was recorded in T_{10} where vermicompost was applied with recommended NPK. With exception of T_1 rest of the fertilized treatment were non significant and found statistically at par to each other. Biological yield duringexperimental year did not varied significantly with the any application mode of zinc through different sources and it was also statistically at par to T_2. Maximum biological yield was recorded in T_{10} where vermicompost was applied with recommended NPK. The effect of any application mode of zinc through different sources on biological yield of rice was non significant and it was also found statistically at par with T_2experimental year. Same result was found in straw yield. It may be due to more translocation of photosynthates from straw to grain in vermicompost and zinc treated plots as evidenced by comparatively

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

higher plant height, number of tillers per meter square, panicle length and higher test weight in comparison to T_2 during both the years. Similar results were also recorded by **Jana *et al.* (2009)** reported thatzinc application produced significantly greater yield attributes, higher grain and straw yields of rice. Application of 30 to 40 kg ZnSO4/ha gave significantly higher values of plant height, number of effective tillers, panicle length, grain number per panicle, grain and straw yields. **Kumar and Kumar (2009)** reported that a significant increase in the yield and yield attributes of rice was noted with the application of 45 kg ZnSO4/ha. **Ehsanullah *et al.* (2011)** exhibited that Zinc application methods and timing had significantly pronounced effect on paddy yield. Maximum paddy yield (5.21 t ha-1) was achieved in treatment Zn2 (Basal application at the rate of 25 kg ha-1 21% ZnSO4) and minimum paddy yield (4.17 t ha-1) was noted in Zn7 (foliar application at 75 DAT @ 0.5% Zn solution). Zinc application increases the crop growth rate of rice.

Table 10: Effect of NPK and zinc sources on yield (q ha^{-1})

Treatments	Biological yield	Grain yield	Straw yield
T_1	67.82	26.80	40.99
T_2	87.07	33.23	53.83
T_3	97.02	39.60	57.81
T_4	95.11	37.30	57.44
T_5	93.98	36.93	57.42
T_6	93.44	36.17	56.96
T_7	92.94	35.77	56.78
T_8	92.02	35.47	56.51
T_9	97.60	40.17	58.52
T_{10}	109.79	43.50	66.29
SE (m)	*3.33*	*1.37*	*2.33*

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College
Muzaffarnagar

CD(p=0.05)	*9.85*	*4.05*	*6.89*

4.1.4.1 Available nitrogen (kgha^{-1})

Data regarding the nitrogen availability estimated at harvesting under different treatments during experimental yearare shown in Table. It is apparent from the table that the nitrogen availability in soil at harvest stage was influenced significantly by different treatments during both the years. The highest nitrogen availability 228.36 and 241.44 kg ha^{-1} during experimental yearwas found in T_2 while minimum 195.52 and 208.89 kg ha^{-1} during experimental yearin T_1. Availability of nitrogen in soil under T_2 was significantly higher than the rest of the treatments during experimental year. Nitrogen availability did not differ significantly with the application of different sources of zinc during both the years. Similarly the nitrogen availability in soil did not differ significantly among the treatments of methods of application. Nitrogen availability in T_{10} was also higher but not to the level of available nitrogen recorded in T_2 during both the years.

4.1.4.2 Available Phosphorus (kgha^{-1})

Data regarding the phosphorus availability at harvesting stage under different treatments during experimental yearare shown in Table. It is apparent from the table that the phosphorus availability in soil at harvest stage was influenced significantly by different treatments during both the years. The highest phosphorus availability 25.17 and 26.29 kg ha^{-1} during experimental yearwas found in T_2, while minimum 13.08 and 14.28 kg ha^{-1} during experimental yearin T_1. Availability of P in soil under T_2 was significantly better than the treatments T_1,T_3, T_4, T_5, T_6, T_7, T_8, and T_9 during experimental year. P availability did not differ significantly with the application of different sources of zinc. Similarly the P availability in soil did not differ significantly among the treatments of methods of application. Phosphorus availability in T_2 and T_{10} was also similar during both the years.

4.1.4.1 Available potassium (kg ha^{-1})

Data regarding the potassium availability at harvesting stage under different treatments during experimental yearare shown in Table. It is apparent from the table that the potassium availability in soil at harvest stage was influenced significantly by different treatments during both the years. The highest K availability 260.54 and 259.22 kg ha^{-1} during experimental yearwas found in T2, while minimum 222.79 and 228.30 kg ha^{-1} during experimental yearin T_1. Availability of K in soil under T_2 was significantly better than the treatments T_1, T_3, T_4, T_6, T_7, T_8, and T_9 experimental year. K availability did not differ

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

significantly with the application of different sources of zinc. Similarly the K availability in soil did not differ significantly among the treatments of methods of application with exception of T_5 and T_9. Availability of K in soil under T_2 was significantly better than the treatments T_3, T_4, T_5, T_6, T_7 and T_9 during experimental year. K availability did not differ significantly with the application of different sources of zinc similarly the K availability in soil did not differ significantly among the treatments of methods of application. Potassium availability in T_2 and T_{10} was also similar during experimental year.

Available nitrogen in soil was affected significantly due to application of different treatments. The highest nitrogen availability during experimental yearwas found in T_2, while minimum during experimental yearin T_1. Nitrogen availability in T_{12} was also higher but not to the level of available nitrogen was recorded in T_2 during experimental year. This effect may be supposed due to lower removal of nitrogen from soil in T_2 as evidenced by N removal by rice grain and straw. Addition of vermicompost will enrich the soil nitrogen but in this treatment higher amount of nitrogen was removed by crop by crop therefore less was left in soil. In general lower amount of available nitrogen in soil in the most of the treatments than T_2 may be related with nitrogen removal pattern.

Phosphorus availability in soil at harvest stage was significantly influenced by different treatments during both the years. The highest phosphorus availability was found in T_2, while minimum in T1during experimental year. Phosphorus availability in T_2 and T_{10} was also similar during both the years. The highest availability of P was recorded in treatment having recommended dose of NPK followed by the treatment which having vermicompost + recommended NPK. The higher amount of phosphorus in T_2 can be explained with the lower P removal from soil due to lower biomass production while in T_{10} with the fact that added vermicompost will produce organic acid in soil which well solubilise the insoluble P.

Available potassium in soil was affected significantly due to application of different treatments. The highest K availability during experimental yearwas found in T_2, while minimum during experimental yearin T_1. Potassium availability in T10 was also higher but not to the level of available K was recorded in T2 during experimental year. The effect may be described with the facts described for available N status. Similar result was recorded by**Chandrapala *et al.* (2010)** thattheNPK+FYM application to rice crop recorded significantly highest quantity of available soil N, P and K content after crop harvest.

4.1.4.4 DTPA extractable Zn (ppm)

Data regarding the availability of Zn at different growth stage as influenced by different treatments during experimental yearare shown in Table. It is evident from the table

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

that the availability of Zn in soil was affected significantly by different treatments during both the years. Available of Zn in soil at 30 DAT stage ranged from 1.28 to 2.74 and 1.24 to 2.79 ppm during experimental year. The highest zinc availability 2.74 and 2.79 ppm during experimental year found in T_3 was significantly higher than the rest of the treatments while minimum zinc availability recorded in T_1 was significantly lower than the rest of the treatments during both the years. The content of DTPA - extractable zinc in soil at 30 DAT was significantly affected by zinc sources and methods of application. It is apparent from the data that the soil application of 5kg Zn ha^{-1} through ZnSO4 in rice crop increased the content of DTPA- extractable zinc significantly by 95.71 to 102.17 % over the recommended NPK which have 0 kg zinc ha^{-1}during experimental year. whereas the foliar application of either source of zinc in rice also increased the content of DTPA - extractable zinc in soil; In general the content of DTPA- extractable zinc at this stage was higher in those treatments where zinc in either source was applied basal than foliar. However, the magnitude of increase was significant during both the years. The zinc content of T_{10} and T_4 was also higher but not to the level of zinc was recorded in T_3 during both the years. Available of Zn in soil at 60 DAT stage ranged from 1.23 to 2.60 and 1.21 to 2.68 ppm during experimental year. The highest zinc availability 2.60 and 2.68 ppm during experimental year found in T_3 was significantly higher than the rest of the treatments while minimum zinc availability recorded in T_1 was significantly lower than the rest of the treatments during both the years. The content of DTPA - extractable zinc in soil at 60 DAT was significantly affected by zinc levels. It is apparent from the data that the soil application of 5kg Zn ha^{-1} through ZnSO4 in rice crop increased the content of DTPA- extractable zinc significantly by 91% over the recommended NPK which have 0 kg zinc ha^{-1} during both the years. Whereas the foliar application of either source of zinc in rice also increased the content of DTPA - extractable zinc in soil; however, the magnitude of increase was significant during both the years. The zinc content of T_{12} and T_4 was also higher but not to the level of zinc recorded in T_3 during both the years. Available of Zn in soil at harvest stage ranged from 1.19 to 2.53 and 1.15 to 2.24 ppm during experimental yearrespectively. The highest zinc availability 2.53 and 2.24 ppm during experimental yearfound in T_3 was significantly higher than the rest of the treatments while minimum zinc availability recorded in T_1 was significantly lower than the rest of the treatments during both the years. The content of DTPA - extractable zinc in soil at harvest was significantly affected by zinc sources and methods of application. It is apparent from the data that the soil application of 5kg Zn ha^{-1} through $ZnSO_4$ in rice crop increased the content of DTPA - extractable zinc significantly by 94.73 and 99.21% over the recommended NPK

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

which have 0 kg zinc ha^{-1} during experimental year. The foliar application of either source of zinc in rice also increased the content of DTPA - extractable zinc in soil. The zinc content of T_{10} and T_4 was also higher but not to the level of zinc was recorded in T_3 during both the years.

Availability of Zn in organic and inorganic treated plots differed significantly. The data showed that the available Zn linearly decreased with the advancement of age of the crop probably due to increased absorption of available Zn with crop growth and development. More availability of Zn during early days (up to 60 Days) was observed in T_3. This effect may be supposed due to the fact that N interact positively with zinc and the synergistic effect of zinc and N are mainly attributed to an increased availability of zinc in soil due to the acid forming effect of N. More availability of Zn during later stages in T_{10} may be due to chelation of zinc by organic acids. Similar result was also recorded by **Kulandaivel *et.al* (2004)** the application of 40 kg ZnSO4+10 kg FeSO4 was found to be the most appropriate combination to maximize the grain yields of this system and improve the zinc and iron status of soil.

4.1.4.5 DTPA extractable copper (ppm)

Data regarding the availability of Cu at harvesting stage as influenced by different treatments during 2011 and 2012 are shown in Table. It is evident from the table that the availability of Cu in soil at harvesting was affected significantly by different treatments during both the years. Availability of Cu in soil at harvest stage ranged from 2.24 to 3.35 and 2.21 to 3.85 ppm during experimental year. The highest Cu availability 3.35 and 3.85 ppm during experimental yearfound in T_{10} was significantly higher than the rest of the treatments while minimum Cu availability recorded in T_1 was significantly lower than the rest of the treatments during both the years. The content of DTPA - extractable Cu in soil at harvest was not significantly affected by zinc sources and methods of application. It is apparent from the data that the soil application of vermicompost with recommended NPK in rice crop significantly increased the content of DTPA- extractable Cu in soil. Whereas the micronutrient mixture with recommended NPK in rice also increased the content of DTPA - extractable Cu in soil. The content of DTPA - extractable Cu in soil did not responded to the basal and foliar application of either source of zinc except T9. The copper availability in T_9 and T_{10} was also similar during both the years.

4.1.4.6 DTPA extractable Iron (ppm)

Data regarding the availability of iron at harvesting stage as influenced by different treatments during experimental yearare shown in Table. It is evident from the table that the availability of iron in soil was affected significantly by different treatments during both the

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

years. Availability of iron in soil at harvest stage ranged from 13.25 to 20.58 and 13.21 to 20.96 ppm during experimental year. The highest iron availability 20.58 and 20.96 ppm during 2011 and 2012 found in T_{10} was significantly higher than the rest of the treatments while minimum iron availability recorded in T_1 was significantly lower than the rest of the treatments during both the years. The content of DTPA - extractable iron in soil at harvest was not significantly affected by zinc sources and methods of application. It is apparent from the data that the soil application of vermicompost with recommended NPK in rice crop significantly increased the content of DTPA- extractable iron in soil. Whereas the micronutrient mixture with recommended NPK in rice also increased the content of DTPA - extractable iron in soil. The content of DTPA - extractable iron in soil did not responded to the basal and foliar application of either source of zinc with exception T_{11}. The iron availability in $T_9$and T_{10} was also similar and statistically at par during experimental year.

4.1.4.7 DTPA extractable manganese (ppm)

Data regarding the availability of manganese at harvesting stage as influenced by different treatments during 2011 and 2012 are shown in Table. It is evident from the table that the availability of manganese in soil was affected significantly by different treatments during both the years. Availability of manganese in soil at harvest stage ranged from 9.18 to 11.90 and 9.20 to 12.55 ppm during experimental year. The highest iron availability 11.90 and 12.55 ppm during experimental year found in T_{10} was significantly higher than the rest of the treatments while minimum manganese availability recorded in T_1 was significantly lower than the rest of the treatments during both the years. The content of DTPA - extractable manganese in soil at harvest was not significantly affected by zinc sources and methods of application. It is apparent from the data that the soil application of vermicompost with recommended NPK in rice crop significantly increased the content of DTPA- extractable manganese in soil. Whereas the micronutrient mixture with recommended NPK in rice also increased the content of DTPA - extractable manganese in soil. The content of DTPA - extractable manganese in soil did not responded to the basal and foliar application of either source of zinc with exception T_9. The manganese availability in T_9 and T_{10} was also similar and statistically at par during both the years.

Available Cu in soil at harvesting was significantly higher in the treatments consisting application of vermicompost +NPK .This effect may be supposed due to more availability of Cu during later stage in T_{12} owing to chelating effect of Cu with organic compound resulting low availability of Cu in early stage, however the availability of Cu in combine use of

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

organic and inorganic fertilizers treated plots improved at harvest because of more release of Cu from chelating agents.

Available iron in soil at harvesting was significantly higher in the treatments consisting application of vermicompost +NPK .This effect may be supposed due to more availability of iron during later stage in T_{10} might be due to more chelating effects of iron with organic compound resulting low availability of iron in early stage, however the availability of iron in combine use of organic and inorganic fertilizers treated plots improved at harvest because of more release of iron from chelating agents.

Available manganese in soil at harvesting was significantly higher in the treatments consisting application of vermicompost +NPK .This effect may be supposed due to more availability of manganese during later stages was recorded in combine use of organic and inorganic treated plots than solely inorganic fertilizers treated plots. This might be due to more chelating effects of manganese with organic compound resulting low availability of manganese in early stage, however the availability of manganese in combine use of organic and inorganic fertilizers treated plots improved at harvest because of more release of manganese from chelating agents. Followed by the treatments having micronutrient mixture +NPK and rest of the treatments are significantly lower. Similar result was also recorded by **Kulandaivel *et.al* (2004)** that application of 40 kg ZnSO4+10 kg FeSO4 was found to be the most appropriate combination to maximize the grain yields of this system and improve the zinc and iron status of soil.

Table .Effect of NPK and different Zn sources on available zinc, copper, iron and manganese (ppm) at different stages in soil

Treatments	Zinc			Copper	Iron	Manganese
	30 DAT	60	At harvest	At harvest	At harvest	At harvest
T_1	1.43	1.32	1.15	2.21	13.21	9.20
T_2	1.44	1.42	1.35	2.28	14.39	9.32
T_3	2.79	2.68	2.59	3.28	15.95	10.55
T_4	2.43	2.32	2.24	2.83	15.87	10.78
T_5	1.95	1.80	1.72	2.32	13.75	9.65
T_6	1.91	1.76	1.66	2.35	14.56	9.73

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

T_7	1.69	1.61	1.50	2.38	14.62	9.79
T_8	1.66	1.56	1.44	2.54	15.23	10.25
T_9	2.20	2.05	1.98	3.64	18.87	11.97
T_{10}	2.49	2.35	2.24	3.85	20.96	12.55
SE (m)	***0.03***	***0.056***	***0.05***	***0.02***	***1.65***	***0.67***
CD(p=0.05)	***0.11***	***0.163***	***0.16***	***0.07***	***4.89***	***2.00***

4.1.4.8 Soil pH

Composite soil sample was prepared by mixing the soil of different replication of a particular treatment and soil pH (1:2) was measured and values recorded are shown in Table.Soil pH did not differ significantly at all the stages during both the years. It was found that soil pH at 30 DAT stage varied from 8.25 to 8.44 and 7.59 to 7.82 during experimental year. Soil pH was found slightly more in the treatment T_1 control and followed by the treatments receiving soil and foliar application of different Zn sources with recommended NPK than the treatment receiving vermicompost with recommended NPK during both the years. At 60 DAT stage soil pH varied from 7.76 to 8.18 and 7.52 to 7.79 during experimental year. At this stage also Soil pH was found slightly more in the treatment T_1 control and followed by the treatments receiving soil and foliar application of different Zn sources with recommended NPK than the treatment receiving vermicompost with recommended NPK during experimental year. At harvesting stage soil pH varied from 7.85 to 8.04 and 7.48 to 7.68 during experimental year. At this stage soil pH was higher in treatment T_1 control and the treatments receiving soil and foliar application of different Zn sources with recommended NPK than the treatment receiving vermicompost with recommended NPK during experimental yearSoil pH was found slightly more in the treatment T_1 control and followed by the treatments receiving soil and foliar application of different Zn sources with recommended NPK than the treatment receiving vermicompost with recommended NPK experimental year. A slight depression in pH from initial to harvest was noticed in all the treatments. However, the treatments with combine use of vermicompost and recommended NPK showed more depressing effect on soil pH as compare to balance inorganic fertilizers alone. Among the inorganic fertilizers the magnitude of reduction was same but among the combine use of vermicompost and recommended NPK reduced more pH as compare to inorganic fertilizers. Application of nitrogen and zinc sulfate could not produce

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

any remarkably variation in soil pH. The results agree with the findings of **Diwakar et al., 2004, Minhas** and **Mehta, 1984, Alok Kumar and Yadav, 1993.**

4.1.4.9 Soil EC

No significant change was noticed in electrical conductivity of soil at all the stages due to application of different treatments. However a slightly decline trend in soil EC was observed with the crop growth advancement. In general EC of soil ranged between 0.34 to 0.38 and 0.31 to 0.35 dS m^{-1} during the entire crop growth period.

No significant change was noticed in the EC under different treatments. This might be due to no improvement in ionic concentration of soil solution due to ionization of NPK fertilizers & mineralization of organic matter .Since it was short (one season) study, the significant changes due to addition of organics could not be expected. **Yadav and Chhipa (2007) and Vijayashankar*et al.* (2007)** had also recorded non-significant changes in soil EC with the application of organic manures.

Available nitrogen (kgha-1) It is apparent from the Table that the nitrogen availability in soil at harvest stage was influenced significantly by different treatments during both the years. The highest nitrogen availability 228.36 and 241.44 kg ha-1 during experimental yearwas found in T2 while minimum 195.52 and 208.89 kg ha-1 during experimental yearin T1 . Availability of nitrogen in soil under T2 was significantly higher than the rest of the treatments during experimental year. Nitrogen availability did not differ significantly with the application of different sources of zinc during both the years. Similarly the nitrogen availability in soil did not differ significantly among the treatments of methods of application.Nitrogen availability in T10 was also higher but not to the level of available nitrogen recorded in T2 during both the years. This effect may be supposed due to lower removal of nitrogen from

soil in T2 as evidenced by N removal by rice grain and straw. Addition of vermicompost will enrich the soil nitrogen but in this treatment higher amount of nitrogen was removed by crop therefore less was left in soil. In general lower amount of available nitrogen in soil in the most of the treatments than T2 may be related with nitrogen removal pattern. Similar result was recorded by Chandrapala et al. (2010) that the NPK+FYM application to rice crop recorded significantly highest quantity of available soil N, P and K content after crop harvest. Bairwa and Yadav (2017) reported that among the different recommended dose (RDF) of NPK (nitrogen, phosphorus and potassium), application of NPK recorded significantly nitrogen, phosphorus and potassium content in plant and availability in soil up to 125% RDF (R3) during both the years. The maximum contents in plants of nitrogen (2.35%, 2.43% and

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

2.39%), phosphorus (0.34%, 0.35% and 0.32%) and potassium (1.54%, 1.61% and 1.58%) and as well as availability in soil of nitrogen (88.62, 92.00 and 90.31 kg ha-1), phosphorus (24.95, 27.90 and 26.43 kg ha-1) and potassium (231.93, 232.90 and 232.41 kg ha-1) were observed in the treatment of 125% RDF (R3).

Available Phosphorus (kgha-1) in the Table shows that the phosphorus availability in soil at harvest stage was influenced significantly by different treatments during both the years. The highest phosphorus availability 25.17 and 26.29 kg ha-1 during experimental yearwas found in T2 , while minimum 13.08 and 14.28 kg ha-1 during experimental yearin T1 . Availability of P in soil under T2 (100% RDF) was significantly better than all the zinc applied treatments during experimental year. P availability did not differ significantly with the application of different sources of zinc. Similarly the P availability in soil did not differ significantly among the treatments of methods of application. Phosphorus availability in T2 and T10 was also similar during both the years. The availability of P high in T12 treatment due dissolution of mineral P in soil and vermicompost also produce the deferent organic acid which help in reducing pH of the soil and also help in solubilise the insoluble P in soil. Shanmugam and Veeraputhran (2001) also noted that application of 187.5 kg N + 25 kg ZnSO4/ha significantly increased available N, P, K, Zn, and organic carbon. some researchers have reported that organic matter enhances available P and indirectly hinders the pre- cipitation of phosphate, which is unavailable to plants, in the pH range of 6–9 (Mkhabela and Warman, 2005). Available potassium (kg ha-1) It is apparent from the Table that the potassium availability in soil at harvest stage was influenced significantly by different treatments during both the years. The highest K availability 260.54 and 259.22 kg ha-1 during experimental year was found in T2, while minimum 222.79 and 228.30 kg ha-1 during experimental year in T1 . Availability of K in soil under T2 was significantly better than the treatments T1 , T3 , T4 , T6 , T7 , T8 , T9 and T10 experimental year. K availability did not differ significantly with the application of different sources of zinc. Similarly the K availability in soil did not differ significantly among the treatments of methods of application with exception of T5 and T1o. Availability of K in soil under T2 was significantly better than the treatments T3 , T4 , T5 , T6 , T7 and T9 during experimental year. K availability did not differ significantly with the application of different sources of zinc similarly the K availability in soil did not differ significantly among the treatments of methods of application.

Table :Effect of different sources and application mode of zinc on available nitrogen,phosphorus , potassium (Kgha^{-1}) and pH and EC (dSm^{-1})at harvesting in soil

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Treatments	Nitrogen	Phosphorus	Potassium	pH	EC dSm^{-1}
	At harvest	At harvest	At harvest	At harvest	At harvest
T_1	208.89	14.28	228.30	7.68	0.41
T_2	241.44	26.29	259.22	7.51	0.43
T_3	220.08	20.70	232.33	7.59	0.47
T_4	213.01	19.37	237.70	7.65	0.44
T_5	226.36	17.71	240.63	7.57	0.42
T_6	224.13	18.49	242.85	7.55	0.45
T_7	223.05	18.93	240.10	7.60	0.44
T_8	227.26	21.02	248.77	7.60	0.43
T_9	219.69	16.0	238.12	7.68	0.40
T_{10}	231.99	22.26	245.97	7.66	0.43
SE (m)	***1.84***	***1.41***	***4.71***	_	_
CD(p=0.05)	***5.44***	***4.17***	***13.90***	***N.S***	***N.S***

Conclusion

On the basis of the results obtained from two year experimentation it is concluded that the application of organic source in rice can supplement the zinc nutrition. The cost of cultivation with the use of organic may be comparatively higher but to some extent it will also replenish the deficit nutrients and therefore the soil health will be maintained. Although the use of 100% NPK and micronutrient mixture is commonly recommended for transplanted rice but the study shows that the application of zinc sulphate at the rate 25 kg ha^{-1} is equally good and effective. Among the different zinc sources zinc sulphate is the best source. The soil application of NPK and zinc was found best method for application than foliar.

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Co-
IQAC, Shri Ra College
Muzaffarnagar

Shri Ram College
Approved by UGC, NCTE and Affiliated to MS University, Saharanpur
Almaspur Telephone Exchange, Circular Road (Parikarma Marg), Muzaffarnagar - 251001, NCR (U.P.)
A++ Grade Accredited by NAAC

Dated- 11/08/2023

To
Director
Bindals Papers Mills Ltd.
Muzaffarnagar

Subject- Acceptance letter for the proposal for a project

Dear Sir

I am beyond excited to write this response to your offer and firstly I would like to pay my gratitude on behalf of our department for having faith in our organization and sending us an offer. Bindals Papers Mills Ltd. has earned a big name in the marketplace having dedication in the field of paper industry and we are glad you have reckoned it.

As I have reviewed your offer thoroughly and discussed with my superiors and we believe it is quite smoothly crafted. All the details are compatible with the service we can provide thus we shall carry it out the way you want. For the successful completion of the project please sanction the required amount Rs.155000. so that the work can be started within time. None the less, we would also like to bring this into your attention that all the proposed methods are subject to change as per the situation. However, our team will make sure to inform you prior to any amendments.

Hoping for a healthy relationship.

Ankush Rawal

Assistant Professor

Department of Business Administration

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Shri Ram College, Muzaffarnagar

Department of Business Administration

Industrial Project for Bindals Papers Mills Ltd, Muzaffarnagar titled

"The impact of marketing communication on consumer brand loyalty of Bindals Papers Mills"

SUMMARY REPORT

INTRODUCTION

In today's competitive marketplace, the role of effective marketing communication in shaping consumer brand loyalty cannot be overstated. This study explores the impact of marketing communication strategies on consumer brand loyalty for Bindals Papers Mills Ltd, a prominent entity in Muzaffarnagar known for its paper products. Understanding how marketing communication influences consumer behavior and loyalty is crucial for companies striving to maintain and expand their market share. Bindals Papers Mills Ltd operates in a dynamic environment where consumers are inundated with choices. Effective marketing communication strategies can differentiate the brand, enhance consumer perception, and ultimately foster long-term loyalty. Muzaffarnagar, with its diverse consumer demographics and competitive landscape, provides an ideal setting to examine these dynamics.

Key factors influencing consumer brand loyalty include brand awareness, perceived brand value, trust and credibility, customer engagement, brand image, and retention strategies. Through targeted marketing communication efforts, Bindals Papers Mills Ltd aims to not only attract new customers but also cultivate a loyal customer base that repeatedly chooses its products over competitors. This study employs both qualitative and quantitative research methods to explore how various marketing communication channels—such as advertising, promotions, public relations, and digital marketing—impact consumer perceptions and behaviors in Muzaffarnagar. By analyzing consumer feedback, survey data, and sales trends, this research aims to uncover insights into the effectiveness of different communication strategies in building and sustaining brand loyalty.

Ultimately, understanding the relationship between marketing communication and consumer brand loyalty for Bindals Papers Mills Ltd in Muzaffarnagar will provide valuable strategic insights. These insights can guide future marketing initiatives and help the company strengthen its competitive position in the local market while fostering enduring relationships with its customer base.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Bindals Papers Mills Limited
MANUFACTURERS OF WRITING & PRINTING PAPER
8th Km., Bhopa Road, Muzaffarnagar - 251 001 UP, INDIA
Tel. : +91-131-2468381, 2468382, +91-9917055355
E-mail : info@bindalpapers.com, technical@bindalpapers.com
Corporate Identity Number : U21011DL2006PLC148926

ISO 9001 CERTIFIED ORGANIZATION ISO 14001 CERTIFIED ORGANIZATION
www.bindalpapers.com

17/08/2023

To,
Mr. Ankush Rawal
Assistant Professor, Department of Business Administration
Shri Ram College, Muzaffarnagar

Subject: Sanction of Funds for Project on "The impact of marketing communication on consumer brand loyalty of Bindal Papers Mills"

Dear Sir,

With reference to **our offer letter dated 26/07/2023 and your accepted letter dated 11/08/2023**, we are herewith sanctioning an amount of Rs. 155000/- for the above mentioned Project under Corporate Social Responsibility (CSR) head.

You are requested to carry on the work. All terms and conditions mentioned in our earlier letter shall be applying to this project.

Thanking You

Yours faithfully

For Bindal Papers Mills Limited

Mayank
(Mayank Bindal)

Director

Date: 17/08/2023

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Marketing Office : 212, Aggarwal City Mall, Road No. 44, Near M2K Cinema, Pitampura, Delhi-110034, INDIA
Tel. : +91-11-47537700 * Fax : +91-11-47537777 * E-mail : marketing@bindalpapers.com
Regd. Office : NP-151 B, Maurya Enclave, Pitampura, Delhi-110088, INDIA

Utilization Certificate

S.N.	Detail of sanction of Fund with Project name and Duration	Amount
1.	3 months project on The impact of marketing communication on consumer brand loyalty of Bindal Paper Mills Ltd, Mzn Date of Sanction of Fund- 17-08-2023 as per Sanction Letter	155000.00 /-
	TOTAL	155000.00/-

It is Certified that out of Rs. 155000.00/- (One Lacs fifty five Thousands only) of grants sanctioned by **Bindal Paper Mills Ltd, Muzaffarnagar** during the year 2023-2024 in favor of **Shri Ram College, Muzaffarnagar,** a sum of Rs. 155000.00 has been utilized for the purpose of the project for which it was sanctioned and that the balance of Rs. **Nil** remaining unutilized at the end of the year has been surrendered. The Extra amount (If any) is met out by Shri Ram College.

2. Certified that we have satisfied our self that the conditions on which the grant was sanctioned have been duly fulfilled/are being fulfilled and that we have exercised the following checks to see that the money was actually utilized for the purpose for which it was sanctioned.

Kinds of checks exercise-

1 Checking of cash book
2 Checking of payment vouchers.
3 Checking of salary register.
4 Checking of expense bill.

For Shri Ram College

Secretary
Date: 05-03-2024
Place: Muzaffarnagar

For Goel Rakesh & Co.
Chartered Accountants

Rakesh Kumar Goel
Proprietor

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

RESEARCH OBJECTIVES

- To guide future marketing communication strategies that can strengthen brand loyalty, improve customer retention, and drive sustainable growth in Muzaffarnagar and beyond.
- Pinpoint weaknesses or gaps in the marketing communication strategy that may be hindering brand loyalty.
- To explore how customer engagement initiatives, such as social media interactions, customer service quality, and loyalty programs, contribute to enhancing brand loyalty for Bindals Papers Mills Ltd.

NEED FOR THE STUDY

Through executing a study on consumer brand loyalty, Bindals Papers Ltd. is able to have a comprehensive understanding of people's familiarity with their products. Knowing this allows them to evaluate the effectiveness of their marketing strategies and highlight any areas that might require improvement. It also assists them in making well-informed decisions that improve customer service, and it's an exciting journey towards growth and client happiness.

RESEARCH METHODOLOGY

Sampling: The sample of 110 consumers selected from Muzaffarnagar, Haridwar, Rorrkee Shamli, Saharanpur and Meerut districts by using simple random sampling method.

Tools used for the study: The study is carried out with the help of both primary and secondary data. Primary data was collected through well-structured questionnaire provided to the consumers. Secondary data was collected from internet, Journals, and articles.

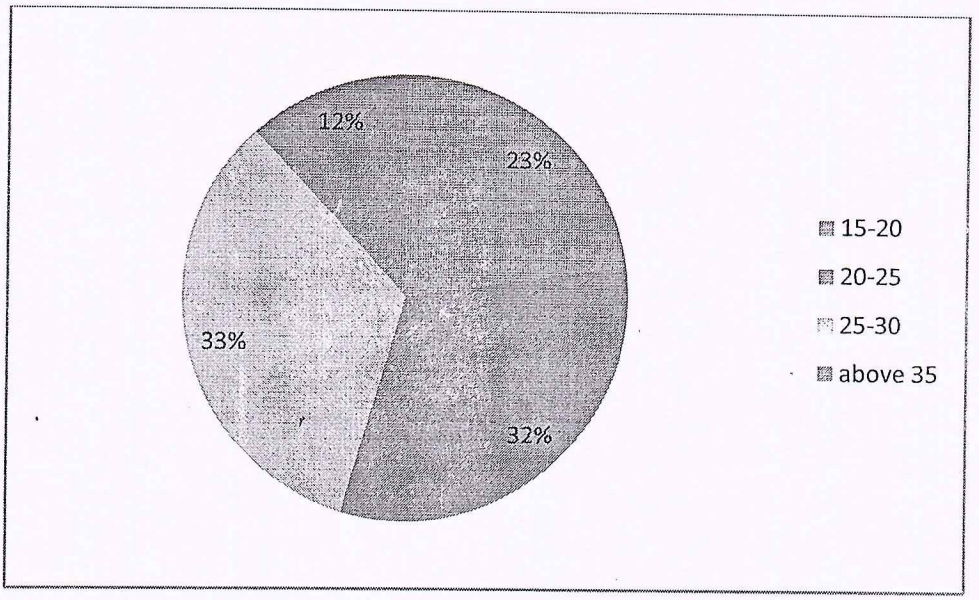
Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

DATA ANALYSIS AND INTERPRETATION

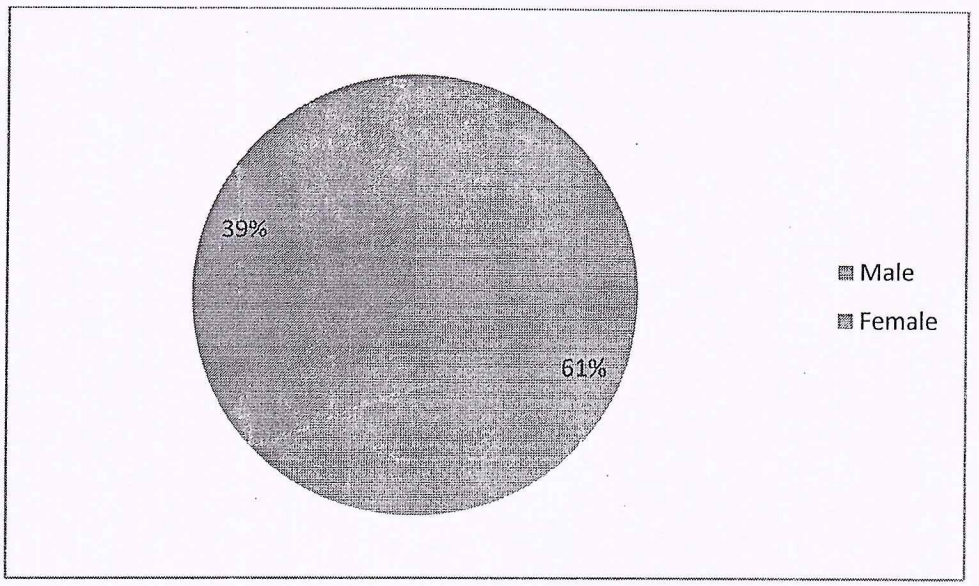
DATA ANALYSIS AND INTERPRETATION

1. Age



33% were of the age between 25-30, 32% were of the age between 20-25, 23% were of the age between 15-20, 12% were the age of above 35.

2. Gender

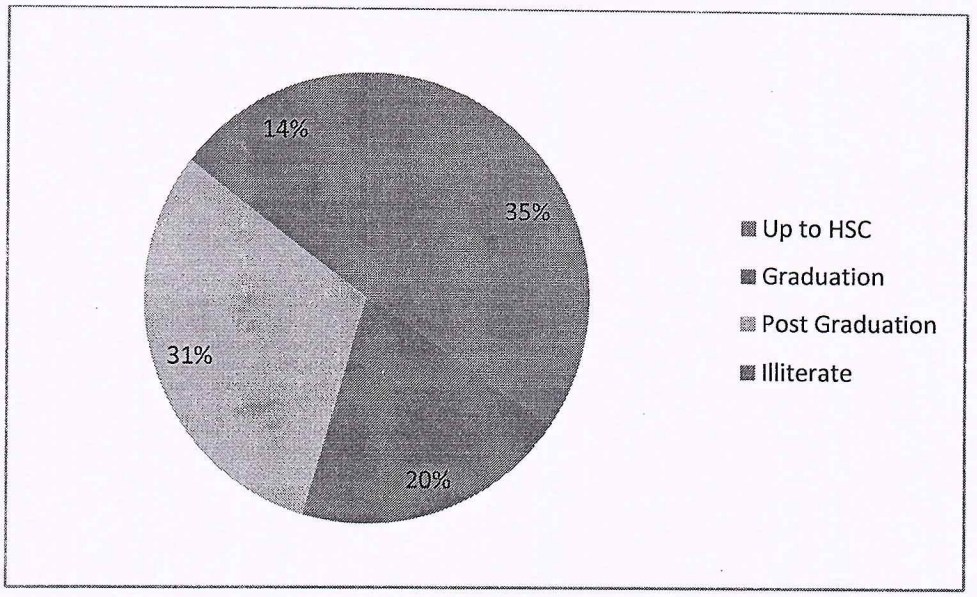


61% people were the male and 39% people were the female.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

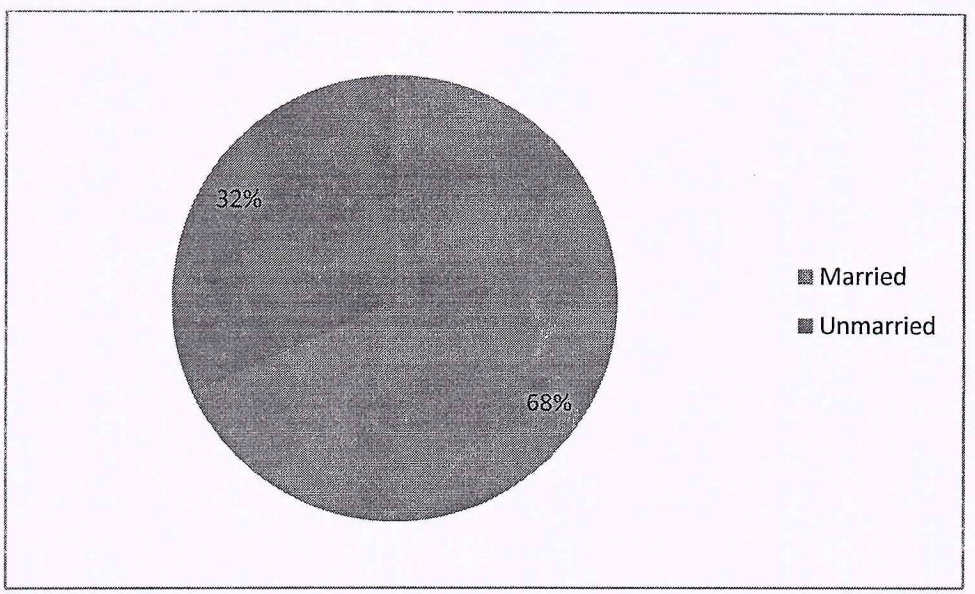
Chairman
IQAC, Shri Ram College
Muzaffarnagar

3. Qualification



35% people were educated upto HSC, 31% people were educated to post graduation, 20% people were educated to graduation, 14% people were illiterate.

4. Marital Status

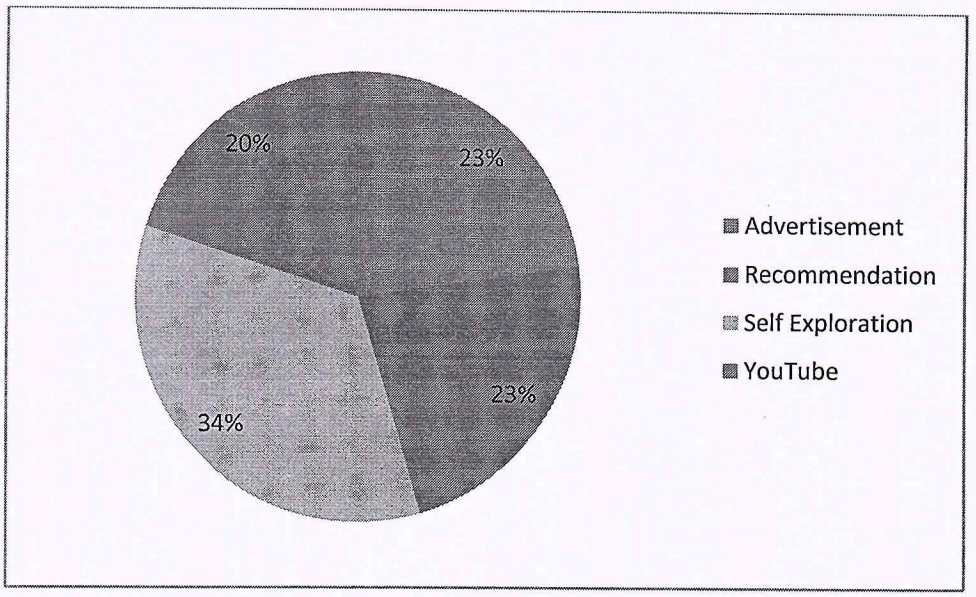


68% people were married and 32% people were unmarried.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

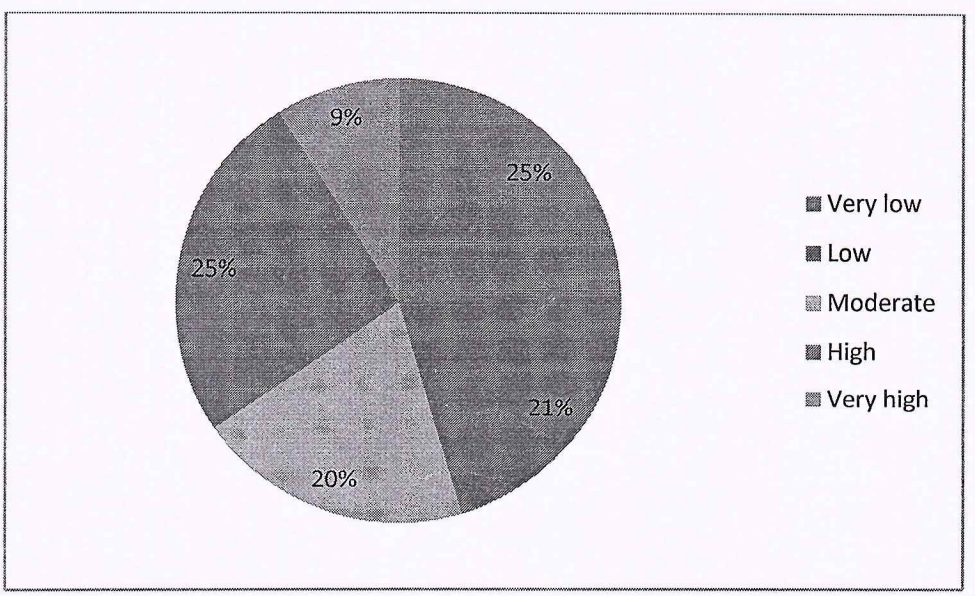
Chairman
IQAC, Shri Ram College,
Muzaffarnagar

5. Have you heard of Bindal Papers Mills? If yes, how did you first become aware of the brand?



34% people were aware by self exploration, 23% people were aware by advertisement, 23% people were aware by recommendation, 20% people were aware by youtube.

6. How would you rate your overall awareness of the Bindal Papers Brand?

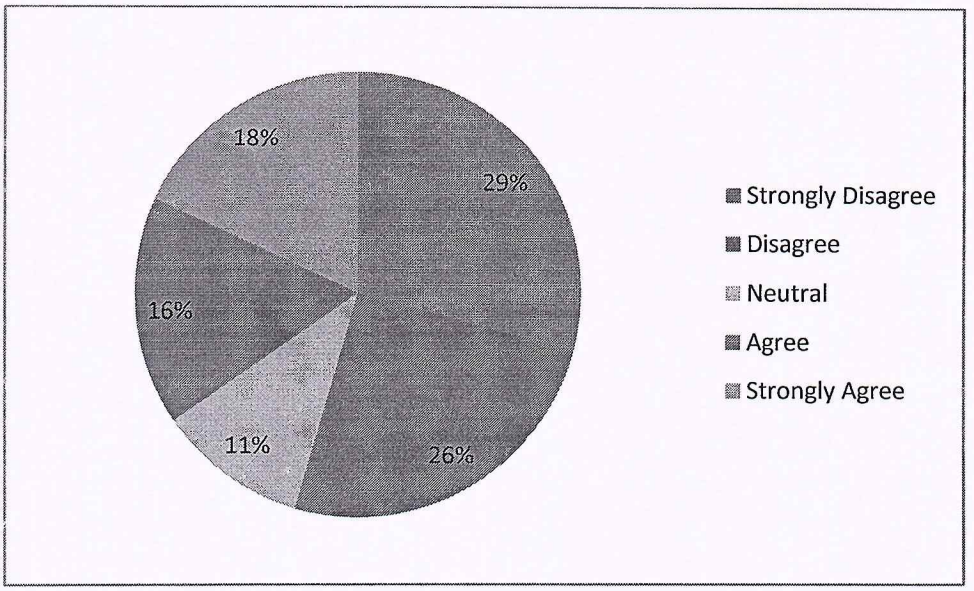


25% people were high, 25% people were very low, 21% people were low, 20% people were moderate, 9% people were very high.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

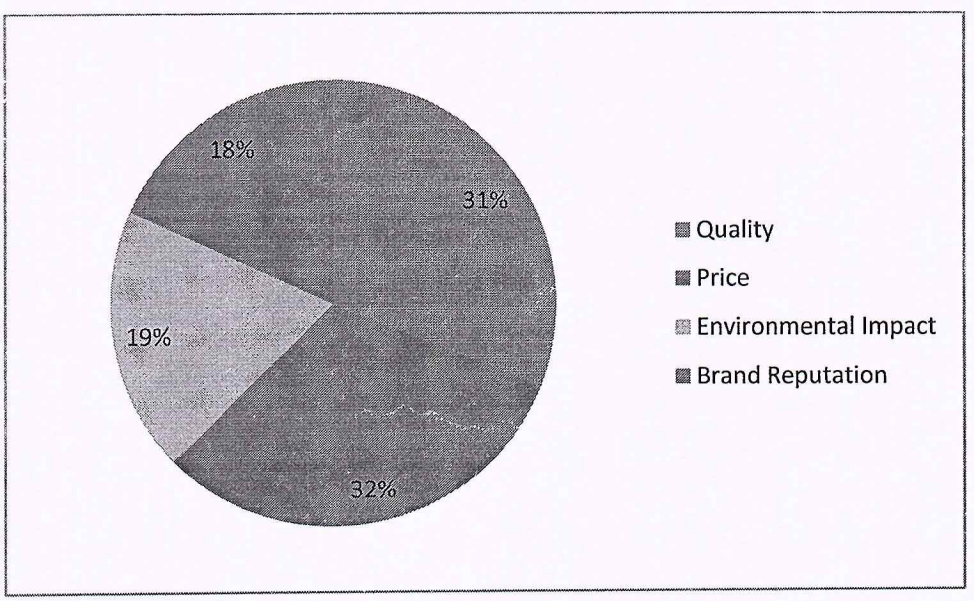
Chairman
IQAC, Shri Ram College,
Muzaffarnagar

7. Do you agree the prices of the Bindal Papers Ltd products are fair?



29% people were strongly disagree, 26% people were disagree, 18% people were strongly agree, 16% people were agree, 11% people were neutral.

8. What are the key factors that influence your decision to purchase paper products?

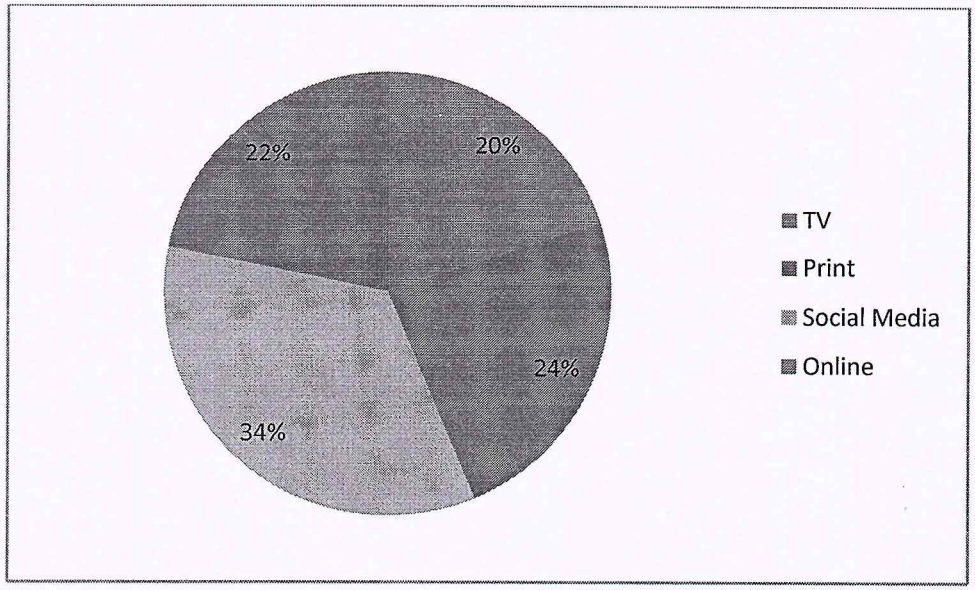


32% people were influence by price, 31% people were influence by quality, 19% people were influence by environmental impact, 18% people were influence by brand reputation.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

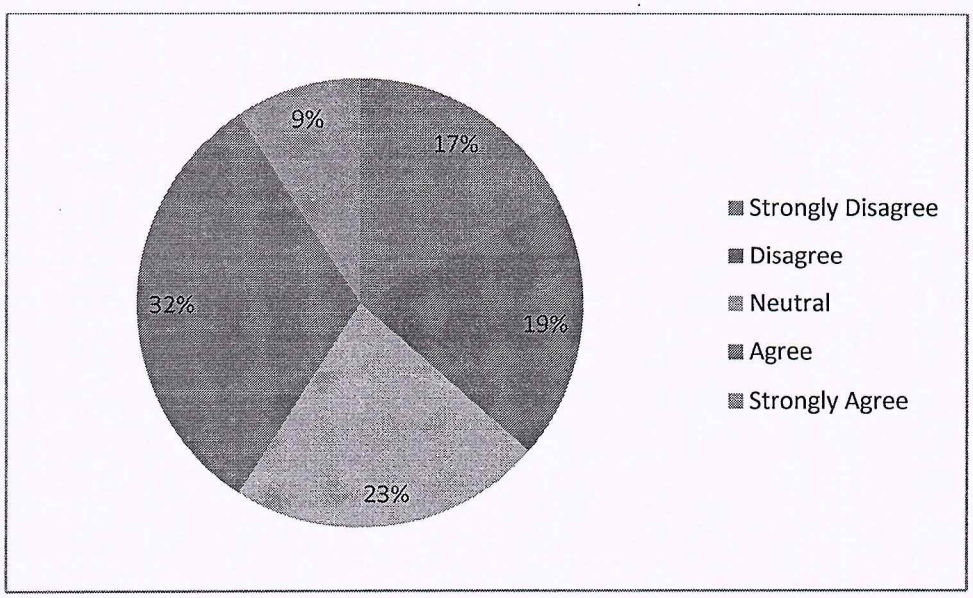
Chairman
IQAC, Shri Ram College,
Muzaffarnagar

9. Which marketing channels do you find most effective in influencing your purchasing decisions?



34% people were influence by social media, 24% people were influence by print, 22% people were influence by online, 20% people were influence by TV.

10. Do you agree that Bindals Papers Ltd products have made a good brand image?

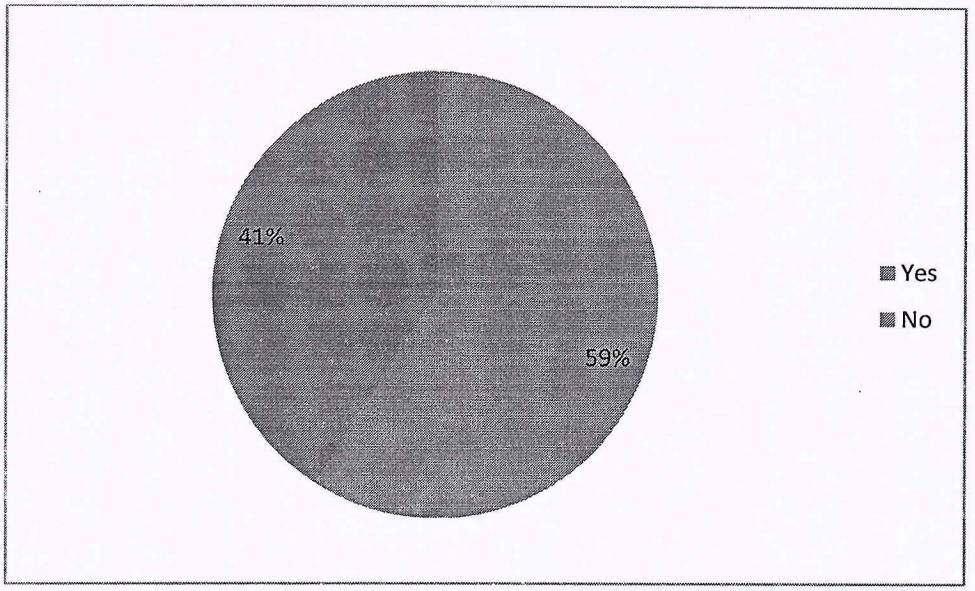


32% people were agree to the good brand image, 23% people were neutral to the good brand image, 19% people were disagree to the good brand image, 17% people were strongly disagree to the good brand image, 9% people were strongly dis agree to the good brand image.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

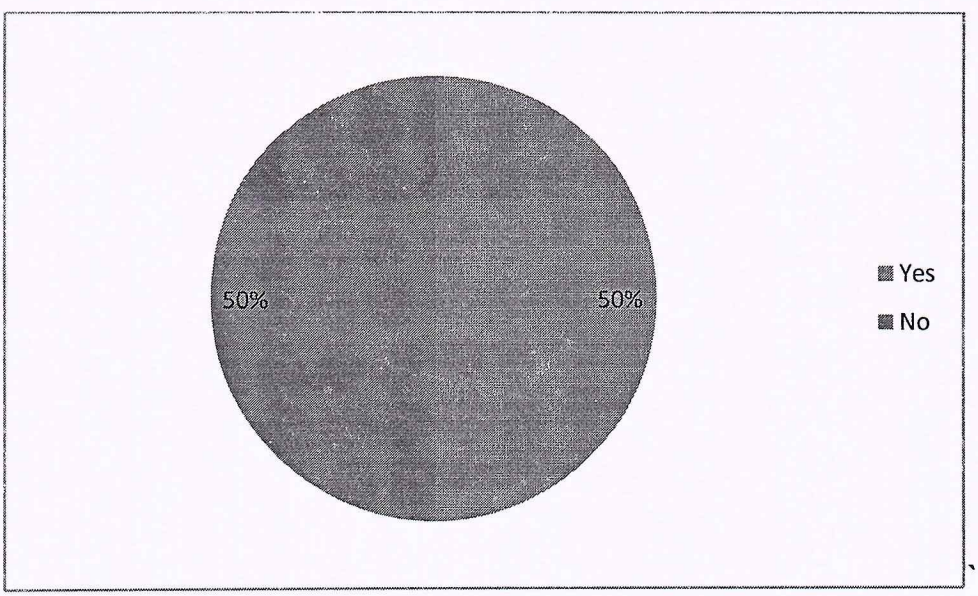
Chairman
IQAC, Shri Ram College,
Muzaffarnagar

11. Do you agree that Bindals Papers Ltd products are chemical-free?



59% people were agreed to chemical free, 41% people were not agreed to chemical free.

12. Have you faced any problem while using the product?

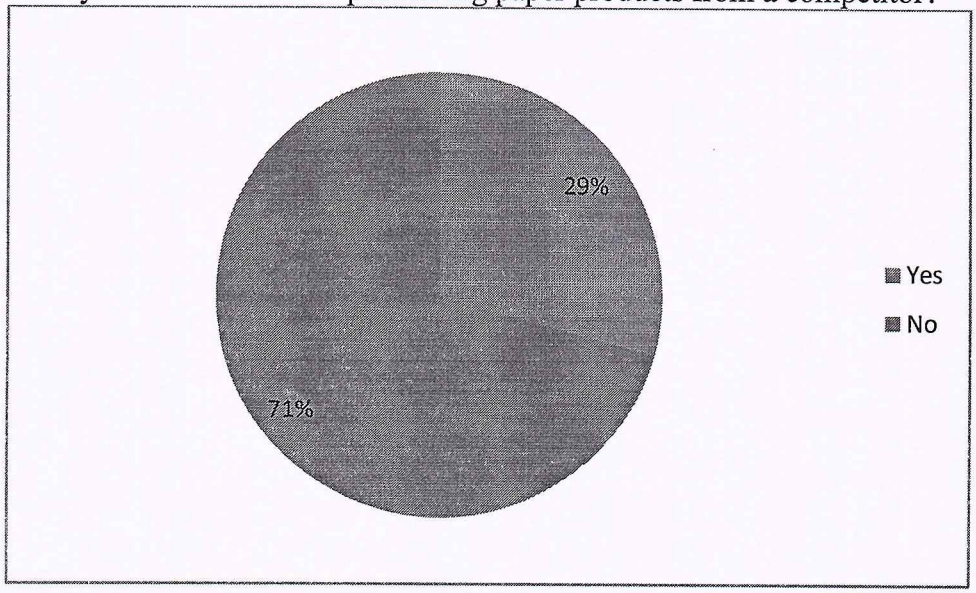


50% people were faced the problem, 50% people were not faced the problem.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

13. Have you ever considered purchasing paper products from a competitor?



71% people were not ready to switch Bindal Paper Product while 29% people were willing to consider other compeititor products.

FINDINGS

- 33% were of the age between 25-30, 32% were of the age between 20-25, 23% were of the age between 15-20, 12% were the age of above 35.
- 61% people were the male and 39% people were the female.
- 35% people were educated upto HSC, 31% people were educated to post graduation, 20% people were educated to graduation, 14% people were illiterate.
- 68% people were married and 32% people were unmarried.
- 34% people were aware by self exploration, 23% people were aware by advertisement, 23% people were aware by recommendation, 20% people were aware by youtube.
- 25% people were high, 25% people were very low, 21% people were low, 20% people were moderate, 9% people were very high.
- 29% people were strongly disagree, 26% people were disagree, 18% people were strongly agree, 16% people were agree, 11% people were neutral.
- 32% people were influence by price, 31% people were influence by quality, 19% people were influence by environmental impact, 18% people were influence by brand reputation.
- 34% people were influence by social media, 24% people were influence by print, 22% people were influence by online, 20% people were influence by TV.
- 32% people were agree to the good brand image, 23% people were neutral to the good brand image, 19% people were disagree to the good brand image, 17% people were strongly disagree to the good brand image, 9% people were strongly dis agree to the good brand image.
- 59% people were agreed to chemical free, 41% people were not agreed to chemical free.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

- 50% people were faced the problem, 50% people were not faced the problem.
- 71% people were not ready to switch Bindal Paper Product while 29% people were willing to consider other compeititor products.

Conclusion

This study aimed to investigate the relationship between marketing communication strategies and consumer brand loyalty for Bindals Papers Mills. The findings revealed a significant positive impact of marketing communication on brand loyalty. Specifically, the study found that advertising, sales promotion, and e-word-of-mouth (eWOM) all positively influenced consumer brand loyalty. These results align with previous research demonstrating the effectiveness of marketing communication in building strong brand relationships. By effectively utilizing a mix of advertising, sales promotions, and eWOM, Bindals Papers Mills can strengthen its brand positioning, increase customer retention, and ultimately drive long-term business growth.

SUGGESTIONS & RECOMMENDATIONS

 In order to retain brand recognition, Bindal Papers might boost advertising efforts across many media.

 They are able to broaden their distribution channels.

 They can keep up their efforts to foster and preserve favorable brand loyalty.

 Bring initiatives into place to improve customer retention and loyalty.

 In marketing initiatives, draw attention to the special qualities of Bindal Paper goods.

 Review your pricing plan to stay ahead of the competition.

 To better understand consumer preferences and modify product offerings, conduct additional market research.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

ANNEXURE

QUESTIONNAIRE:

1) Name.....

2) Age.....

(a) 15-20 ( ) (b) 20-25 ( ) (c) 25-35 ( ) (d) above 35 ( )

3) Gender

(a) Male ( ) (b) Female ( )

4) Qualification

(a) Up to HSC ( ) (b) Graduation ( ) (c) Post Graduation ( ) (d) illiterate ( )

5) Marital Status

(a) Married ( ) (b) Unmarried ( )

6) Have you heard of Bindal Papers Mills? If yes, how did you first become aware of the brand?

(a) Advertisement (b) Recommendation (c) Self Exploration (d) YouTube

7) How would you rate your overall awareness of the Bindal Papers Brand?

(a) (1-5 scale), (b) (1 being low), (c) (5 being high)

8) Do you agree the prices of the Bindal Papers Ltd products are fair?

(a) Strongly agree ( ) (b) Agree ( ) (c) Neutral ( ) (d) Disagree ( ) (e) Strongly disagree ( )

9) What are the key factors that influence your decision to purchase paper products?

(a) Quality ( ) (b) Price ( ) (c) Environmental Impact ( ) (d) Brand Reputation ( )

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

10) Which marketing channels do you find most effective in influencing your purchasing decisions?

(a) TV ( ) (b) Print ( ) (c) Social Media ( ) (d) Online

11) Do you agree that Bindals Papers Ltd products have made a good brand image?

(a) Strongly agree ( ) (b) Agree ( ) (c) Neutral ( ) (d) Disagree ( ) (e) Strongly disagree ( )

12) Do you agree that Bindals Papers Ltd products are chemical-free?

(a) Yes ( ) (b) No ( )

13) Have you faced any problem while using the product?

(a) Yes ( ) (b) No ( )

14) Have you ever considered purchasing paper products from a competitor?

(a) Yes ( ) (b) No ( )

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

PROJECT COMPLETION REPORT

The project was funded by Bindals Papers Mills Ltd. Project was exclusively conducted for Bindals Papers. The Company had paid Rs.100000/- in advance and remaining Rs. 55000/- after the submission of the report. The project undertaken was started on 21/08/2023 and it was completed on 24/02/2024. Seven students of BBA final year were involved to assist the principal investigator throughout the project. They collected primary data through questionnaire and assisted from starting to the completion of the project. Students were also provided with reasonable stipend. People dedicated to the project were as follows-

Principal Investigator- Mr. Ankush Rawal (Assistant Professor Department of Business Administration)

SN	Roll Number	Name of the student	Remuneration (in Rs.)	TA (In Rs.)
1	200855105029	AYUSHI GARG	7100	1800
2	200855105050	HARSH BANSAL	7100	1000
3	200855105075	MEGHNA GAGNEJA	7100	1800
4	200855105064	NAINA RANA	7100	1500
5	200855105138	SATYAM TYAGI	7100	1500
6	200855105092	NANDINI SHARMA	7100	1700
7	200855105057	ISHA	7100	2000
8	200855105143	SHEKHAR GUPTA	7100	1400
9	200855105178	VIKAS VERMA	7100	1550
10	200855105163	TANISHA BHATNAGAR	7100	1200
11	200855105177	VIGAM TOMAR	7100	1600
12	200855105179	VRINDA TYAGI	7100	1900
13	200855105155	SOMYA ARORA	7100	1500
14	200855105153	SHUBHAM SINGHAL	7100	1600
15	200855105144	SHIPRA	7100	1750
16	200855105125	RIYA GOEL	7100	1600
17	200855105115	RAMAN KUMAR	7100	1400
		Total	**120700**	**26800**

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Remuneration Paid	Rs. 120,700
Travelling Allowances Paid	Rs. 26800
Miscellaneous expenses	Rs. 8050
Total	**Rs. 155550/-**

Ankush Rawal
Principal Investigator to the Project

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

To
The Principal
Shri Ram College
Muzaffarnagar

Date: 21/08/2023

Subject: Request for Proposal (RFP) for Website Development for IIMT College, Saharanpur

Dear Sir/Madam

I hope this message finds you well. On behalf of IIMT College Saharanpur, I wish to inquire about your web development services as we are looking to design and develop a new website for our college.

Requirement Overview:

Our goal is to develop a modern, user-friendly, and responsive website that will serve as comprehensive digital hub for our college. The website will cater to a variety of audiences, including prospective students, current students, faculty and other stakeholders. The primary objectives of the website are as follows –

1. **Showcasing our College:** The website should reflect our college's values, mission, history and [illegible] with an emphasis on engaging prospective students and enhancing our reputation in academic community
2. **Enhancing User Experience:** We are looking for clean, intuitive design that prioritizes easy navigation, mobile responsiveness, and an accessible user experience for all visitors.
3. **Functionality Requirements:** The website should include feature such as –
   a. Admission Portal with online applications and forms
   b. Academic program details, course catalogs, and faculty directories.
   c. News and events section for both the college community and prospective students.
   d. Placement records.
4. **Content Management System (CMS):** We require an easy to use CMS that will allow our team to regularly update the website with new content, event and announcements.
5. **Security and Performance:** The Website must be secure, optimized for speed, and scalable for future growth.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Proposal Submission Requirements:

We kindly request that your proposal include the following:

1. **Project Plan & Timeline:** A proposed timeline for the website design and development process, including milestones for review and feedback.
2. **Cost Estimate:** A detailed breakdown of the cost for the entire project, including design, development, testing, and post-launch support/maintenance.
3. **Support & Maintenance:** Information on the type of ongoing support you offer after the website is launched, including costs for maintenance.
4. **Team Members:** Details about the project team, including their experience and roles in the website development process.
5. **Portfolio:** Examples of similar projects, including live links to websites you have developed for other clients.

Proposal Deadline:

Please submit your proposal to us by 01/09/2023. We plan to review all proposals and select a vendor by 11/09/2023. If you have any questions or need additional information, please do not hesitate to contact us.

Contact Information:

- **Contact Person:** Mr. Vikas Sharma
- **Email:** vikas.mca.2791@gmail.com
- **Phone:** 7983188688

We look forward to reviewing your proposal and exploring the opportunity to work together to create an exceptional website for IIMT Saharanpur.

Thank you for your time and consideration.

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Regards,

(Dr. Anju Walia)
Principal

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Date: 04/09/2023

To
The Principal
IIMT College
Saharanpur

Subject: Response to Request for Proposal (RFP) for Website Development for IIMT College, Saharanpur

Dear Madam,

Thank you for considering **Shri Ram College, Muzaffarnagar** for the development of IIMT College's new website. We are excited to have the opportunity to submit our proposal in response to your Request for Proposal (RFP) for the design, development, and deployment of a modern, user-friendly, and responsive website for your esteemed institution.

We have carefully reviewed your requirements and are confident that our expertise in web development, combined with our understanding of the educational sector, positions us to deliver a high-quality solution tailored to IIMT College's needs.

Proposal Overview

At **Shri Ram College, Muzaffarnagar**, we specialize in creating custom websites for educational institutions, focusing on both functionality and aesthetics. Our proposal outlines how we intend to meet the objectives defined in your RFP, and we are excited to collaborate closely with your team to deliver a website that will elevate the digital presence of IIMT College.

Our Approach

1. **Design and Development**: We will create a fully customized design that reflects the values and branding of IIMT College, ensuring a modern, visually appealing, and accessible website. Our team will work closely with your stakeholders to ensure the design meets the specific needs of students, faculty, and other visitors.
2. **Responsive Design**: The website will be designed with a mobile-first approach, ensuring that it is fully optimized for desktops, tablets, and smart phones. We will make sure that the site adapts seamlessly across different devices, providing users with a consistent experience.
3. **CMS Integration**: We shall provide a control panel for ease of content management. This will allow your staff to easily update pages, news, events, and announcements without requiring technical expertise.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

4. **Key Features:**
   We will develop the following key features for the website:
   - **Academic Program Pages:** Detailed descriptions of each program with admission guidelines.
   - **Admissions Portal:** A streamlined admissions form and detailed information for prospective students.
   - **Research Portal:** Secure access to resources, grades, schedules, and notifications.
   - **News and Events:** An interactive events calendar and news section.
   - **Placement:** A searchable database for faculty profiles.
   - **Contact Forms & Social Media Integration:** Easy access to contact forms and integration with IIMT's social media platforms.
5. **SEO and Performance:**
   The website will be built with search engine optimization (SEO) best practices in mind to improve visibility in search engines. We will also ensure that the website loads quickly and functions smoothly, providing an optimal user experience.
6. **Training and Support:**
   Once the website is developed, we will provide comprehensive training for your team to manage and update the site via the CMS. Additionally, we offer post-launch support to handle any updates, troubleshooting, or enhancements.

Project Timeline:

Phase	Timeline	Description
Discovery & Planning	2 weeks	Initial meetings, gathering requirements, defining scope.
Design Phase	4 weeks	Developing wireframes and design prototypes.
Development Phase	5-7 weeks	Front-end and back-end development of the website.
Content Integration Phase	1 week	Inserting content and finalizing website structure.
Testing & QA Phase	1 week	Conducting usability testing, bug fixing, and optimization.
Deployment Phase	1 week	Website goes live and post-launch monitoring begins.

Total Duration: Approximately **14-16 weeks** from project initiation to final launch.

Cost Estimate:

Services	Cost
Design Phase	
UI Design	Rs. 22000 - 30000
Graphic Elements and Imagery	Rs. 18000 – 22000
Development Phase	
Content Management System (CMS) Integration	Rs. 21000 - 24000
User Authentication and Profiles	Rs. 10000 - 14500
News and Events System	Rs. 9500 - 10500
Online Forms and Applications	Rs. 14000 - 17000
Testing Phase	
Quality Assurance	Rs. 14000 - 17000
Miscellaneous	

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Domain and Web space	Rs. 10000 - 13000
Contingency	
Contingency Fund	Rs. 10000
Total Estimated Budget	
Low-End Estimate	Rs. 128500
High-End Estimate	Rs. 158000

Timeline:

A. Planning Phase (2 Weeks):
   - **Project Kickoff:**
     Define project scope, objectives, and requirements.
     Identify key stakeholders and establish communication channels.
   - **Research and Analysis:**
     Conduct a comprehensive analysis of the existing website.
     Gather requirements from different departments and user groups.

B. Design Phase (4 Weeks):
   - **UI Design:**
     Develop wireframes and prototypes.
     Collect feedback and iterate on design concepts.
   - **Graphic Elements and Imagery:**
     Procure or create necessary graphic elements and high-quality images.

C. Development Phase (5-7 Weeks):
   - **Content Management System (CMS) Integration:**
     Implement and customize the CMS.
   - **User Authentication and Profiles:**
     Develop and integrate user authentication features.
   - **News and Events System:**
     Implement an interactive calendar system.
   - **Online Forms and Applications:**
     Digitize and streamline various forms and applications.

D. Content Integration (1 week):
   - Inserting content
   - Finalizing website structure

E. Testing & QA Phase (1 Week):
   - **Quality Assurance:**
     Conduct thorough testing and debugging.
   - **User Acceptance Testing (UAT):**

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Involve stakeholders in UAT to ensure the system meets expectations.

F. **Deployment Phase (1 Week):**
   - **Launch Preparation:**
     Finalize server configurations and deploy the website to a staging environment.
   - **Training:**
     Train content managers, administrators, and end-users.
   - **Launch:**
     Deploy the website to the live environment.

G. **Post-Launch Phase (Ongoing):**
   - **Monitoring and Optimization:**
     Monitor website performance and user feedback.
     Implement optimizations as needed.

Next Steps

If you are interested in moving forward with our proposal, we would be happy to schedule a meeting or call to discuss any questions you may have and fine-tune the details of the project. Please feel free to reach out to us:

Contact Information:

- **Contact Person:** Mr. Sanjaykant
- **Email:** sanjaykanttyagi@gmail.com
- **Phone:** 84457447163

We are excited about the possibility of collaborating with IIMT College, Saharanpur, and look forward to your feedback.

Thank you for considering **Shri Ram College, Muzaffarnagar** for this important project.

Regards,

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

(Dr. Prerna Mittal)
Principal

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

To
The Principal
Shri Ram College
Muzaffarnagar.

Date: 12/09/2023

Subject: Acceptance of Website Development Proposal

Dear Sir/ Madam,

I am pleased to inform you that IIMT College, Saharanpur has reviewed the proposal for the website development project, and we are excited to accept your proposal. We believe that Department Of Computer Application, Shri Ram College is the ideal partner to bring our vision to life, and we are eager to commence the project.

Key Points of Acceptance:

- **Project Commencement:**
  We agree to initiate the website development project on 18/09/2023 as outlined in your proposal.
- **Payment Terms:**
  We acknowledge the estimated cost of Rs. 145000 for the project and agree to adhere to the proposed payment schedule.
- **Collaboration and Communication:**
  We are committed to providing all necessary information and resources promptly to ensure the smooth progress of the project. Effective communication will be maintained throughout the development process.
- **Timeline:**
  We understand and accept the proposed timeline for project completion, targeting 14 to 16 weeks.

Point of Contact:

Mr. Vikas Kumar, shall be the point of contact for all necessary communications in this regard (Contact No: 7983188688)

We are confident that your team's expertise and dedication will result in a website that meets and exceeds our expectations. We appreciate your commitment to delivering a high-quality product, and we look forward to a successful collaboration.

Please share any additional details or documentation required to formalize the agreement. We are ready to proceed with the next steps outlined in your proposal.

Thank you for the comprehensive proposal, and we are excited about the journey ahead.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Regards,
(Dr. Anju Walia)
Principal

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Statement of Expenditure

Project Title : **Website of IIMT College, Saharanpur**

Project Duration : **18-Sep 2023 to 01-Jan 2024**

Services	Expenditure
Design Phase	
UI Design	Rs. 27000
Graphic Elements and Imagery	Rs. 19000
Development Phase	
Content Management System (CMS) Integration	Rs. 21000
User Authentication and Profiles	Rs .14500
News and Events System	Rs. 9500
Online Forms and Applications	Rs. 17000
Testing Phase	
Quality Assurance	Rs. 16500
Miscellaneous	
Domain and Web space	Rs. 10500
Travelling Exp., System Maintenance & other Contingency	Rs. 10000
Total Expenditure	Rs. 145000

Prepared By : **(Mr. Sanjaykant)**
Project Manager

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Approved By : **(Dr. Prerna Mittal)**
Principal

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Utilization Certificate

S.N.	Detail of sanction of Fund with Project name and Duration	Amount
1.	3.5 months project on Website Development of IIMT College, Saharanpur Date of Sanction of Fund- 12-09-2023 as per Sanction Letter	145000.00 /-
	TOTAL	145000.00/-

It is Certified that out of Rs. 145000.00/- (One Lacs Forty five Thousands only) of grants sanctioned by **IIMT College, Saharanpur** during the year 2023-2024 in favor of **Shri Ram College, Muzaffarnagar,** a sum of Rs. 145000.00 has been utilized for the purpose of the project for which it was sanctioned and that the balance of Rs. **Nil** remaining unutilized at the end of the year has been surrendered. The Extra amount (If any) is met out by Shri Ram College.

2. Certified that we have satisfied our self that the conditions on which the grant was sanctioned have been duly fulfilled/are being fulfilled and that we have exercised the following checks to see that the money was actually utilized for the purpose for which it was sanctioned.

Kinds of checks exercise-

1 Checking of cash book
2 Checking of payment vouchers.
3 Checking of salary register.
4 Checking of expense bill.

For Shri Ram College

Secretary
Date: 08-01-2024
Place: Muzaffarnagar

For Goel Rakesh & Co.
Chartered Accountants

Rakesh Kumar Goel
Proprietor

Coordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Progress Report

1. Discovery & Planning Phase

(Website Development for IIMT College, Saharanpur)
[18/09/2023 to 30/09/2023] - (2 Week)

- In view of transformative redesign of website for IIMT, College is to plan the development of a new website.
- Mr. **Vikas Kumar** provides the communication bridge to interact with all stakeholders to gather information from different departments and user groups.

The project team consists of the following members:

Project Manager: **Mr. Sanjaykant Tyagi**
UI/UX Designer: **Mr. Hans Tyagi**
Web Developer: **Mr. Vishwas Sharma**

In this phase we reviewed the following tasks:

- A review of the performance of existing websites
- A website content audit
- Outlining a top-level information architecture
- Outlining a Multi-layer information architecture
- A content strategy and content guidelines

In order to effectively address the above requirements we conducted comprehensive analysis with pre existed website and collect real-time capabilities or access to current data. To enable us to gather the insights required for this project, we developed a research plan designed to cover online information and stakeholders to produce qualitative and quantitative findings.
We used a range of research methods, including:

- Telephone interviews with stakeholders
- Surveys of various IIMT College audiences
- Review of IIMT college's website analytics
- Review of existing documents

Detailed findings in the planning phase of this project are included in their relevant sections, but some of our key points are as follows:

- Stakeholders were less clear on other uses of the website or Portal.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

- A large majority of website visitors are prospective students. They are drawn to course pages on their first visit, and then subsequent visits are likely to incorporate secondary information such as fee structure, courses, placements, and library.
- Prospective students are keen to hear from current students about their experiences of IIMT College and they expect to find this content on the website.
- The IIMT College audience is likely to think of the content they need in terms of its relationship to their role in the university – students will organize by Course and Student Life, whereas staff will think of categories based on the internal structures they are aware of.

The discovery of research methods aims:

- To Provide a user-friendly interface
- To Develop a visually appealing homepage
- To better define IIMT College audiences and their behavior
- To identify IIMT College own desires and requirements for the website
- To understand the competition and marketplace in which IIMT College operates
- To identify potential challenges and opportunities

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

2. Design Phase

(Website Development for IIMT College, Saharanpur)
[02/10/2023 to 28/10/2023] - (4 Weeks)

- The design team visited the IIMT College on August 30, 2023 to initiate the design phase of the website development of the college.

- Two meetings with the different stakeholders conducted with the help of Mr. Vikas Kumar.

The design team, led by Mr. Sanjaykant Tyagi, undertook the following activities:

- Conducted user research to understand preferences and expectations.
- Created wireframes and multi-layer architecture of the website pages.
- Developed a comprehensive style guide including color schemes.
- Incorporated feedback from stakeholders and potential users.

The design team produced detailed wireframes and interactive prototypes for critical pages of the website, including:

Home
About
- About Us
- Chairman Desk
- Secretary Desk
- Director Desk

Why IIMT?
- Infrastructure
- Facilities
- Scholarships

Academics
- Engineering & Technology
- Polytechnic
- Pharmacy
- Basic Science
- Management
- Commerce
- Computer Application
- Education
- Arts and Humanities

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Admission

- Admission Process
- Online Registration
- Admission Helpline

Placement

- Placement Cell
- Placement Records

Research

- Seminars and Workshops

News Gallery

Events

Contact Us

Above multilayer architecture of the website were reviewed by the stakeholders and refined based on feedback to ensure alignment.

- A meeting held with the important stakeholders to finalize the color scheme for the web pages of website. Some issues regarding quality of photographs also discussed in the meeting.

- Regular communication and collaboration occurred with Mr. Vikas Kumar to ensure a seamless transition from design to implementation. Design specifications were documented and shared to guide the development process.

- Challenges encountered during the design phase included old/blurred images of institute and other activities. Solutions implemented to send a professional photographer to capture current images of your institute/activities then incorporate into the design of the website.

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

3. Development Phase

(Website Development for IIMT College, Saharanpur)
[30/10/2023 to 9/12/2023] - (6 Weeks)

- Development of the decided structure or multilayer architecture is started by the development team on October 30, 2023.

- They started implement the design specifications, create functional features, and ensure the technical integrity of the website.

The development team undertook the following activities:

- The website designed with the help of the frontend technology like HTML, JavaScript & .NET.
- Translated design specifications into code for the homepage and key content pages.
- Integrated interactive elements and functionalities based on approved prototypes.
- The database structure, using SQL Server, was implemented to support dynamic content and seamless data management.
- Conducted regular code reviews and quality checks.
- Integration with the Content Management System (CMS) was successfully executed.

Key milestones achieved during the development phase include:

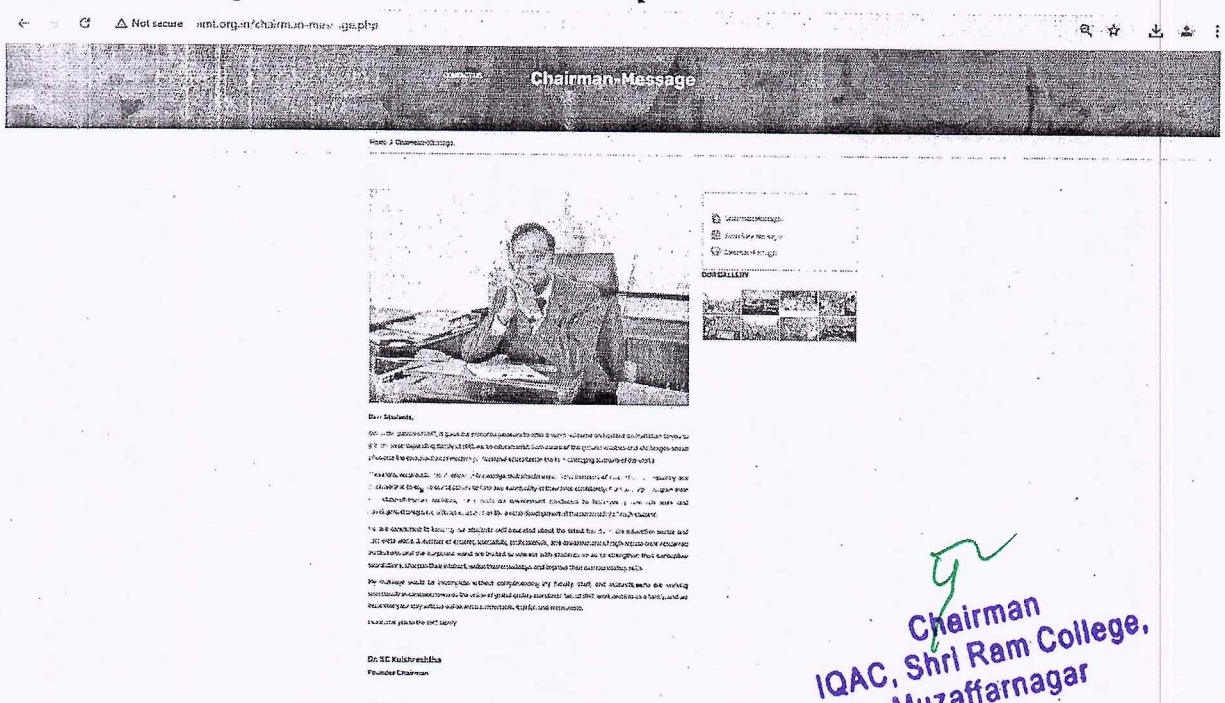
- **Homepage**

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

- About Us

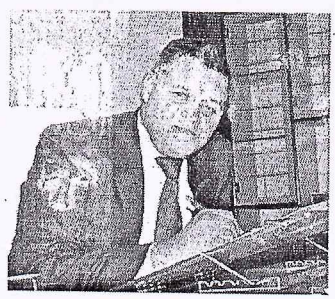
- Chairman Message



Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

- **Secretary Message**

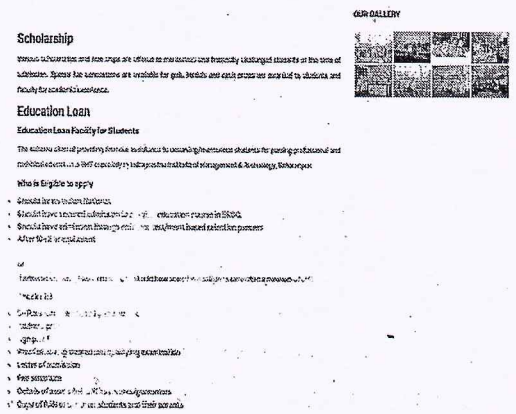


- **Director Message**

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

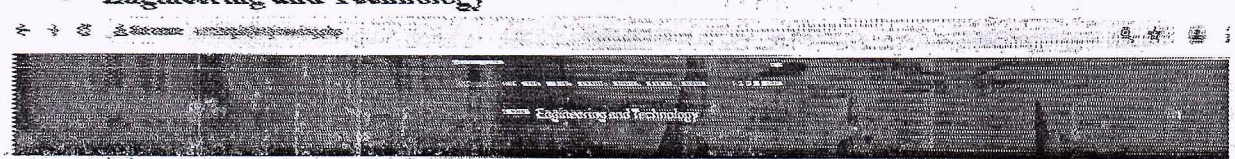
Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

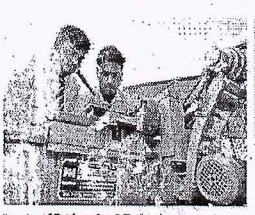
- **Scholarship**



Academics

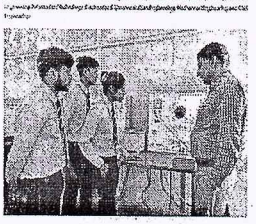
- **Engineering and Technology**





Faculty of Engineering & Technology

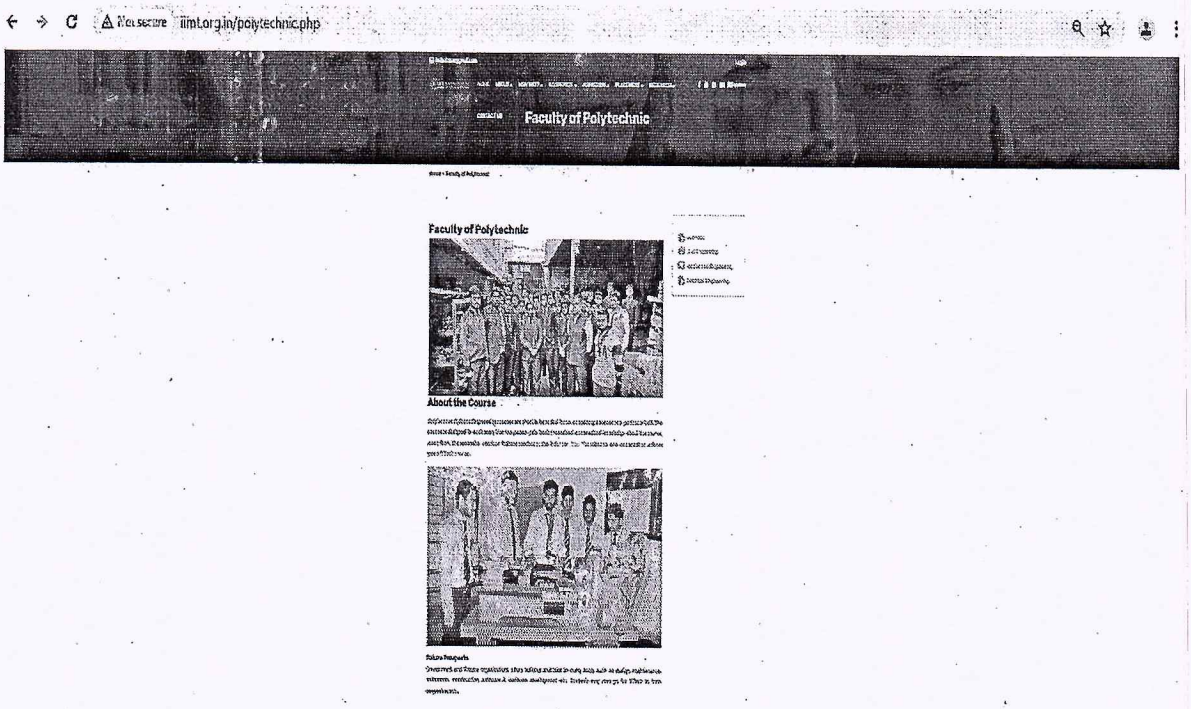
About the Course



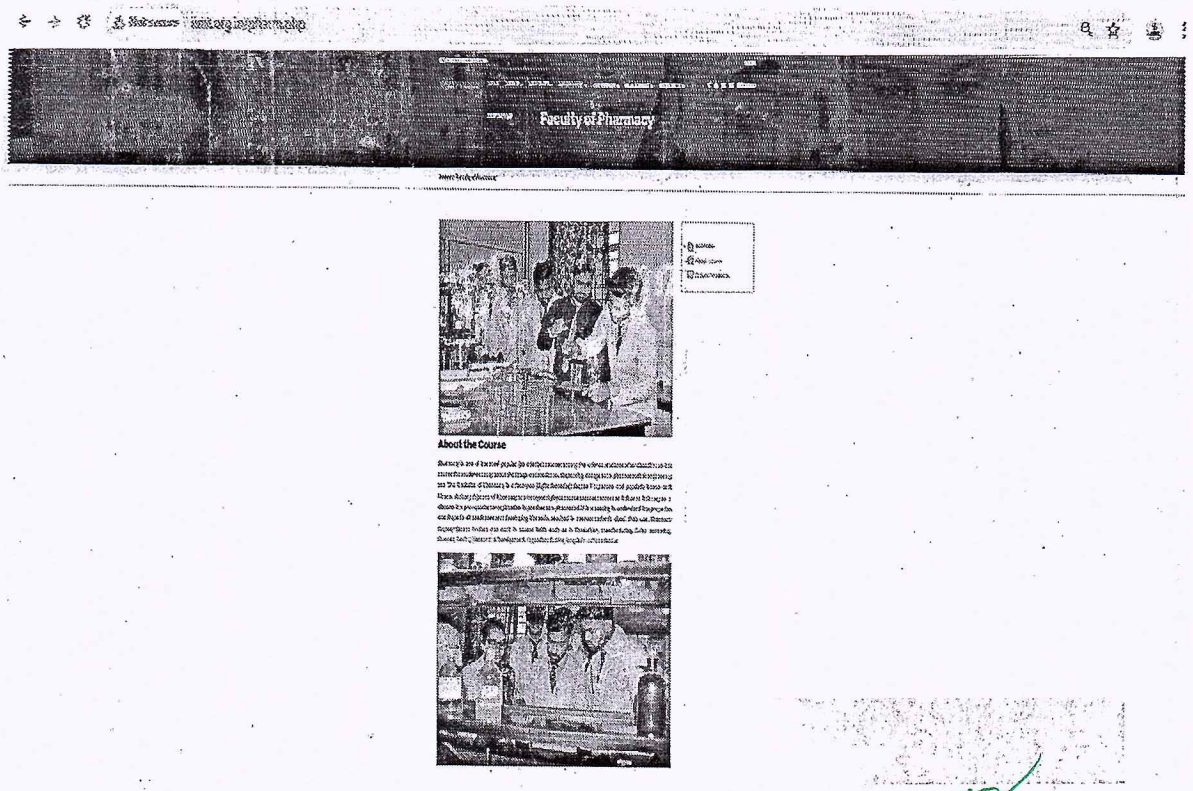
Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

- **Polytechnic**



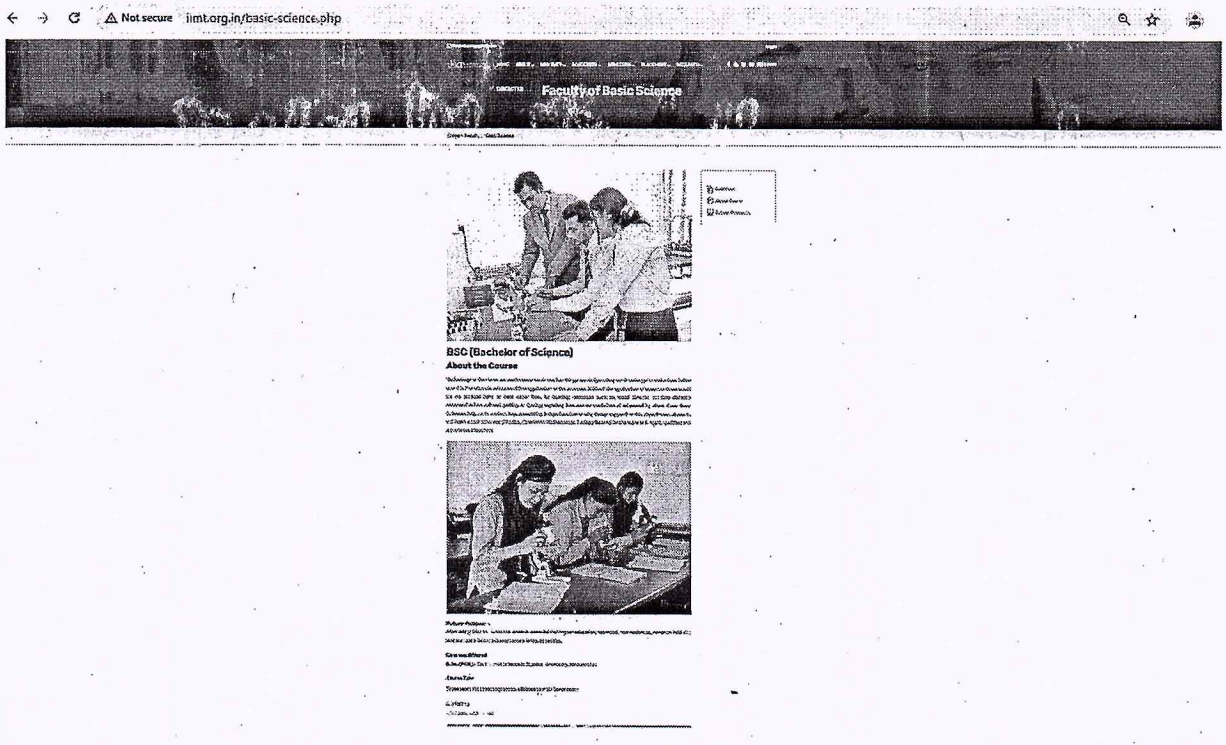
- **Faculty of Pharmacy**



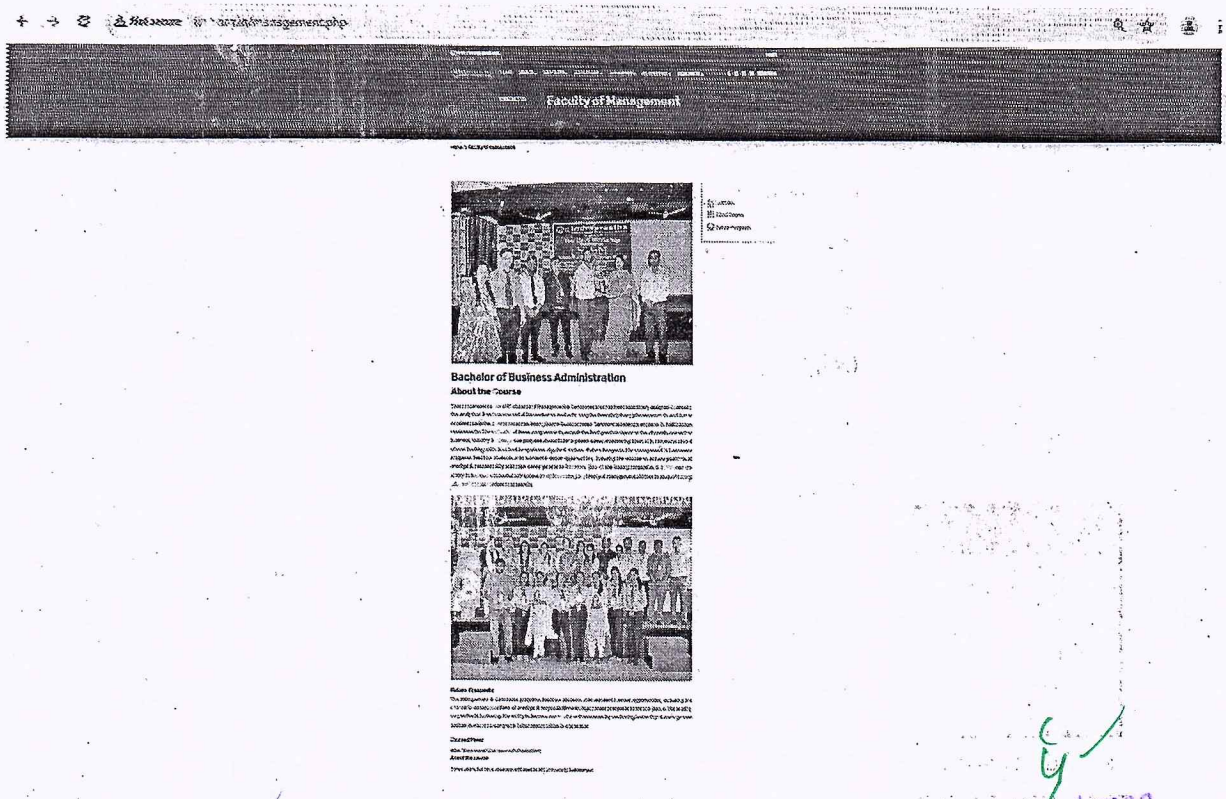
Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

- **Faculty of Basic Science**



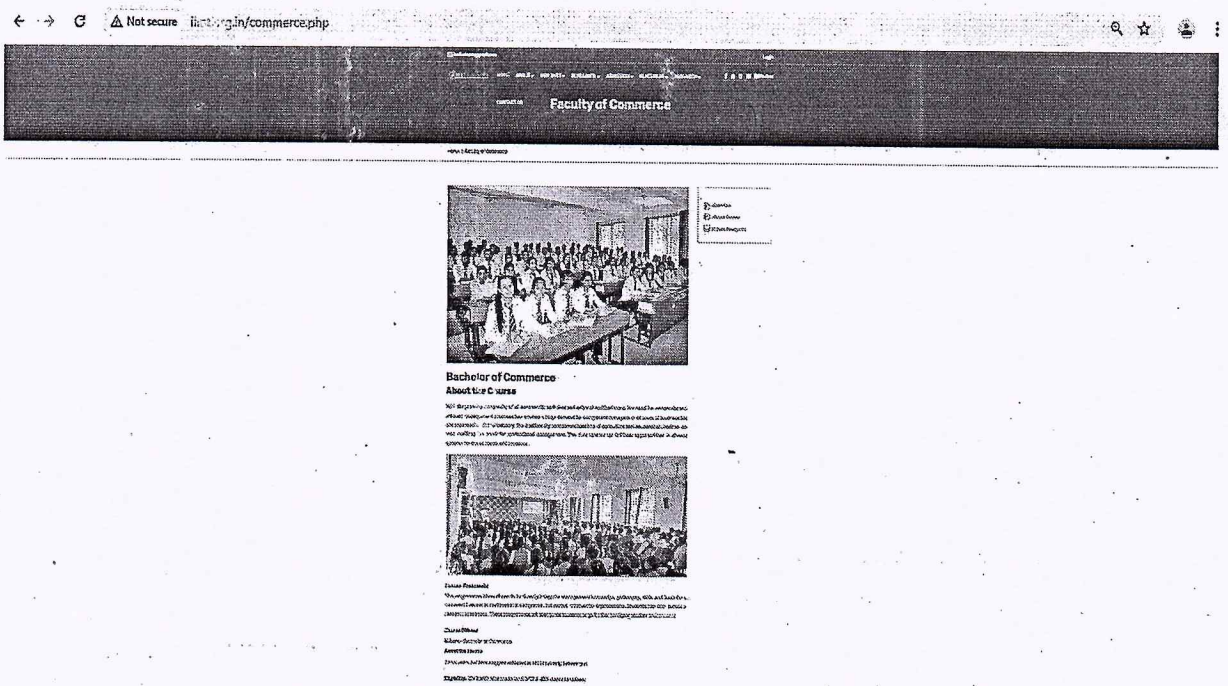
- **Faculty of Management**



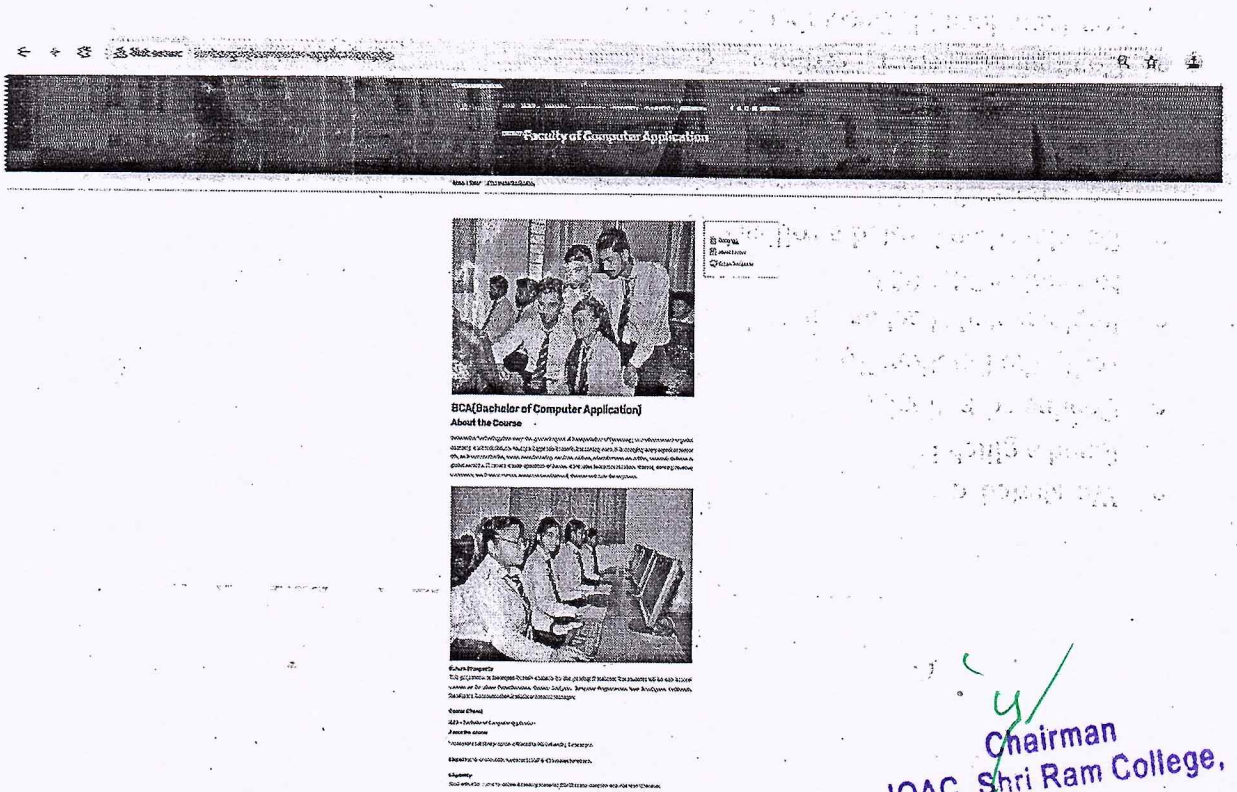
Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College
Muzaffarnagar

- **Faculty of Commerce**



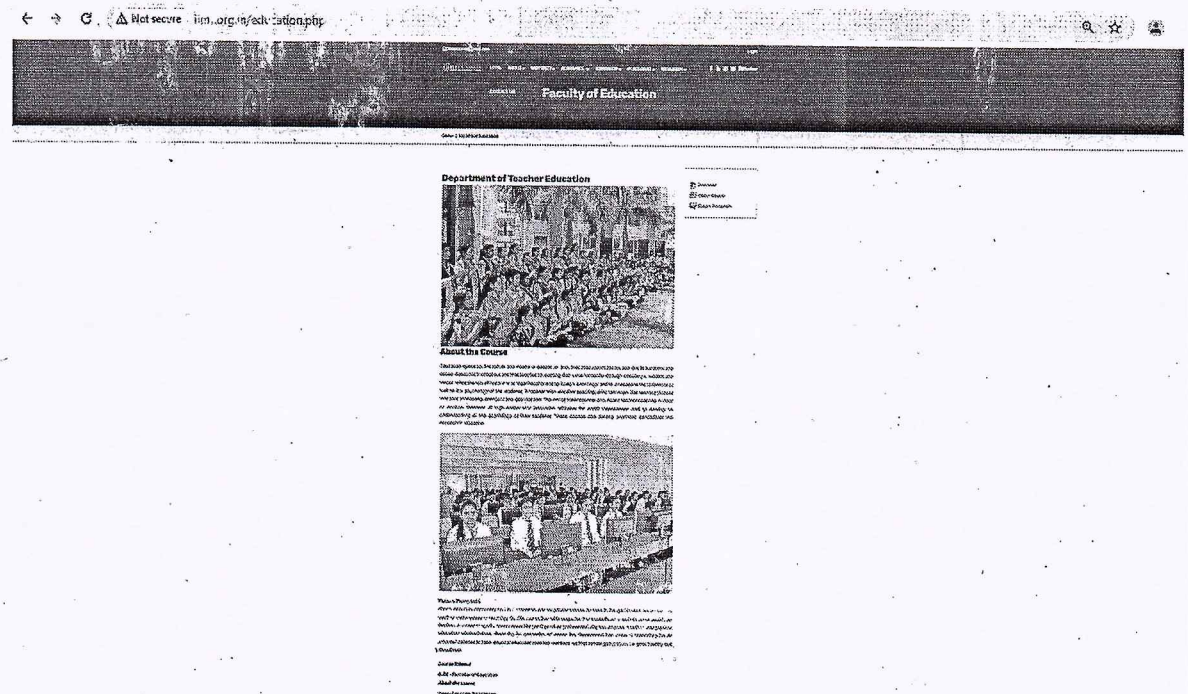
- **Faculty of Computer Application**



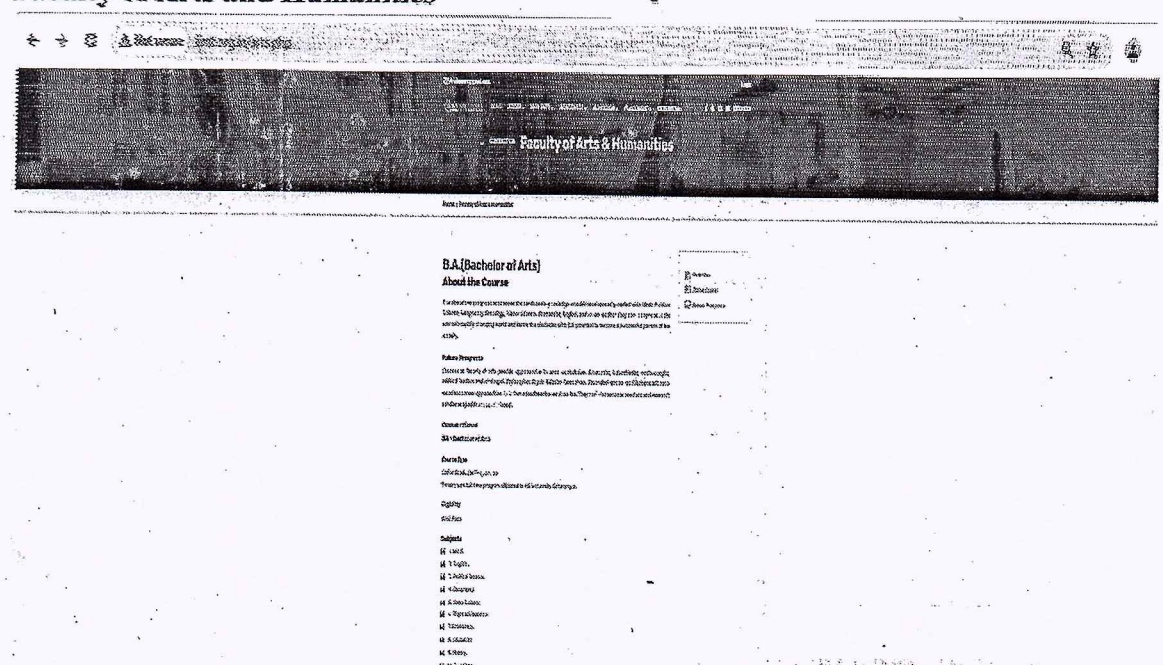
Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

- **Faculty of Education**



- **Faculty of Arts and Humanities**

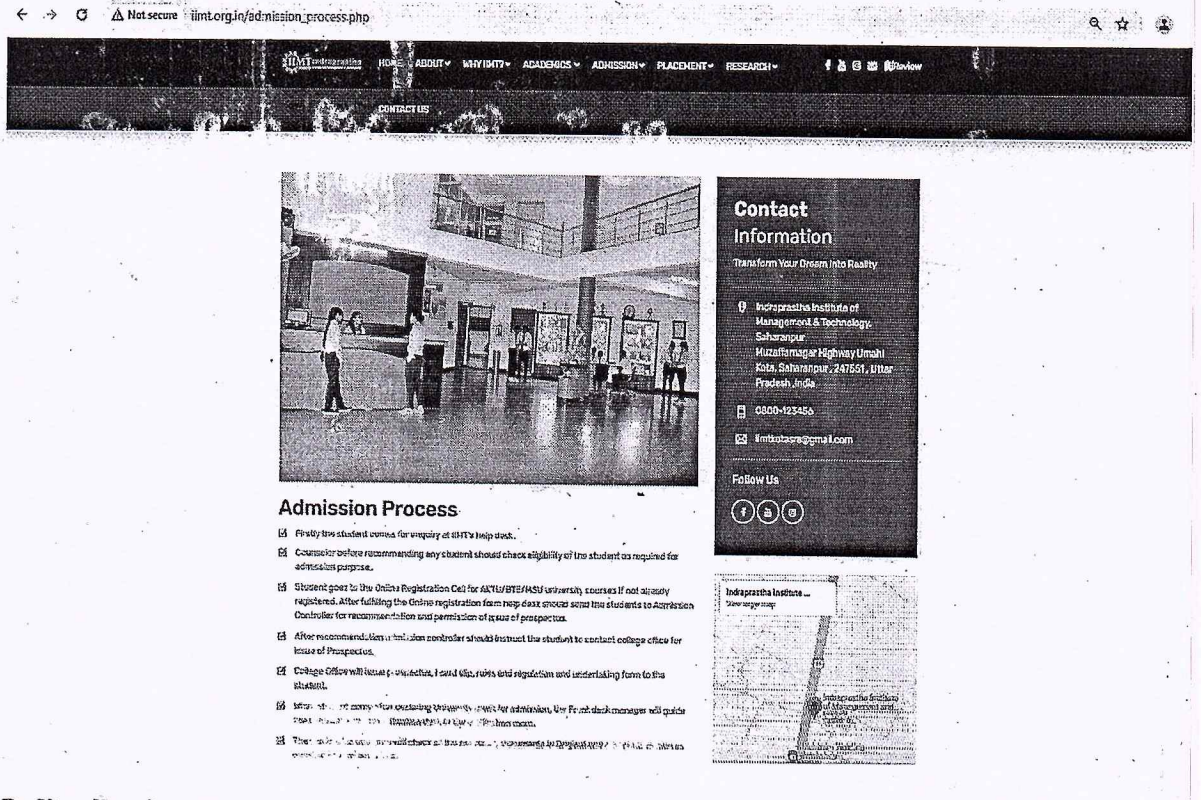


Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

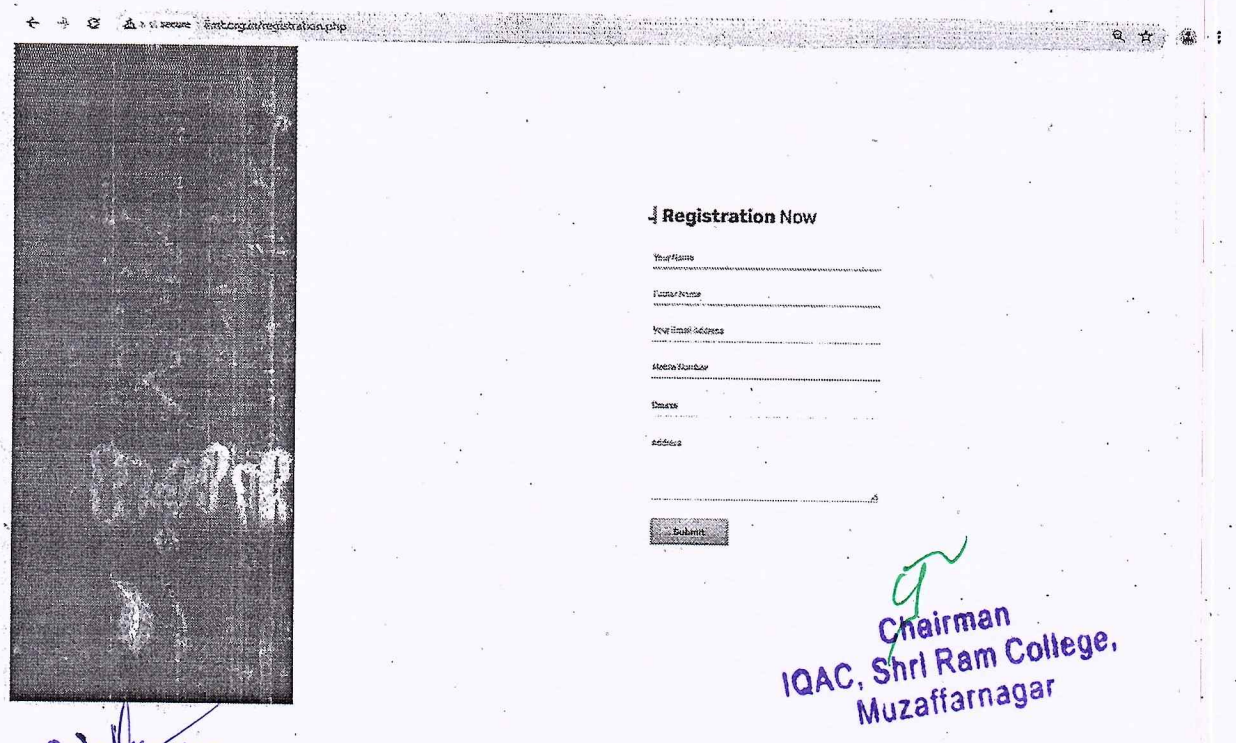
Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Admission

- **Admission Process**



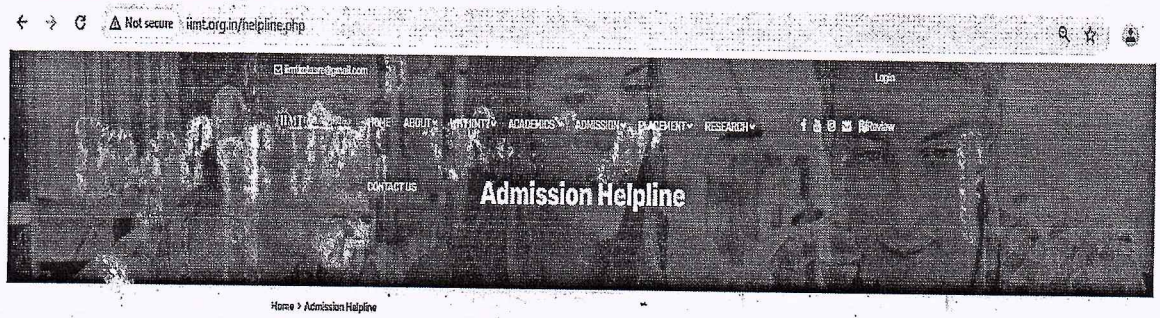
- **Online Registration**

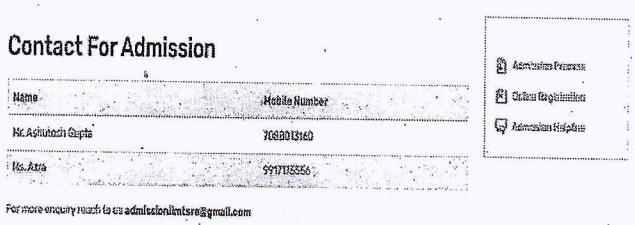


Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

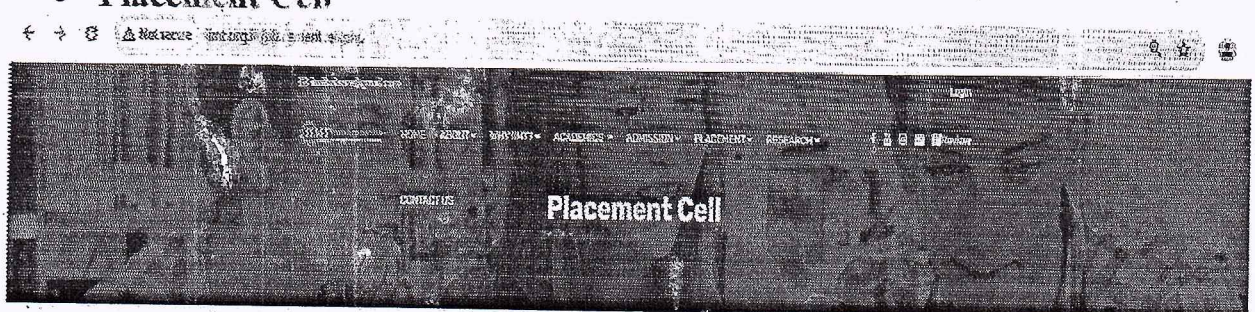
- **Admission Helpline**





Placement

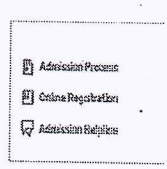
- **Placement Cell**



Placement Cell

Placement Cell- IIMT has very active placement cell, which is operating under the supervision of placement officer. It provides the best career options t. the students through an active interaction with extensive resources. Placement cell works closely with the corp. te world to provide employment opportunities to IIMT students. The institute also provides additional skills enhancement support to its student. Besides maintaining active contacts with the industry IIMT has close links with placement agencies to ensure good placement. The aim of career ... is to provide the students with a variety of options available and provide help to plan ... effectively ... plan and the next career move. IIMT takes the full responsibility to arrange placements ... for the successful candidates.

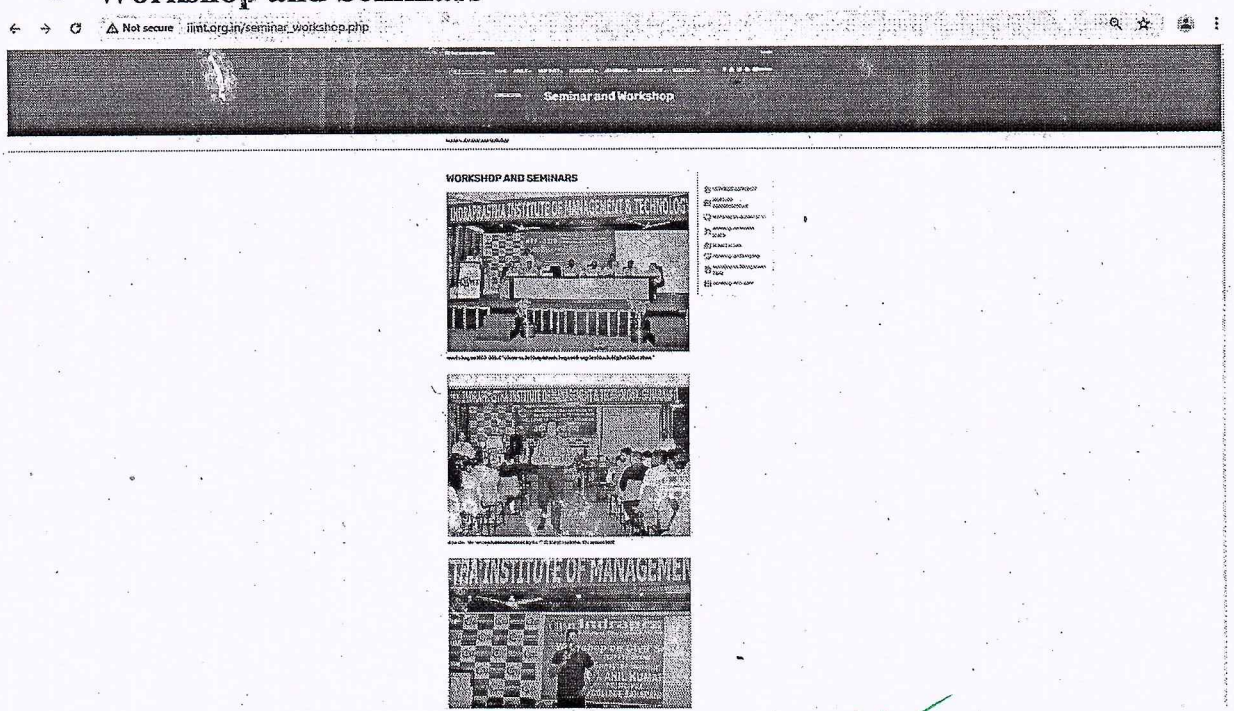
Industrial Visits- The students of IIMT frequently get an opportunity to visit various industries as the part of the industrial visit component of the programs offered. These are excellent opportunities for students to gain exposure to real life work environment and culture. IIMT maintains a close interaction with industry professionals that helps the students to have a glimpse of corporate working environment.



Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

- **Workshop and Seminars**



Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

4. Content Integration Phase

(Website Development for IIMT College, Saharanpur)
[11/12/2023 to 17/12/2023] - (1 Week)

The **Content Integration Phase** for the IIMT College Website is a critical step in the development and launch of the site. This phase involves gathering, organizing, and implementing all the necessary content elements to ensure the website is informative, engaging, and aligned with the college's goals and branding. Below is a comprehensive breakdown of the steps involved in this phase.

1. Content Inventory and Gathering

1. **Review Existing Content:** Begin by reviewing all existing content such as brochures, pamphlets, course catalogs, presentations, and any online content.
2. **Identify Gaps:** Determine any missing or incomplete content that is required for the new website. This may include additional program details, academics, Admission, Placement, research work, or student testimonials.
3. **Stakeholder Input:** Engage with key stakeholders (e.g., department heads, faculty, administration, students, alumni) to gather content relevant to their areas, such as:
    - **Course information**
    - **Academics Information**
    - **Placement Records**
    - **Seminars and Workshops**
    - **Admission Information**
4. **Multimedia Assets:** Gather images, videos, logos, graphics, and any multimedia content required for the site. Ensure these assets are of high quality and formatted correctly.

2. Content Categorization and Structuring

- **Create Content Categories:** Define the main content categories that will structure the website. Examples might include:
    - **About Us**: History, mission, values, leadership, etc.
    - **Academics**: Undergraduate and postgraduate programs, syllabus, admission process, etc.
    - **Admissions**: Application process, eligibility criteria, fees, deadlines, FAQs.
    - **Research**: Ongoing research projects, publications, conferences, etc.
    - **Placement**: Events, clubs, facilities, student organizations, etc.
    - **Contact Us**: Contact forms, location map, office details, etc.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

5.Testing Phase

(Website Development for IIMT College, Saharanpur)
[18/12/2023 to 24/12/2023] - (1 Week)

- We started the testing from December 18, 2023 of developed website outcomes for to ensure the website's functionality & performance.
- This phase was conducted in two modes; On-site testing and testing from the remote locations to identify and rectify any issues related to functionality, performance, security, and user experience before the website's launch.
- User acceptance testing was conducted in two phases to ensure that the website meets the expectations of the end users.
- We called two groups of students on December 21, 2023 and got them to survey the entire website, which revealed some flaws, which our team fixed the next day.
- On 22- December - 2023, we called a group of teachers to check the flow of the website and its functioning, after spending a lot of time they found that the website was working well.
- In a meeting with management members, financial clerks and important stakeholders on 23- December - 2023, they were agreed for implementation of the website. Then the decision was taken to deploy the website.
- Ultimately our team made preparations for deployment under the guidance of Mr. Sanjaykant. The college administration was asked to provide the required equipments and facility.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

6. Deployment Phase

(Website Development for IIMT College, Saharanpur)
[25/12/2023 to 01/01/2024] - (1 Week)

- We started deploying the website on December 26, 2023. One of our team members found a glitch in the functionality of the main page. We were resolved in the same day.
- Conducted a final round of testing on December 27, 2023 in the live environment to verify the functionality and performance.
- Implemented backup procedures to safeguard existing data and configurations on November 28, 2023.
- Developed and tested a rollback plan in case of unexpected issues during deployment on November 29, 2023.
- Executed the migration of the database on December 29, 2023 to ensure the availability of the latest data.
- Configured server settings, domain mappings, and other environment-specific configurations till December 30, 2023.
- We release the finalized website on January 01, 2024 to the live environment for public access.
- Ensured that the correct version of the application was deployed.

Upon deployment, the team actively monitored the live environment for any anomalies and verified that the website was functioning as expected:

- Performance Monitoring: Checked server performance metrics to ensure optimal response times.
- User Access Verification: Verified that users could access the website without encountering errors.

Notified to Mr. Vikas Kumar and stakeholders including project sponsors about the successful deployment and conducted a handover session on January 05, 2024 to transfer control to the operational team and provided necessary training for maintenance tasks.

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Approved by UGC, NCTE and Affiliated to MS University, Saharanpur
Muzaffarnagar - 251001 (U.P.)

Date 13-07-2023

To

The Manager
Agarwal Duplex Board Mills Ltd., Muzaffarnagar

Sub: Proposal letter for approval of research project.

Sir,

I, Dr Vipin Kumar Saini, am working as Associate Professor in Department of Bioscience, Shri Ram College. I am planning to start a research project on **Effect of paper mill effluent from Muzaffarnagar on Rice crop growth and productivity.** I would like to request your approval for our project proposal; our team has been hard at work envisioning the ideal to study the effect of treated paper mill effluent on rice crop and their positive & negative effects on growth and productivity.

Here is a brief summary of our proposal including the scope, budget and objective. Here are a few aspect of the proposal we are most excited about accomplishing. We hope these highlight accurately demonstrate the goal and vision of our project to you. Please let us know if there is any other information you need regarding our proposal to help you make your decision.

With Regards

Dr. Vipin Kumar Saini

Associate Professor
Department of Bioscience
Shri Ram College, Muzaffarnagar

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Contact @ 9927028908, 99270114
Website : www.srgcmzn.com E-Mail : src_mzn@rediffmail.c

Proposed Project Report

On

Effect of paper mill effluent from Muzaffarnager on Rice crop growth and productivity

Submitted by

Dr. Vipin Kumar Saini

Associate professor, Department of Bioscience, Shri Ram College, Muzaffarnagar

Submitted to

Agarwal Duplex Board Mills Ltd., Muzaffarnagar

2023-2024

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Expected Duration of Project: 10 Months

Proposed Amount for Project: Amount – 150,000/-

Supervisor: Dr. Vipin Kumar Saini , Faculty of Bioscience, Shri Ram College, Muzaffarnagar

Man Power Require: One

Problem: The two most important environmental concerns related to the pulp and paper industries are the high consumption of fresh water and the generation of a huge volume of toxic wastewater. Hence, it is necessary to study the impact of these effluents on soil and crop before they recommended for agricultural purpose. This effluent is rich in dissolved solids as well as varying amounts of suspended organic materials. In addition to these constituents, effluents also contain some trace metals like Hg, Pb, and Cr. Most of the Indian paper and pulp mills discharge their effluents, which contain bleach and black liquor, directly into the receiving water bodies, thus causing serious environmental concerns. The paper mill effluent contains high concentrations of recalcitrant dissolved organic matter and when aquatic systems are overloaded, it can induce a high biochemical oxygen demand. On the other hand, treated paper mill effluent or wastewater is considered a resource that can be applied for productive uses since it contains nutrients that have the potential for use in agriculture and other activities. So we can use this wastewater efficiently for agricultural crops as a source of fertilizer as well as irrigation water.

Objective

1) **Collection of effluent samples from Paper Mill.**
2) **Physico-chemical analysis of water sample collected from Paper Mill.**
3) **Isolation, Screening and Identification of fungal strain**
4) **Effect of treated effluent on Rice crop productivity and germination rate.**

Expected Outcome: Pulp and paper mill wastewater will be treated by effective microorganism to reduce lignin contents, BOD, and COD. After bioremediation effluent will exhibits minimal phytotoxicity and will be appropriate for plant growth.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

TIN 09372800375

AGARWAL

DUPLEX BOARD MILLS (P) LTD.

Office & Works : 4TH KM. STONE, BHOPA ROAD, MUZAFFARNAGAR-251001(U.P.)
✆ 0131-2614623, 2614200, 2614134, 2411509 FAX . 2614881

Ref. No. .....

Dr. Vipin Kumar Saini

Associate Professor
Department of Bioscience
Shri Ram College, Muzaffarnagar

Sir,

With reference to your letter dated 13-07-2023 regarding approval of proposal of research project. We are glad to offer our association with you for this Industry sponsored project. Our Industry is ready to release a grant as per mention in proposal letter by you.

Please send your acceptance if you are ready to handle this project on the following terms and conditions.

1) The company is ready to pay Rs. 150000/- as the cost of the project.
2) The company will not bear TA and other cost including stay arrangements.
3) Cost of project will be paid in advanced at the beginning of the task.
4) After completion of the project, it will be necessary to submit the final report.
5) A Certificate of completion will be issued after satisfactory completion of the project.

Hope you find the document in order. Please send a signed copy of the letter as your acceptance as soon as possible, so that we send the other required documents and the payment of **Rs. 150000/-**

Thanks and regards

Date: 28-07-2023

For Agarwal Duplex Board Mills Ltd., Muzaffarnagar

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Correspondence Address : 122, SOUTH BHOPA ROAD, NEW MANDI, MUZAFFARNAGAR - 251001 (U.P.)
Regd. Office : 301-AGARWAL CITY MALL, OPP. M-2-K CINEMA, PITAMPURA, NEW DELHI-110034

Utilization Certificate

S.N.	Detail of sanction of Fund with Project name and Duration	Amount
1.	10 months project on Effect of Paper Mill effluent from Muzaffarnagar on Rice crop growth and productivity Date of Sanction of Fund- 29-05-2023 as per Sanction Letter	**150000.00 /-**
	TOTAL	**150000.00/-**

It is Certified that out of Rs. 150000.00/- (One Lacs fifty Thousands only) of grants sanctioned by **Agarwal Duplex Board Mills Ltd, Muzaffarnagar** during the year 2023-2024 in favor of **Shri Ram College, Muzaffarnagar,** a sum of Rs. 150000.00 has been utilized for the purpose of the project for which it was sanctioned and that the balance of Rs. **Nil** remaining unutilized at the end of the year has been surrendered. The Extra amount (If any) is met out by Shri Ram College.

2. Certified that we have satisfied our self that the conditions on which the grant was sanctioned have been duly fulfilled/are being fulfilled and that we have exercised the following checks to see that the money was actually utilized for the purpose for which it was sanctioned.

Kinds of checks exercise-

1. Checking of cash book
2. Checking of payment vouchers.
3. Checking of salary register.
4. Checking of expense bill.

For Shri Ram College

Secretary
Date: 04-06-2024
Place: Muzaffarnagar

For Goel Rakesh & Co.
Chartered Accountants

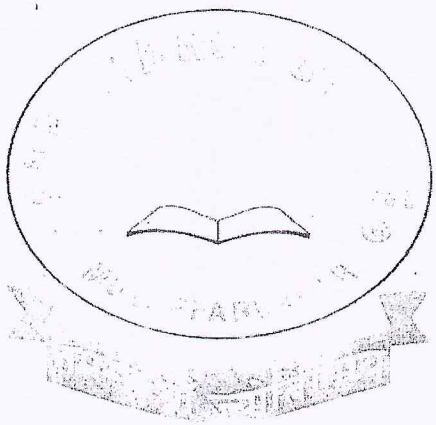
Rakesh Kumar Goel
Proprietor

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Project Report

On



Effect of paper mill effluent from Muzaffarnager on Rice crop growth and productivity

Submitted by

Dr. Vipin Kumar Saini

Associate professor, Department of Bioscience, Shri Ram College, Muzaffarnagar

Submitted to

Agarwal Duplex Board Mills Ltd., Muzaffarnagar

2023-2024

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Duration of Project: 10 Months

Amount for Project: Amount – 150,000/-

Supervisor: Dr. Vipin Kumar Saini , Faculty of Bioscience, Shri Ram College, Muzaffarnagar

Man Power Require: One

ABSTRACT

Field experiments were conducted in the premises of Shri Ram College, Muzaffarnagar during 2023 and 2024 to study the effect of paper mill effluent (PME) on soil properties, growth and yield of rice with ten treatments replicated thrice using RCBD design. Secondary treated paper mill effluent was acidic (6.26 ± 0.2) in nature, medium in electrical conductivity (1.81 ± 0.1 dS m-1), BOD load (35.2 ± 2 mg l-1) was optimum and COD load was higher (287 ± 4.2 mg l-1) but low in plant nutrients. In rice-rice cropping system treatment which received irrigation with fresh water + 150 % RDN recorded significantly higher grain (5.14 t ha-1) and straw yield (6.34 t ha-1) compared to other treatments. Significantly lower grain (4.06 t ha-1) and straw yield (5.14 t ha-1) was recorded in treatment receiving paper mill effluent + RDF.

INTRODUCTION

Paper is an essential part of human life since it was created in ancient Egypt during 3700-3200 BC. Modern paper making techniques were subsequently developed in China during 105 AD, but the most substantial production innovation came in 1282 with the introduction of the paper mill. The invention of the printing press during 1440 created the means to print books, but mass production of paper was not possible until the industrial revolution. The processes and materials for making paper evolved in various societies over the centuries, in turn increasing the demand for paper-based products and establishing the paper and pulp industry much as we know it today (Hunter, 1970). The evolution of paper making and creation of paper products occurred over centuries, not overnight. However, in the past two centuries, the advances in paper making technologies, increase in global commerce and affordability for paper products have led to alarming increases in paper consumption. Such increase in paper manufacturing to meet the demand of the society has also caused significant environmental damage. Paper industry is one of the largest water consuming and effluent generating industries in the world. There are about 600 paper mills in India with an annual installed capacity of 8.5 million tonnes of paper. The average quantity of water consumed for each tonne of paper produced is about 300 m3(Hazarika et al., 2007). The global population uses approximately more than 300 million tonnes of paper and its products per annum and the estimates show that this number is likely to increase gradually in the coming years (Garg and Modi, 1999). India ranks 20th among the paper producing countries of the world. Paper consumption is linked to the economic development of a country. India has 17% of the world's population, but it consumes just 3% of paper globally. The per capita consumption of paper in India is still abysmally low, at around 10 kg, which is well below the global average of 55 kg. However,

Coordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

with increasing demands, the projected trends indicate that India will need about 8.5 million tonnes of paper, board and newsprint annually by 2010 and 10 million tonnes per year by 2015 (Jain and Goyal, 2001). Paper industry in India can be categorized into three basic types based on the nature of raw materials used. Forest-based paper industry use forest products like soft woods or hard woods for paper production. Agro-based paper mills utilize agricultural residues like wheat straw, rice straw, sabai grass and bagasse. Besides these two, the third type of paper mill is waste paper based type, which utilizes waste paper as its raw material. In 1992, forest based raw materials accounted for about 49% of total raw material inputs for paper, paper board and newsprint production, while the share of agricultural residues and waste paper amounted to 29% and 22%, respectively (Sharma et al., 1998). The consumption share of forest-based materials in paper, paper board and newsprint declined to 47% by the year 2000 and it continued to decrease. On the other hand the share of agricultural residues showed a steady increasing trend from 1980 onwards till date and is expected to further rise in the future (Schumacher and Sathaye, 1999). However, the share of waste paper as raw material remained at 22 per cent (Srivastava and Pandey, 1999). The major pollutants in the effluents from pulp and paper mill are color, oil and grease, detergents, resin acid, unsaturated fatty acids, chlorinated resin, detergents, alcohol, lignin degradation products and polychlorinated bi-phenyl. Discharge of these effluents into water body enhance the pH, BOD, COD, lignin, total suspended solids, colour, heavy metal ions and other toxic substances and thus change the natural quality of water (Singh et al., 2002).

Treated waste water was considered as a potential water resource because it contains considerable amount of nutrients which may prove beneficial for plant growth (Mishra and Behera, 1991) and hence the use of waste water in agriculture has gained importance rapidly. The option of land application of the waste water has been suggested as one of the methods of disposal. This will serve not only as a means of disposal but also as a method of nutrient recycling and water conservation and is becoming increasingly popular as an alternative to discharge into water bodies. This will also release clean water for use in other sectors that need fresh water and provide water to sectors that can utilize waste water for irrigation and other ecosystem services. This renewed interest in land application of waste waters is partly because of the need to conserve nutrients and water resources and partly to protect water bodies. Also land-based systems are considered to be one of the best waste water treatment processes, especially in arid and semi-arid regions. The results of the experiments showed that the main benefits from waste water irrigation are effective water and nutrient recycling, higher crop yields, a diversified cropping pattern and disposal cost savings. It is important to emphasize that waste water irrigation for the existing cropping pattern brings net positive revenue as against zero revenue in case of sea-based disposal. Although the nutrient content of wastes makes them as attractive as fertilizers for crop production. However, land application of many industrial wastes is constrained by the presence of heavy metals, hazardous organic chemicals, salts and extreme pH values. Hence, serious concern has been raised about the effects of use of wastewater for irrigation (Hussain et al., 2002). Among the cereal crops, rice which can tolerate salinity or alkalinity to a moderate level and occupy the first and second position in terms of area and production, respectively. Rice (Oryza sativa L.) is one of the diverse crops grown in different agro-eco systems. Rice cultivation is well-suited to countries and regions with low labor costs and high rainfall, as it is labor-intensive to cultivate and requires ample water. It occupies prime place among the food crops cultivated around the world and is grown in an area of 147 m ha with a production of 525 m t. About 90 per cent of rice grown in the

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

world is produced and consumed in Asian region only. Among rice growing counties, India has the largest area (41.91 m ha) with a production and productivity of 89.1 m t and 2.12 t ha-1respectively. In Karnataka, rice is grown in an area of 1.48 m ha with an annual production and productivity of 3.69 m t and 2.48 t ha-1, respectively (Anon., 2012). Literature survey indicated that diluted form of paper mill effluent could be used for irrigation purpose to enhance production of agricultural crops (Baruah and Das, 1998). The extent of dilution varies depending upon the crops and soil properties. On the other hand, after application of paper mill effluent in different concentrations, the physico-chemical properties of the soil may be changed or it may be toxic to the plants. So, before applying the effluent in the agricultural field, the physicochemical characteristics of the effluent have to be ascertained to predict its effect when used in crop production. The effluents from the paper mills also contain substantial amount of nutrients. When such waste water disposed to water body there will be increase in nutrients in the recipient water body causes increase in the growth of microbes. This also affects the flora and fauna of the water bodies and alters the biological spectrum (Virkola and Honkanen, 1985). However, use of the effluents as irrigation water provides avenue for reducing the disposal problem of effluent and enhancing the productivity of crops owing to the use of dissolved nutrients in water (Hussain et al., 2002).

Use of paper mill effluent successfully involves questions concerning safe protocol of its use for crops, impact of its use on soil properties, growth and yield of crops. Hence, this study was taken up to standardize the practices of its safe usage in agriculture. Keeping these points in view, the present investigation entitled "Effect of paper mill effluent from Muzaffarnager on Rice crop growth and productivity" was carried out in the premises of Shri Ram College, Muzaffarnagar using rice as test crop during in Kharif 2023 and summer2024 with the following objectives;

1. To characterize the paper mill effluent for physico-chemical properties.
2. To characterize the soils which have been subjected to repeated irrigation with paper mill effluent over the years.
3. To study the effect of paper mill effluent irrigation on physical, chemical and biological properties of soil.
4. To study the effect of paper mill effluent irrigation on growth, yield and nutrient uptake by rice.

MATERIAL AND METHODS

Field experiments to "Effect of paper mill effluent from Muzaffarnager on Rice crop growth and productivity" were carried out in the premises of Shri Ram College, Muzaffarnagar during Kharif 2023 and summer 2024.

Characterization of secondary treated paper mill effluent

Sample collection

To characterize the paper mill industry effluent, the effluent samples were collected at bimonthly interval from the secondary treatment outlet, from June 2023 to May 2024.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Sample was collected in a 5 liter plastic can. After collection the sample was stored under refrigerated condition until further analysis.

Sample processing and analysis

Before analysis, the effluent sample was taken out from the refrigerator and placed outside to bring it to room condition. The secondary treated sample was used for the estimation of pH, electrical conductivity, BOD, COD, total solids, total suspended solids and total dissolved solids using standard procedures (Manivasakam, 1987). For the estimation of total nitrogen, phosphorus, potassium, sodium, calcium, magnesium, chlorides, sulphates and micronutrients (Zn, Cu, Fe, Mn and B) a known volume of sample was digested and then the contents were determined by following the standard procedures (Manivasakam, 1987).

Sample digestion for nitrogen

A known volume of effluent sample was digested in a Kjeldhal digestion tube and it was added with three gram digestion mixture and 25 ml of concentrated sulphuric acid till a bluish green residue was obtained. After cooling the volume was made up to 100 ml using distilled water and a known volume of aliquot was distilled in an alkaline medium and liberated ammonia was trapped in boric acid containing mixed indicator and titrated against standard sulphuric acid solution.

Sample digestion for other elements

A known volume of effluent sample was taken in 250 ml conical flask and it was added with 15 ml HNO_3 and kept overnight for pre digestion to take place. After keeping it for overnight, the sample was added with 10 ml of diacid mixture (HNO_3:$HClO_4$ in 9:4 ratio) was added kept for digestion on sand bath and digested until the volume was reduced to 3-5 ml and as now white residue was obtained. After cooling the volume was made to 100 ml using distilled water and it was used for the estimation of all other elements.

Soil characteristics of experimental site

One composite soil sample was collected from 0-15 cm depth from the experimental plot before laying out the experiment and analyzed for physical, chemical and biological properties.

Physical properties

Particle size distribution

- Sand (%) - 63.42
- Silt (%) - 12.75
- Clay (%) - 23.10
- Texture - SCL
- Bulk density (Mg m-3) - 1.25
- Maximum water holding capacity (%) - 41.9

Chemical properties

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

- pH - 6.28
- EC (dS m-1) - 0.20
- OC - (g kg-1) 6.9
- CEC (c mol (p+) kg-1) - 26.0
- Available Nitrogen (kg ha-1) - 380.2
- Available Phosphorus (kg ha-1) - 48.1
- Available Potassium (kg ha-1) - 450.8
- Exchangeable Calcium (c mol (p+) kg-1) - 9.6
- Exchangeable Magnesium (c mol (p+) kg-1) - 4.5
- Available Sulphur (mg kg-1) - 10.8
- Exchangeable Sodium (c mol (p+) kg-1) - 0.18
- DTPA-Iron (mg kg-1) - 29.1
- DTPA-Copper (mg kg-1) - 9.6
- DTPA-Manganese (mg kg-1) - 3.6
- DTPA-Zinc (mg kg-1) - 8.8
- Boron (mg kg-1) - 0.65

Biological properties

- Urease activity (µg NH4 N g-1 soil h-1) - 40.3
- Dehydrogenase activity (µg TPF g-1 soil h-1) - 7.9

Experimental details

The experiment was conducted during Kharif 2023 and summer 2024, the experimental details are as follows;

- Crop : Rice
- Gross Plot size : 3.6 m x 3.0 m
- Spacing : 20 cm x 10 cm
- Season : Kharif-2023 and Summer-2024

Design and layout:

The experiment was laid out in Randomized Complete Block Design (RCBD). The treatments were replicated thrice. The field experiments were carried out continuously with rice-rice sequence without disturbing the plots for two seasons.

Crop husbandry

Land preparation

The land was ploughed with tractor drawn mould board plough followed by harrowing, leveling and then the land was inundated with 10 cm water and puddled using puddler. After puddling the layout was made according to the experimental design and plot size.

Preparation of nursery and raising of seedlings

Raised dry nursery beds were prepared and soaked seeds were broadcasted on the beds and covered with thin film of soil + FYM mixture. Water was sprinkled with help of rose-can. After 10 days of sowing, 150 g of urea, 50 g SSP and 50 g MOP were applied by broadcasting and 25 days old seedlings were transplanted in the all experimental plots.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Irrigation schedule

After transplanting, 2 cm of standing water was maintained during first ten days and then gradually it was increased to 5 cm and maintained throughout crop growth period. Fresh water and effluent water were used to irrigate the plots as per the treatment details. Irrigation was with held 10 days before harvesting of crop to facilitate easy harvesting.

Harvesting and threshing

The crop was harvested after attaining the physiological maturity in different plots. Two rows on all the sides of each plot were harvested as border rows and the remaining area was treated as net plot. The crop in each net plot was harvested and threshed separately. The grains were cleaned and weight was recorded at 14 percent moisture content. The straw from the individual plot was sun dried weighed and expressed in tonnes per hectare.

Statistical analysis and interpretation of data

The analysis and interpretation of the data were done using the Fisher's method of analysis of variance technique as given by Panse and Sukhatme (1967). The level of significance used in 'F' and 't' test was 5 % probability and wherever 'F' test was found significant, the 't' test was performed to estimate critical differences among various treatments.

EXPERIMENTAL RESULTS

Soil survey and field experiments were carried out to study the effect of paper mill effluent irrigation on soil properties and growth and yield of rice in rice-rice cropping system. Besides, the characterization of the secondary treated effluent generated from Paper Mill was carried out. The results on characters of effluent, soil and plant analysis are presented.

Characterization of secondary treated paper mill effluent

Paper mill effluent (PME) discharged from secondary treatment plant was collected at bimonthly interval during 2023 and 2024. The analysis of the samples revealed that the pH value of paper mill effluent was acidic in nature which ranged from 6.0- 6.5. Electrical conductivity was in the range of 1.70 to 1.93 dS m-1. The BOD and COD values of the effluent sample varied from 32 to 38 and 280 to 293 mg l-1, respectively. The total nitrogen, phosphorus, potassium and sulphur contents were in the range of 40 to 70, 0.64 to 0.71, 41.8 to 47.0 and 20.0 to 23.3 mg l-1, respectively. The Na, Ca and Mg concentrations ranged from 142.6 to 174.8, 212 to 224 and 150.6 to 167.7 mg l-1,respectively. The dissolved solids, total suspended solids and total solids content were ranged from 1950 to 2250, 500 to 620 and 2550 to 2910 mg l-1, respectively. Among the anions, chloride content was in the range of 25.6 to 29.1 mg l-1. While, that of bicarbonate content varied from 390.4 to 439.2 mg l-1. The carbonate content in the effluent was found in traces. The SAR of the effluent sample varied from 2.10 to 2.58. Residual sodium carbonate (RSC) values were negative.

Effect of paper mill effluent irrigation on soil properties and growth and yield of rice in rice cropping system

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Plant growth parameters

The data on plant height, number of tillers per plant, dry matter production and its distribution in leaf, stem, panicle and total dry matter accumulation of rice during Kharif 2023 and summer 2024 as influenced by irrigation treatments at different growth stages are presented below.

Plant height

The data on plant height at different growth stages as influenced by effluent irrigation. At 30 DAT plant height showed significant difference with respect to paper mill effluent irrigation during Kharif 2023 and summer 2024. Significantly higher plant height was observed during 2023 and 2024 in the treatment receiving irrigation with fresh water + 150% RDN and irrigation with paper mill effluent + 150% RDN (T6: 25.7, 26.8 and T7: 24.8, 25.2cm, respectively) which were on par with each other. Further, significantly lower plant height was observed in treatment receiving irrigation with paper mill effluent + RDF during 2023 and 2024 (T2: 21.3 and 21.7 cm, respectively). Similar trend was observed at 60 DAT, 90 DAT and at harvest. At 30 days after transplanting, pooled analysis of two year experimental results revealed that significantly taller plants (26.3 cm) was noticed due to irrigation with fresh water + 150% RDN (T6) followed by irrigation with paper mill effluent + 150% RDN (T7: 25.0 cm) and were on par with each other. Whereas, the treatment receiving cycle of 1 irrigation with fresh water + 2 irrigations with paper mill effluent + 150% RDN (T10: 25.0 cm), cycle of 2 irrigations with fresh water + 1 irrigation with paper mill effluent + 150% RDN (T9: 24.5 cm) and alternate irrigation with fresh water and paper mill effluent + 150% RDN (T8: 24.0 cm) were on par with each other. However, significantly lower plant height was observed in T2 which received irrigation with paper mill effluent + RDF (21.5 cm). Similar trend was observed at 60 DAT, 90 DAT and harvest. In general plant height was higher in the summer 2024 crop compared to Kharif 2023 crop.

Number of tillers At 30 DAT, number of tillers did not show any significant difference due to treatments. Higher number of tillers was observed in all the treatments during 2024 as compared to 2023. At 60 DAT, significantly higher number of tillers was recorded in treatment T6 which received irrigation with fresh water + 150% RDN (T6: 15.0 and 17.2 during 2023 and 2024, respectively) and lower number of tillers was recorded in T2 (11.4 and 11.8 during 2013 and 2014, respectively) which received irrigation with effluent + RDF. Similar trend was observed at 90 DAT and at harvest of the crop. Pooled analysis of two years data (2013 and 2014) revealed that at 60 DAT, the treatment which received irrigation with fresh water + 150% RDN (T6) recorded significantly higher number of tillers (16.1) followed by irrigation with paper mill effluent + 150% RDN (T7: 15.2) and irrigation with fresh water + 100 % RDN (14.1) compared to number of tillers recorded with effluent irrigation + 100 % RDF (T2:11.6). The number of tillers in the treatment receiving irrigation with fresh water + RDF (T1: 14.1) was on par with the treatment receiving cycle of 1 irrigation with fresh water + 2 irrigations with paper mill effluent + 150% RDN (T10: 13.7), cycle of 2 irrigations with fresh water + 1 irrigation with paper mill effluent + 150% RDN (T9: 13.2) and alternate irrigation with fresh water and paper mill effluent + 150% RDN (T8: 12.6). Similar trend was observed at 90 DAT and at harvest.

Dry matter accumulation

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

The data on dry matter (DM) production and accumulation in different plant parts (leaf, stem and panicle) of rice at harvest are presented.

At harvest, leaf, stem, panicle weight and total dry matter production was higher in all the treatments during 2024 summer compared to 2023 Kharif crop. The treatment T6 which received irrigation with fresh water + 150% RDN recorded significantly higher leaf, stem, panicle weight and DM (16.2, 65.6, 36.6, 118.4 g and 17.5, 67.4, 37.8, 122.7 g per plant during 2023 and 2024 respectively). Further, significantly lower leaf, stem, panicle weight and DM were noticed due to irrigation with paper mill effluent + RDF (T2: 13.1, 54.8, 30.2, 98.1 g per plant and 13.3, 55.3, 30.4 and 99.0 g per plant during 2013 and 2014, respectively). At harvest, pooled analysis of two years of experiments indicated that significantly higher total dry matter accumulation (120.6 g per plant) was recorded due to irrigation with fresh water + 150% RDN (T6) and it was on par with the treatment which received irrigation with paper mill effluent + 150% RDN (T7: 115.9 g per plant) and cycle of 1 irrigation with fresh water + 2 irrigations with paper mill effluent + 150% RDN (T10: 114.6 g per plant), cycle of 2 irrigations with fresh water + 1 irrigation with paper mill effluent + 150% RDN (T9: 114.5 g per plant), alternate irrigation with fresh water and paper mill effluent + 150% RDN (T8: 111.7 g per plant) and irrigation with fresh water + RDF (T1:108.4 g per plant). However, significantly lower dry matter accumulation was recorded in the treatment that received irrigation with paper mill effluent + RDF (T2: 98.6 g per plant). Similar trend was observed in leaf, stem and panicle weight.

Yield and yield parameters

The test weight, panicle length, number of panicles, number of grains per panicle, grain yield and straw yield differed significantly due to paper mill effluent irrigation.

The yield (grain yield and straw yield) and yield parameters (test weight, panicle length, number of panicles per hill and number of grains per panicle) were higher in all the treatments during 2024 compared to 2023 Kharif crop. During 2023 and 2024, the treatment T6 receiving irrigation with fresh water + 150% RDN recorded significantly higher number of panicles, panicle length, number of grains per panicle and test weight (18.7, 26.8 cm, 170.2, 29.0 g and 21.0, 27.0 cm, 171.1, 29.9 g, respectively) followed by T7. While, significantly lower number of panicles, panicle length, number of grains per panicle and test weight were recorded in treatment receiving irrigation with paper mill effluent + RDF (T2: 12.9, 21.3 cm, 148.4, 24.4 g and 13.5, 21.0 cm, 148.8, 24.8 g, respectively). The pooled analysis of data of two years (2023 and 2024) revealed that the treatment which received irrigation with fresh water + 150% RDN (T6) recorded significantly higher number of panicles, panicle length, number of grains per panicle and test weight(19.9, 26.9 cm, 170.7 and 29.5 g, respectively) followed by irrigation with paper mill effluent + 150% RDN (T7: 18.7, 24.6 cm, 168.6 and 28.8 g, respectively) and cycle of 1 irrigation with fresh water + 2 irrigations with paper mill effluent + 150% RDN (T10: 17.9, 25.1 cm, 165.3 and 28.5 g, respectively) which were on par with each other. Significantly lower number panicles, panicle length, number of grains per panicle and test weight were recorded in treatment T2 (13.2, 21.2 cm, 148.6 and 24.6 g, respectively). Significantly higher grain and straw yield during 2023 was recorded in T6 (4.94 and 6.25 t ha-1, respectively) and lower grain and straw yield was observed in T2 (4.03 and 5.10 t ha-1, respectively). Similar trend was observed in 2024 with respect to grain and straw yield.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Pooled analysis revealed that grain and straw yield in effluent irrigated plot with 100 % RDF (T2) was 4.06 and 5.14 t ha-1, respectively which significantly increased to 5.14 and 6.34 t ha-1, respectively with fresh water + 150% RDN (T6) and 4.93 and 6.01 t ha-1, respectively with paper mill effluent + 150% RDN(T7). Grain and straw yield recorded with fresh water + RDF (T1) was 4.49 and 5.57 t ha-1, respectively which was on par with grain and straw yield obtained in all the other treatments except irrigation with fresh water + 150% RDN (T6). Similarly, the yield obtained with T6 was statistically on par with grain and straw yield obtained by T7 (4.93 and 6.01 t ha-1, respectively), T10 (4.78 and 5.92 t ha-1, respectively) and T9 (4.75 and5.77 t ha-1, respectively).

CONCLUSION

Based on the results of field trials, it can be concluded that rice crop performed well under paper mill effluent irrigation in presence of 150 % RDN. The effluent also has dissolved nutrients which make it a valuable resource and application of effluent also increases the available nutrients status in soil. Accumulation of scum on the soil surface was seen in rice-rice cropping system and in the surveyed fields due to continuous use of paper mill effluent which forms impervious layer, as well as it contributes to the deterioration of soil quality by decreasing the water movement and retention.

REFERENCES

BARUAH, B. K. AND DAS, M., 1998, Study on the effect of paper mill effluent on physiochemical characteristics of soil. J. Nat. Con., 10(1): 101-106.

GARG, S. K. AND MODI, D. R., 1999, Decolorisation of pulp-paper mill effluents by white rot fungi. Critical Reviews in Biotech., 19(2): 85-112

HAZARIKA S., TALUKADAR, N. C., BORAH, K., BARMAN, N., MEDHI, B. K., THAKURIA D. AND BAROOAH A. K., 2007, Long term effect of pulp and paper mill effluent on chemical and biological properties of a heavy textured acidic soil in Assam. J. Indian Soc. Soil Sci., 55: 45-51.

HUNTER, D., 1970, Paper making: The history and technique of an ancient craft. New York, USA: Dover Publications.

HUSSAIN RASCHID, L., HANJRA, M. A., MARIKAR, F. AND HOEK, W. V. D. 2002. "A frame work for analyzing socio-economic, health and environmental impacts of waste water use in agriculture in developing countries". Working Paper 26, Colombo, Sri Lanka: International Water Management Institute (IWMI).

JAIN, S. AND GOYAL, A., 2001, Clean development mechanism (CDM): Business.

MANIVASAKAM, N., 1987, Phisico-chemical examination of water, sewage and industrial effluent.Pragathi Prakashan, Merut.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

MISHRA, R. N. AND BEHERA, P. K., 1991, The effect of paper industry effluent on growth, pigment, carbohydrate and protein of rice seedlings. Environ. Pollu.,72: 159-168.

SCHUMACHER, K. AND SATHAYE, J., 1999, "India's Pulp and Paper Industry: Productivity and Energy Efficiency", Lawrence Berkeley National Laboratory, Berkeley, pp.1-46.

SHARMA, B. L., SINGH, S., SHARMA, S., VEDAPRAKASH AND SINGH, R. R., 2002, Integrated response of pressmud cake and urea on sugarcane in calcareous soil. Co-operative Sugar, 33: 1001-1004.

SINGH, S., SINGH, A. K., YADAV, B. P., JOSHI, H. C., SINGH, S. AND SINGH, N. P., 2002.Utilization of agro-based pulp and paper mill effluent for crop irrigation. Proceedings of International Conference and Exhibition on Asian Water Industry, Jan 30 to Feb1, 2002, New Delhi.

SRIVASTAVA, P. K. AND PANDEY, G. C., 1999, Paper mill effluent induced toxicity in Eicchornia crassipes and Spirodella polyrrhiza. J. Environ. Biol., 20(4): 317-320.

VIRKOLA, N. AND HONKANEN, K., 1985, Wastewater characteristics. Water Sci. Tech.,17:1-28.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

2023-2024

Duration of Project

10 Months (From 28-07-2023 to 30-05-2024)

Sanctioned Amount of Project

Amount – 150,000/-

Supervisor

Dr. Vipin Kumar Saini, Faculty of Bioscience, Shri Ram College, Muzaffarnagar

Student Engaged in project

One student was involved in research and data collection for the project

Expenditure

Head	Number of Unit	Amount (in Rs./-)
Manpower	01	12,000 × 10 (Months) = 120,000/-
Honorarium	Given to Project Supervisor	10,000/-
Miscellaneous		20,000/-
Total		150,000/-

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

TIN : 09372800375

AGARWAL

DUPLEX BOARD MILLS LIMITED

Office & Works : 4TH KM. STONE, BHOPA ROAD, MUZAFFARNAGAR-251001(U.P.)
T. 0131-2614623, 2614200, 2614734, 2411509 FAX : 2614881

Ref. No. .....

Date 05-06-2024

Completion Certificate

We are pleased to certify that Dr. Vipin Kumar Saini, Associate Professor , Department of Bioscience Shri Ram College, Muzaffarnagar worked for Agarwal Duplex Board Mills Ltd., Muzaffarnagar on a industry Sponsored consultancy project on **Effect of paper mill effluent from Muzaffarnagar on Rice crop growth and productivity.** He and his team have worked up to the entire satisfaction of company's Management and his findings and recommendation are found to be useful for Increasing rise crop yield and decreasing company effluent load.

We wish him all the best his future.

For Agarwal Duplex Board Mills Ltd.
Muzaffarnagar

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Correspondence Address : 122, SOUTH BHOPA ROAD, NEW MANDI, MUZAFFARNAGAR - 251001 (U.P.)
Regd. Office : 301-AGARWAL CITY MALL, OPP. M-2-K CINEMA, PITAMPURA, NEW DELHI-110034

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

PROJECT

ON

"Study on Osmo- Convective Dehydration of Papaya Slices and Evaluation Quality During Storage"

SUBMITTED BY:

Dr. Vikrant Kumar
Assistant Professor

Session – 2023-24

DEPARTMENT OF AGRICULTURE

SHRI RAM COLLEGE, MUZAFFARNAGAR

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

NAMASTE MIDWAY, MUZAFFARNAGAR
Approved by FSSAI and ISO-9001 & 14001

To
The Principal
Shri Ram College, Muzaffarnagar

Date: 25-10-2023

Respected Madam

Greetings

Namaste Midway Restaurant, where culinary excellence meets the warmth of traditional hospitality! Nestled conveniently along, Mansurpur, Muzaffarnagar, our restaurant is the perfect spot for a delightful dining experience, whether you're on a road trip, enjoying a family outing, or catching up with friends. At Namaste Midway, we pride ourselves on offering an eclectic menu that showcases a fusion of flavors from various cuisines, emphasizing fresh, locally-sourced ingredients. Our skilled chefs craft each dish with passion and creativity, ensuring that every bite is a memorable one. From savory appetizers to hearty entrees and delectable desserts, there's something to satisfy every palate. In addition to our delicious food, we aim to create a welcoming atmosphere where guests can relax and enjoy their meals. Our friendly staff is dedicated to providing exceptional service, making your visit a true dining pleasure. Whether you're here for a quick bite or a leisurely meal, Namaste Midway Restaurant is your go-to destination for quality food and a delightful dining experience. Therefore, we want to create a positive impact in the market by preparing new dishes according to the customers' wishes. And we want to introduce a new dish in our restaurant by conducting research through Shri Ram College, Muzaffarnagar. In this context, the Namaste Midway Restaurant Muzaffarnagar wants to conduct research through Shri Ram College which can show the direct impact of new dish on customers. Namaste Midway Restaurant requests to Shri Ram College to take a step forward in fulfilling its social responsibilities by helping in this work. The Namaste Midway Restaurant will always be ready to bear all the expenses incurred in this research.

Awaiting your reply on the above.

(Sarthak Tomar)
Secretary,
Namaste Midway Restaurant,
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

NH 58, Delhi-Haridwar Highway, near 104 Km Mile Stone, Mansurpur, Uttar Pradesh 251203
Contact Number: 099171 86060, Gmail: namastemidwaysf@gmail.com

Shri Ram College

Approved by UGC, NCTE and Affiliated to MS University, Saharanpur
Muzaffarnagar - 251001, NCR (U.P.)

A++ Grade Accredited by NAAC

Date:15-09-2023

To

The Secretary

Namaste Midway, Muzaffarnagar

Respected Sir

With reference to your letter, it gives me immense pleasure to informed you that Shri Ram College will be grateful to participate in Innovative contribution with Namaste Midway through the conduct of this research. We nominate **Dr Vikrant Kumar**, Assistant Professor in the Department of Agriculture, as the Principal Investigator for the research.

Dr. Vikrant Kumar is a distinguished academician with extensive experience in teaching and research. His expertise in "Food Processing and significantly worker for this project. Dr Vikrant Kumar has consistently demonstrated his ability to lead and deliver high-quality research outcomes. As the Principal Investigator, he will be responsible for overseeing the project, ensuring adherence to the proposed timeline and objectives, and contributing to the advancement of knowledge in the field. You are also requested to discuss regarding project expenses duration and total expected budget with him.

I am confident that Dr Vikrant Kumar is expertise and commitment will make this project a success and bring significant recognition to our institution.

We extend our best wishes to him for the successful execution of this research endeavour.

Regards,

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

(Dr Prerna Mittal)
Principal, SRC
Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Contact @ 9927028908, 9927011422
Website : www.srgcmzn.com E-Mail : src_mzn@rediffmail.com

NAMASTE MIDWAY, MUZAFFARNAGAR

Approved by FSSAI and ISO-9001 & 14001

Date:02-10-2023

To
The Principal
Shri Ram College, Muzaffarnagar
Subject: Sponsorship for Research Project and Requirement for Fund Utilization Report

Honorable Madam

The **Namaste Midway, Mansurpur, Muzaffarnagar**, is pleased to sponsor funds amounting to **50,000/-** for the research project titled **"Study on Osmo –Convective Dehydration of Papaya Slices and Evaluation Quality During Storage"**undertaken by your esteemed college. This initiative aligns with our vision of fostering innovation and contributing to the advancement of knowledge in areas critical to industrial and societal development.

We request that these funds be utilized strictly for the purpose outlined in the approved project proposal, including but not limited to (mention broad categories such as research materials, assessment & analysis, and reporting).

To ensure transparency and proper accountability, we kindly ask you to provide a detailed utilization report upon the project's completion. This report should include:

1. A summary of activities and outcomes achieved.
2. A financial statement detailing the allocation and expenditure of funds.
3. Copies of invoices, receipts, and any supporting documentation.

We value this collaboration and trust that the institution will make the most effective use of this sponsorship to achieve the desired outcomes. Should you require any additional assistance or clarification, please do not hesitate to reach out to us.

We look forward to receiving the utilization report and wish your institution great success in this research endeavour.

Yours sincerely,

(Sarthak Tomar)
Secretary,
Namaste Midway,
Mansurpur, Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

NH 58, Delhi-Haridwar Highway, near 104 Km Mile Stone, Mansurpur, Uttar Pradesh 251203
Contact Number: 099171 86060, Gmail: namastemidwaysf@gmail.com

Project Fund and Completion Detail

Date: 31-03-2024

1. Title of Project: **"Study on Osmo –Convective Dehydration of Papaya Slices and Evaluation Quality During Storage"**
2. Principal Investigator and Co-Investigator: **Dr Vikrant Kumar, Shri Ram College, Muzaffarnagar.**
3. Implementing College and Sponsored Body: **Department of Agriculture, Shri Ram College & Namaste Midway, Mansurpur, Muzaffarnagar**
4. Sanctioned Project Amount by **Namaste Midway, Mansurpur, Muzaffarnagar: Rs. 150,000/-**
5. Project Duration: **October 2023 to March 2024**
6. Project Completion Date: **March 31th, 2024**

Statement of Expenditure

Amount Received	**Rs. 50,000/-**
Expenditure:	
Non Consumable Materials	**30,000/-**
Consumable Materials	**3,000/-**
Printing & Stationary	**10,000/-**
Travels	**7,000/-**
Grand Total	**50,000/-**

(Dr. Vikrant Kumar)
Research Project Coordinator

(DrPrerna Mittal)
Principal Shri Ram College

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Utilization Certificate

S.N.	Detail of sanction of Fund with Project name and Duration	Amount
1.	6 months project on Study of Osmo-Convective dehydration of papaya slices and evaluation quality during storage Date of Sanction of Fund- 02-10-2023 as per Sanction Letter	50000.00 /-
	TOTAL	50000.00/-

It is Certified that out of Rs. 50000.00/- (fifty Thousands only) of grants sanctioned by **Nameste Midway** during the year 2023-2024 in favor of **Shri Ram College, Muzaffarnagar,** a sum of Rs. 50000.00 has been utilized for the purpose of the project for which it was sanctioned and that the balance of Rs. **Nil** remaining unutilized at the end of the year has been surrendered. The Extra amount (If any) is met out by Shri Ram College.

2. Certified that we have satisfied our self that the conditions on 'which the grant was sanctioned have been duly fulfilled/are being fulfilled and that we have exercised the following checks to see that the money was actually utilized for the purpose for which it was sanctioned.

Kinds of checks exercise-

1 Checking of cash book
2 Checking of payment vouchers.
3 Checking of salary register.
4 Checking of expense bill.

For Shri Ram College

Secretary
Date: 10-04-2024
Place: Muzaffarnagar

For Goel Rakesh & Co.
Chartered Accountants

Rakesh Kumar Goel
Proprietor

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Chapter-1

INTRODUCTION

Papaya (***Carica papaya*** **L.)** is an important fruit crop grown widely in tropical and subtropical low land regions. Papaya is a powerhouse of nutrients and is available throughout the year. The fruit is nutritive, rich in **vitamins A** and **C** and presents good organoleptic characteristics. Papaya is emerging as a popular fresh fruit which offers health benefiting properties. By the mid-19 century, papaya had spread over the tropical region, from India, Sri Lanka, Malaysia, Indonesia, to Africa **(Morton and MacLeod, 1990).**

Total annual world production is estimated at 6 million tones of fruits. India leads the world in papaya production with an annual output of about 3 million tones. Alone in Andhra Pradesh the total area under cultivation is 11.2 thousand hectare and productivity is 100 MT/hectare. Despite large acreage of land devoted to papaya the fruit loss is reported to be between 40-100 per cent of total annual produce. (***Source: Database of National Horticulture Board, Ministry of Agriculture, Govt. of India***), **(Singh *et al.*, 2015)**

As with many agricultural commodities, the high moisture content of papayas renders them highly perishable and, due to various microbial, enzymatic and chemical reactions, they start to deteriorate immediately upon harvesting. Therefore, it becomes imperative to determine effective preservation methods that maintain the quality of the fruit. This is frequently accomplished through various forms of drying such as heat processing and dehydration. Water removal is the main task while preserving food **(Lenart, 1996)** reducing the moisture contents to a level, which allows safe storage over an extended period of time. Dried foods also present low storage and transportation cost when compared to the fresh ones **(Okos *et al.*, 1992).**

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

The drying of fruits permits longer storage periods, reduces shipping weights, and minimizes their packaging requirements. Quince fruits are usually processed into preserves, compotes, jellies, jams, juices and brandies. Quince fruits contain phenolic compounds, which contribute to sensory properties such as bitterness and astringency. **(Yeomans and Yang 2014).**

Osmotic dehydration of fresh produce can also be used as a pre-treatment to additional supplementary drying processing to improve sensory, functional and even nutritional properties. Fresh cut tropical fruits, including papaya, were found to be of unacceptable quality after only 2 days of storage at 4°C, primarily owing to tissue softening. Ripening is an important process directly related to papaya quality. This may be due to a wound-induced increase in the activity of enzymes targeting cell walls and membranes contributing to the rapid deterioration of fresh-cut papaya (as compared with intact fruits stored under the same conditions). The rate of softening after processing depends on many factors related to the product and to the processing and storage conditions. Pretreatment with osmotic solution having concentration lower than the natural cell concentration can improve the rehydration characteristics **(Chandra and Kumari, 2015).**

The use of fresh-cut papaya in food service institutions is very limited owing to the many technical problems involved in maintaining its quality and microbiological safety during storage. A recent study by **(Rivera-Lopez *et al.*, 2005)** determined the effects of cutting shape (cubes or slices) and storage temperature (5, 10 or 20°C) on the overall quality of fresh cut papaya. Parameters such as CO_2 production, color, firmness, total soluble solids, weight loss, sensory quality, ascorbic acid content, β-carotene and antioxidant capacity were evaluated during storage **(Arganosa *et al.*, 2008).**

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Water removal from fruit and vegetables by drying is one of the oldest forms of food preservation known to man and is the most important process to preserve food. Water, being one of the main food components, has a decisive direct influence on the quality and durability of foodstuffs through its effect on many physico-chemical and biological changes. The use of the osmotic dehydration process in the food industry has several advantages: quality improvement in terms of color, flavor and texture, energy efficiency, packaging and distribution cost reduction, no chemical pretreatment, providing required product. **(El-Aour *et al.*, 2006).**

Osmotic dehydration (OD) is one of most important complementary treatment and food preservation technique in the processing of dehydrated foods, since it presents some benefits such as reducing the damage of heat to the flavor, color, inhibiting the browning of enzymes and decrease the energy costs **(Alakali *et al.*, 2006; Torres *et al.*, 2006).** Osmotic dehydration results in increased shelf-life, little bit loss of aroma in dried and semidried food stuffs, lessening the load of freezing and to freeze the food without causing unnecessary changes in texture **(Petrotos and Lazarides, 2001).** It has been reported that osmotic dehydration reduced up to 50% weight of fresh vegetables and fruits **(Rastogi and Raghavararo, 1997).**

Osmotic dehydration involves the immersion of foods (fish, vegetables, fruits and meat) in osmotic solution such as salts, alcohols, starch solutions and concentrated sugars, which some extent to dehydrates the food **(Erle and Schubert, 2001).** Different types of solutes such as fructose, corn syrup, glucose, sodium chloride and sucrose are used as osmotic agent for OD **(Azuara and Beristain, 2002).** Low molar mass saccharides (sucrose, glucose

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

and fructose) make easy the sugar uptake due to high diffusion of molecules **(M.R. Khan 2012).**

The different types of osmotic agents such as glucose, sorbitol, sucrose and salts are used according to the final products **(Singh *et al.*, 2008).** However combination of different solutes can be used **(Taiwo *et al.*, 2003).** Water loss from vegetables and fruits took place in first two hours and maximum sugar gain within 30 minutes. Osmotic dehydration is used with other drying methods such as freezing and deep fat frying to make available better quality final product. **(Torreggiani and Bertolo, 2001a; Behsnilian and Speiss, 2006).**

Drying is a technique of conservation that consists of the elimination of large amount of water present in a food by the application of heat under controlled conditions, with the objective to diminish the chemical, enzymatic and microbiological activities that are responsible for the deterioration of foods **(Barnabas *et al.*, 2010).** To carry out osmotic dehydration, fruit pieces were immersed in a concentrated solution containing one or more solutes **(Yousefi *et al.*, 2013)** In the osmotic dehydration, because of high concentration in solutes promoting two simultaneous flows in counter current, a water outflow from the food, and an inflow of solutes from the solution to the food, due to the establishment of gradients of chemical potential of water and solutes **(Petchi and Manivasagan, 2009).** In the process, more water than solute is usually transfers due to the deferential permeability of cellular membranes **(Mauro and Menegalli, 2005).**

Papaya puree is the major semi-processed product that is used in juices, nectars, fruits cocktails, jams, jellies and fruit leather **(Salunkhe and Kadam, 1995).** Commercially, papaya puree is produced by pushing the whole fruit into a pulpier fitted with a 0.033 inch screen. The puree is not heated to inactive the enzymes and even contain pulverized peel and & seeds. The

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

next step is subjected to subsequent thawing and freezing to dispatch and preserved the puree. As mentioned above, squeezing of the whole fruit into the pulpier will because the cellular disruption that allows enzymes and substrates to be able to interact, resulting in a similar sweet flowery due to the release of a large amount of linalool, benzaldehyde and other trace compounds **(Wijaya and Chen 2013).**

Hot air drying often degrades the product quality, provides low energy efficiency and lengthy drying time during the falling rate period. It has been reported that hot-air drying of food materials, involving their prolonged exposure to elevated drying temperatures, results in substantial deterioration of such quality attributes as color, nutrient concentration, flavor and texture. The desire to eliminate this problem, prevent significant quality loss and achieve fast and effective thermal processing, has resulted in the increasing use of microwaves for food drying. Microwave drying has offered an alternative way to improve the quality of dehydrated products. It is rapid, more uniform and energy efficient. Microwave drying is of increased interest among food researchers because of the energy saving possibilities it might represent. **(Zaki *et al.*,2007).**

Major advantages of microwave drying of foods are higher drying rate, energy saving and uniform temperature distribution giving a better product quality. The microwave energy can penetrate directly into the material, releases volumetric heating out of the material and provides fast and uniform heating throughout the entire product. This helps to shorten the dehydration time and control undesirable biological transformations. The quick energy absorption by water molecules causes rapid evaporation of water, resulting in higher drying rate of the food and creating an outward flux of rapidly escaping vapor. Because the removal of moisture is accelerated, the heat transfer to the solid is slowed down significantly due to the

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

absence of convection. The increase in drying rate and decrease of heat transfer provide energy saving of microwave drying. However, microwave drying is known to result in a poor quality product when applied improperly. Fruit dehydration by immersion in osmotic solutions has been of rising interest during the last decades since it can improve food quality when combined with other type of dehydration method **(Mauro and Menegalli, 2005).**

Microwave-vacuum drying has been studied as an alternative method of drying to obtain high quality products including fruits, vegetables and grains. Microwave-vacuum drying combines the advantages of both microwave heating and vacuum drying. In vacuum drying, removal of moisture from food products takes place under low pressure. The low pressure allows reduction of drying temperature and furthermore provides high quality products. Color is one of the most important properties of food products. The first quality assessment of a product is based on its color, it is the first thing a consumer notices and it can determine the acceptability of a product. Exposing fruits to high temperatures during drying may have detrimental effects on their quality **(Radejcin *et al.*, 2015).**

Vacuum expands the air and water vapor present in the food products and creates a frothy or puffed structure. The low temperature and rapid mass transfer conferred by vacuum incorporated with quick energy transfer by microwave heating generate very rapid but low temperature drying. Thus microwave-vacuum drying has the potential to improve energy efficiency and product quality. Despite those investigations, there is scanty information available on the drying characteristics of papaya undergoing microwave-vacuum drying technique. Therefore, the aim of this project is to study the effect of microwave power intensities on drying characteristic of *Carica papaya* L. Structural changes noticed in the

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

product texture, are frequently observed as a result of the osmotic process (**Sormani *et al.*, 1999; Pereira *et al.*, 2007**).

Dehydration method and various processing parameters have huge effects on the quality of dried fruits and thus selection of proper drying techniques and conditions is necessary to optimize the drying performance and retain the quality of the dehydrated products. Hot air drying often degrades the product quality, provides low energy efficiency and lengthy drying time during the falling rate period. It has been reported that hot-air drying of food materials, involving their prolonged exposure to elevated drying temperatures, results in substantial deterioration of such quality attributes as color, nutrient concentration, flavor and texture. The desire to eliminate this problem, prevent significant quality loss and achieve fast and effective thermal processing, has resulted in the increasing use of microwaves for food drying. Microwave drying has offered an alternative way to improve the quality of the dehydrated products. It is rapid, more uniform and energy efficient. Microwave drying is of increased interest among food researchers because of the energy saving possibilities it might represent. **(Nurul *et al.*, 2007).**

Loss of cell turgidity, deformation and/or cell wall rupture, splitting and degradation of the middle lamella, lysis of membrane, cellular collapse, plasmolysis and tissue shrinkage are indicated as the main effects of osmotic dehydration on the cellular structure of plant tissues (**Lewicki and Porzecka-Pawlak, 2005**). Moreover osmotic dehydration methods also affected the properties of the final product. Two osmotic dehydration methods including fast osmotic dehydration (FOD) and slow osmotic dehydration (SOD) commonly use to produce osmo-dried fruit. However, scientific data has rarely been reported on the physical, chemical and sensory of osmo dried cantaloupe affected by osmotic dehydration methods.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

TABLE 1.1: Chemical composition of papaya, row nutritional value per 100 g.

Energy	163 KJ
Sodium	3 mg
Potassium	257
Phosphorus	5
Magnesium	10
Iron	0.10
Calcium	24
Vitamin A	61.8
Vitamin C	68
Vitamin B_6	0338
Thiamin (vitamin B_1)	328
Protein	0.61
Fat	0.14
Sugars	5.9

(Source: Aravind *et al.* 2013)

Thus, the pretreatment step by using calcium salt was studied to preserve the structure of fruit prior to osmotic dehydration. The influence of various process variables such as the concentration of osmotic agents, process temperature, osmotic dehydration time, the ratio of food to osmotic solution, geometry of food and agitation speed on the mass transfer during osmotic dehydration and properties of the final products have been extensively studied (**El-Aouar *et al.*, 2006; Ispir and Togrul, 2009; Mundada *et al.*, 2011; Naknean, 2012**).

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

OBJECTIVES:

The present investigation is an alternate to make an acceptable quality of osmo convective dehydration papaya slices during storage period using the following objectives.

1. To study the effect of pre treatments on osmotic dehydration of papaya slices.
2. To study the effect of drying methods on the osmo-dehydrated papaya slices.
3. To study the nutritional quality and sensory attributes during the storage periods.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Chapter-2

REVIEW LITERATURE

A review of literature on important aspects pertaining to study entitled "**To Study on Osmo-Convective Dehydration of Papaya (*Carica Papaya* L.) Slices and Evaluation of Quality During Storage**" is very vital from factors that effect on mass transfer during osmotic dehydration such as types of osmotic agent, processing temperatures, concentrations of osmotic agent, agitation or stirring process and edible coating were reviewed. Efforts have been made to incorporate the information as far as possible.

2.1 Osmotic dehydration

Osmotic dehydration is a useful technique for the concentration of fruit and vegetables, realized by placing the solid food, whole or in pieces, in sugars solution of high osmotic pressure. It gives rise to at least two major simultaneous countercurrent flows: a significant water flow out of the food into the solution and a transfer of solute from the solution into the food. Use of osmotic dehydration practically eliminates the need to use preservatives such as sulfur dioxide in fruits. Many workers have studied different aspects of osmotic dehydration like the solute to be employed, the influence of process variables on drying behavior and the quality of the final products. The quantity and rate of water removal depend on several variables and processing parameters. In general it has been shown that the concentration of solution, immersion time, temperature, solution to sample ratio, specific surface area of the food, and by using vacuum, stirring and continuous re-concentration are few variables affecting the osmotic dehydration process.

Silvana *et al.*, (2016) were used to evaluate chemical effects on shelf life, quality and sensory acceptability of fresh-cut papaya (Carica papaya L.). Papaya slices were packed and

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

covered with polypropylene film, stored at 5°C and evaluated after 1, 3, 6, 9, 12, and 15 days for microbiological and physicochemical changes. A sensory evaluation was performed at 1, 3, 6, 9, and 12 days. The combination treatment decreased the CO_2 concentration and increased the maintenance of papaya firmness. All the treatments had acceptability. The combination treatment was the most effective treatment for flavor, taste, and preservation until day 12.

Yousefi and Ghasemian (2016) were developed in order to predict the moisture content of papaya slices during hot air drying in a cabinet dryer. For this purpose, parameters including drying time, slices thickness and drying temperature were considered as the inputs and the amount of moisture ratio (MR) was estimated as the output.

Radjcin *et al.*, (2015) experimented that osmotic drying of quinces was conducted using parameters applicable in the production process and therefore the study has practical significance. Higher concentration of saccharose supported its retention on the surface of samples, thus preventing fruit tissue darkening during convective drying. The applied processes of sulfurization and osmotic drying had a positive effect on preservation of the colour of the dried quince.

Singh *et al.*, (2015) was carried out with treatment of papaya slices with sucrose solution as osmotic agent at 50,55,60□brix at 50□C temperature with immersion timing 30min followed by further dehydration in dryer at 70□C temp. The result obtained showed that a product osmo- treated at 60□brix at 50□C temp shows the better rehydration property along with better nutrient retention, texture, color, taste and overall acceptability.

Milivoj *et al.*, (2015) reported that study was to examine the effects of osmotic pretreatment on some physical properties of quinces. Osmotic drying was performed in a

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

saccharose and water solution. The temperatures of osmotic solution were 40°C and 60°C, and the initial concentrations were 50°Brix and 65°Brix. All four combinations were used in the experiment. High values of the total color change were recorded following the treatment of quince samples with the osmotic solution of 65°Brix. Lower values of the total color change were recorded in the same samples after convective drying. Slighter changes in color after convective drying were caused by a greater amount of solute retained on the surface of the fruit, forming barriers between the fruit tissue and the surrounding air. Mechanical properties of quinces during osmotic drying expressed by the force ratio $f = (F_0 - F_i)/F_0$ and modulus of elasticity showed dependence on the temperature of the osmotic solution. At 60°C, the osmotic solution caused softening of the quince tissue. Thermal softening had a positive influence on the naturally hard quince tissue. The results of the study demonstrate positive effects of osmotic drying on physical properties and quality of dried quinces.

Ruskova *et al.*, (2015) found that osmotic treatment temperature, solution concentration, and ratio product/solution on weight reduction of black currants were studied. Response surface methodology with combinations of osmotic treatment temperature (43, 50, 60, 70, and 77°C), solution concentration (47, 50, 55, 60, 63°Brix), and blackcurrants: solution ratio (1:2, 1:3, 1:4, 1:5, 1:6) was applied. The weight reduction values varied from 17 to 62%. The linear effect due to the osmotic treatment temperature had the highest impact on weight reduction.

Deepika and Gayathri (2015) revealed that the osmotic dehydration process was optimized for water loss, solid gain, and weight reduction. The optimum conditions were found to be in temperature = 44.61°C, immersion time =30min, salt concentration =5%. At

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

this optimum point, water loss, solid gain and weight reduction were found to be (27.99g/100g initial sample), (1.08g/100g initial sample) and 26.45 g/100g initial sample, respectively.

Swati and Bhosale (2015) carried out to standardize the pretreatment of pomegranate arils and study drying characteristics during convective drying. The effect of process parameters during osmotic dehydration such as duration of osmosis, concentration and temperature of syrup on mass reduction, water loss and sugar gain were studied. It was found that the mass reduction, water loss and sugar gain increased with increase of syrup concentration and temperature. The water loss, mass reduction and sugar gain during osmosis.

Josephine *et al.*, (2014) incorporated the osmotic dehydration has diverse application in fruits, vegetables and food processing industry. It is the process of partial removal of water from the sample by immersing it in the osmotic solution. This preservation technique removes water in the form of liquid which does not involve latent heat of vaporization. This is one of the major attractions of osmotic dehydration to be used as the upstream partial dehydration technique. When compared to drying, osmotic dehydration combined with other drying techniques produces more desirable product qualities in terms of less enzymatic browning, retaining texture, color and flavor. Sensory characters are closer towards the natural product. The main problem with osmotic dehydration is, it is a slow and time consuming process, especially when it is used as infusion technique than as partial dehydration technique. Osmotic dehydration is focused on water removal where as infusion is focused on solid gain from osmoactive solution.

Najafi *et al.*, (2014) investigated research on osmotic dehydration of red pitaya (*Hylocereus polyrhizusis*) cubes using sucrose solution at mild temperature (35°C) was investigated. Sucrose solution (40, 50 and 60% w/w) was employed for osmotic dehydration

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

process. Responses of weight reduction (WR), solid gain (SG), water loss (WL), color (L*, a* and b*) and texture (hardness) were evaluated. It was found that sucrose concentration significantly ($p < 0.05$) affected the mass transfer terms during osmosis process. Osmotically dehydrated samples were considerably softer than untreated samples. Increasing of sucrose concentration and dehydration time caused softer tissue of dehydrated product compared with the fresh red pitaya.

Selva *et al.*, (2014) presented the study of osmotic dehydration (OD) is one of the most promising pre-treatment techniques. It gives product of high quality and preserves reasonably good quantity of naturally occurring microelements and vitamins in fruits and vegetables. It also provides good returns in terms of less energy consumption, palatable, aesthetically acceptable and consumer preferred product. It is found that using techniques like chemical treatment, mechanical treatment, blanching, high hydrostatic pressure, high electric field pulse, gamma irradiation and vacuum centrifugal force before or with osmotic dehydration will increase the efficiency of osmotic degradation in terms of drying rate and mass transfer rate.

Akbarian *et al.*, (2014) carried out the osmotic dehydration (OD) is an operation used for the partial removal of water from plant tissues by immersion in a hypertonic solution, sugar and/or salt solution, to reduce the moisture content of foods before actual drying process. Research applications of osmotic dehydration to food processing in technology and in component transfer mechanisms are being carried out in several countries. This technique is a partial dehydration process to give the product a quality improvement over the conventional drying process. Osmotic dehydration is affected by several factors such as osmotic agent, solute concentration, temperature, time, size, and shape and tissue compactness of the

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

material, agitation and solution/sample ratio. The osmotic dehydration step can be done before, during or after the conventional drying process to enhance the mass transfer rate or to shorten the duration of drying time the quality of osmotic dehydrated products is better and shrinkage is considerably lower as compared to products from conventional drying processes. This technique helps to conserve the overall energy relative to other drying procedures. In this review, the mechanism of osmotic dehydration is described. In addition, some factors that affect on mass transfer during osmotic dehydration reviewed. The major objective of this paper is to discuss the advantage of osmotic dehydration in terms of energy reduction.

Yeomans and Yang (2014) determined the optimal osmotic dehydration parameters for papaya. The functional form of the osmotic dehydration model is established via a standard response surface technique. The format of the resulting optimization model to be solved is a non-linear goal programming problem. While various alternate solution approaches are possible, an FA-driven procedure is employed. For optimization purposes, it has been demonstrated that the FA is more computationally efficient than other such commonly-used metaheuristics as genetic algorithms, simulated annealing, and enhanced particle swarm optimization. Hence, the FA approach is a very computationally efficient procedure. It can be shown that the resulting solution determined for the osmotic process parameters is superior to those from all previous approaches.

Pisalkar *et al.*, (2014) investigated in this study Increase in drying air temperature from 50 to 80°C decreased the drying time from 450 to 180 min for both pre-treated and non-treated samples. The entire drying process occurred in falling rate period and constant rate period was not observed. Five thin-layer drying equations were investigated for their suitability to describe the drying behavior of Aloe Vera cubes.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Yadav and Singh (2014) osmotic dehydration can be used successfully for 50%weight reduction in the material and require further drying or processing to enhance the shelf life. It is an energy saving and quality improvement process, it is predicted that osmo-air drying process has good potential for fruits such as banana, jackfruit, sapota, guava, mango and pineapple. This process could be used on small scale for development of self-entrepreneurs and home scale industries. Consumption of such nutritional and valued products could be popularized through exhibition and media. During the last three decades a lot of work had been done on osmotic dehydration and found that it is one of the best methods for preservation because it does not destroy much nutritional parameters, color, flavor and texture etc. On the other hand this process is too economical and since no preservative was used, it does not adversely affect the human body. It can be used to decrease the post harvest losses of fruits and vegetables.

Priyono *et al.*, (2014) participants described the process of processing the fruit into dried candied fruits and their demonstration of the stages of making candied dried, the introduction of processed foods as well as the introduction of other pieces of equipment simple manufacture of candied dried fruit. This activity was greeted with enthusiasm by the participants, is evident from the number of questions of the participants were either dried or candied questions about other processed foods from fruit items. Set up cooperatives, marketing, and consumer behavior in buying, small business bookkeeping, as well as on taxation in the world of small industry. The best treatment is treatment with the concentration of $Ca(OH)_2$ 1.8 % and a long drying time 11 hours.

Surendar *et al.*, (2014) was conducted tray drying of guava in two stages. In the first stage, osmosis was carried out using three different concentrations of sugar solution (40, 50 and 60 %) with 0.2 % potassium metabisulphite (KMS) and sodium meta bisulphate in the

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

osmotic solution at three temperature levels (35°C, 45°C, and 55°C) were maintained for three time interval (3, 6 and 9 hours), The combined effect of solution temperature, sugar concentration and time of moisture loss and solid gain was investigated by developing treatment combinations. It was found that relationship exists between moisture loss, solution temperature and sugar concentration time. Similar relationship was observed with solid gain. The final conditions of osmotic dehydration were determined on the basis of permissible solid gain in guava slices and these were found as 60%sugar solution concentration, 55°C solution temperature and 9 hours time.

Akbarian *et al.*, (2013) were concluded that Osmotic dehydration provides minimum thermal degradation of nutrients due to low temperature water removal process. It presents some benefits such as reducing the damage of heat to the flavor, color, inhibiting the browning of enzymes and decreases the energy costs. The dehydero freezing process also concerned with improving of quality. Some factors affecting mass transfer during osmotic dehydration are depending on types of osmotic agent, concentrations of osmotic agent, processing temperatures, agitation or stirring process and pretreatment methods. The use of edible coating Firstly, low molecular weight osmotic agent tends to easier penetrate into the fruit tissue than high molecular weight osmotic agent. In addition, increased osmotic agent concentrations result in the increment of solid gain and water loss. The increase in the processing temperature facilitates the mass transfer process during osmotic dehydration. Additionally, the agitation process had a significant.

Stefan *et al.*, (2013) were carried out on banana fruit and red beetroot samples. Hypertonic solutions of fructose for the banana and those of sucrose for the red beetroot were used, each one at three different concentrations. After osmotic dewatering treatment conducted

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College.
Muzaffarnagar

at different time intervals and after osmotic dehydration the samples were dried convectively until equilibrium with the surroundings was attained. The values of Solids Gain (SG), water loss (WL) and weight reduction (WR) were measured and changes in the samples, color and shape after convective drying with and without osmotic pretreatment were assessed.

Fasogbon *et al.*, (2013) studied the effect of Osmotic Dehydration and Rehydration Characteristics of Pineapple Slices and observed that the osmotic dehydration enhanced solid gain water loss dry matter loss and rehydration capacity.

Kedarnath *et al.*, (2013) studied in osmotic dehydration, the sapota samples were dried by immersing in a sugar syrupsolution in three sugar concentrations 30, 40 and 50°Brix at three syrup temperatures 30, 40 and 50°C. In the exchange of various components as loss of water and sugar gain from and by the samples takes place. The water loss, sugar gain and mass reduction were found to be 13.54 to 30.25; 23.84 to 36.66 and 3.80to 6.40 per cent in 30, 40, and 50 brix sugar solution at 30, 40, and 50°C.

Phisut *et al.*, (2013) this research was to studied the effect of osmotic dehydration process (fast osmotic dehydration; FOD and slow osmotic dehydration; SOD) on the physical, chemical and sensory properties of osmo-dried cantaloupe. First, the effect of calcium salts (calcium chloride and calcium lactate) on the firmness of fresh cantaloupe was investigated to obtain the suitable immersion time, types of calcium salt and their concentrations for the pretreatment step prior to osmotic dehydration process. It was found that the proper condition for pretreatment step was 2% calcium lactate for 3 h as considered from the firmness and sensory evaluation. After pretreatment, cantaloupe slices were subjected to two osmotic dehydration processes and then dried in hot air oven to obtain osmo-dried cantaloupe.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Khatir *et al.*, (2013) was determined the optimum processing conditions that yield maximum water loss and weight reduction and minimum solid gain during osmotic dehydration orange pieces in sugar solution using response surface. The experiments were conducted according to a Central Composite Design 'CCD'. The independent process variables for osmotic dehydration process were temperature (40, 50, 60 °C), processing time (60, 120 and 240 min) and sugar concentrations (45, 55, 65 % w/w).

Aravind *et al.*, (2013) papaya, botanical name *Carica papaya*, was a lozenge tropical fruit, often seen in orange-red, yellow-green and yellow-orange hues, with a rich orange pulp. The fruit is not just delicious and healthy, but whole plant parts, fruit, roots, bark, peel, seeds and pulp are also known to have medicinal properties. It also contains many biological active compounds including chymopapain and papain which is the ingredient that aids digestive system, and again used in treatment of arthritis.

Narang and pandey (2013) used response surface methodology for quantitative investigation on water and solids transfer during the osmotic dehydration process of the grapes in sucrose solution using Box-Behnken experimental design. Effects of temperature (35–55°C), sucrose concentration (40–60°Brix) and processing time (100–200 min)), on osmotic dehydration of grapes were estimated. Quadratic regression equations describing the effects of these factors on the water loss, solids gain, rehydration ratio and sensory score were developed. It was found that effects of concentration and temperature were more significant on the water loss than that of processing time. As for solids gain processing time and temperature were the most significant factors. The osmotic dehydration process was optimized for water loss, solute gain, rehydration ratio and sensory score.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Rahimi *et al.*, (2013) effected of different concentrations of sugar solution (hypertonic) (30%, 45% and 60% w/v) and carboxyl methyl cellulose (CMC) (0%, 1% and 2% w/v) coating on freeze drying of apple slices was studied. In total, nine treatments with respect to concentrations of hypertonic solution and coating layer were prepared to analyze their influence on the physical and chemical properties of freeze dried apple slices. It was observed that increase in the sugar solution concentration, decreased the moisture content of the apple slices significantly impacting its water activity, texture and sugar gain. Application of different concentrations of CMC coating had no significant effect on the properties of dried apple slices. A significant change was observed for color of CMC coated freeze dried apple slices pretreated with 60% sugar solution. Drying kinetics of pretreated apple slices were fitted by using two drying models, Newton's and Page's. Page's model showed higher *R*-square and lower root Mean square error (RSME) compared to Newton's model.

Kaur and Singh (2013) were carried out to investigate the mass transfer kinetics and optimization during osmotic dehydration of beetroot. The samples were osmotically treated in different hypertonic sugar solution (55, 65 and 75°Brix) with salt concentration of 5 % (w/v), at different solution temperature (30, 45 & 60 °C). Mass transfer kinetics was modeled according to Magee and Azuara model, and kinetic parameters were calculated. It was found that the magee's model was appropriate for predicting water loss (WL) and solute gain (SG), while Azuara's model fitted water loss as well as solute gain (SG) data represented more accurately the condition of the complete process close to equilibrium. Quadratic regression equations describing effects of process variables on water loss, solute gain and weight reduction were developed and optimization of osmotic dehydration was done using response surface methodology (RSM).

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Yousefi *et al.*, (2013) was studied that the mathematical modeling of microwave (MW) assisting hot air drying of thin-layer papaya (*Carica papaya* L.) slices with 5 ± 1 mm thickness in an experimental drying process is presented. The osmosis solution comprised 50% sucrose + 2% NaCl solutions. The osmosis dehydration characteristics obtained by solid gain (SG), water loss (WL) and weight reduce (WR) parameters. The drying air velocity (0.9 ± 0.1 m/s) and temperatures (40, 50 and 60°C) were examined in drying papaya slices from initial moisture content of 700 ± 2% (d.b) to moisture content of 20 ± 1% (d.b).

Kumari *et al.*, (2013) were analyzed the effect of slices thickness of banana slices on mass transfer properties as moisture loss, solid gain and water loss during osmotic dehydration. Moisture content of slice thickness was increased. Per cent moisture loss, weight loss and solid gain increased with decreased with slice thickness then increased.

Chavan and Amarowicz (2012) received greater attention in recent years as an effective method for preservation of fruits and vegetables. Being a simple process, it facilitates processing of fruits and vegetables such as banana, sapota, fig, guava, pineapple, apple mango, grapes, carrots, pumpkins, etc. with retention of initial fruit characteristics viz., colour, aroma, texture and nutritional composition. It is less energy intensive than air or vacuum drying process because it can be conducted at low or ambient temperature. It has potential advantages for the processing industry to maintain the food quality and to preserve the wholesomeness of the food. It involves dehydration of fruit slices in two stages, removal of water using as an osmotic agent and subsequent dehydration in a dryer where moisture content is further reduced to make the product shelf stable.

Phisut (2012) pretreated applications of osmotic dehydration to food processing in technology and in component transfer mechanisms are being carried out in several countries.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Osmotic dehydration is a traditional process applied to food dewatering. It leads to attractive products that are ready to eat or can be applied as a pretreatment to the next process such as drying or freezing. The new osmotically dehydrated products and industrial applications require appropriate manufacturing procedures at the industrial level. Thus, an understanding of factors affecting mass transfer during osmotic dehydration is required for the process optimization. In this review, the mechanism of osmotic dehydration is described. In addition, some factors that affect on mass transfer during osmotic dehydration such as types of osmotic agent, concentrations of osmotic agent, processing temperatures, agitation or stirring process, pretreatment methods and edible coating were reviewed.

Wijaya and Chen (2012) evaluated the biosynthesis pathways are becoming more important for the flavor industry in recent years, as this could aid in the production of the flavor volatiles in the same manner as the natural biosynthesis. It is also necessary to understand the aroma active compounds and their changes during processing because unexpected changes in aroma may cause a product unmarketable even if other quality factors are acceptable. A fairly wide range of different types of compounds was identified in different studies. These volatiles are released by harvested intact fruit in small amount per unit time, and some of the reported volatiles are only generated in quantity from non-volatile precursors due to the disruption of fruit tissue.

Egea *et al.*, (2012) developed a functional product from the osmo dehydrated Fuji apple incorporating FOS with acceptable physical, chemical and sensorial characteristics and potential for commercial scale production. Some treatments were discarded due to texture and water activity that did not reach the desired quality parameters. The products submitted to the osmo-dehydration treatments presented a greater vitamin C loss. All the treatments obtained

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

sensory scores of 6 in a 9 points scale for all the attributes, except the crispness, indicating good acceptance. The sensory scores and incorporated FOS quantities indicated that the osmodehydrated apple products have potential for commercial-scale production.

Renu *et al.*, (2012) effected of osmotic dehydration on water loss, solids gain, and weight reduction during osmotic dehydration were investigated in order to determine the usefulness of this technique as pre-treatment for further drying of bananas slices. Banana slices, 10 mm thick, were immersed in sucrose solutions with concentrations of 30, 40 and 50 Brix at 40, 50 and 600C for 60, 90 and 120 minutes. Water loss, weight reduction and solids gain increased with treatment time. Longer treatment time in high concentrations of sucrose resulted in a very soft product, which is difficult to handle and unsuitable for further drying. Increasing concentration at the same temperature did not cause significant increments in weight change. Higher concentrations of sucrose caused higher rates of water removal. The effective normalized moisture content for water and Normalized solid content were determined, considering banana as slices configuration. The temperature was controlled using constant temperature stirred water bath.

Yadav *et al.*, (2012) studied the osmotic dehydration was the combination of different osmotic agents and more effective than sucrose alone due to combination of properties of solutes. During the experiments it was found that optimum osmosis found at approximately 40 °C, 40 °B of osmotic agent and in near about 132 min. Pretreatments also leads to increase the osmotic process in fruits and vegetables. Mass transfer kinetics study is an important parameter to study osmosis. Solids diffusivity were found in wide range (5.09– 32.77 ml/mol) studied by Fick's laws of diffusion. These values vary depending upon types of fruits and vegetables and osmotic agents.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Ramalloa and Mascheronib (2012) reported that the pineapple samples dried at 45°C had better rehydration ability and more l-ascorbic acid retention than that obtained by air drying 75°C. Hence, 45°C drying temperature was best condition for pineapple quality preservation.

Chavan and Amarowicz (2012) studied on the osmotic dehydration process for preservation of fruits and reported that it has potential advantage for the processing industry to maintain the food quality to preserve the wholesomeness of food. It involves dehydration of fruit slices in two stages, removal of water using as an osmotic agent and subsequent dehydration in a dryer where moisture content is further reduced to make the product shelf stable.

Khan (2012) revealed the osmotic dehydration (OD) is one of most important complementary treatment and food preservation technique in the processing of dehydrated foods, since it presents some benefits such as reducing the damage of heat to the flavor, color, inhibiting the browning of enzymes and decrease the energy costs. The main advantages of osmo-dehydro freezing are not only economical but save energy, packaging and cost of distribution due to importance of product. The dehydro freezing process also concerned with improving of food quality.

Bellary *et al.*, (2011) studied the osmotic dehydration of assisted impregnation of curcuminoids (curcumin, demethoxycurcumin and bisdemethoxycurcumin) in coconut slices and the rate of mass transfer of moisture, solid and curcuminoids with or without application of ultrasound. Show that increased concentration of osmotic solution beyond 25% resulted in the reversal of direction of moisture and solid gain mass transfer.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Jose *et al.*, (2011) studied that osmotic dehydration of pineapple the effects of temperature (25-45°C) and citric acid concentration (0.5 -2.5% w/w) in osmotic dehydration of pineapple in a sucrose solution. The results suggest that WL, ML and SG can reach 42.62%, 36.54% and 292.16% respectively, after 4 to 6 h of the process, with 100% sensory acceptance and reductions in microbial counts with 100% sensory acceptance and reductions in microbial counts.

Jain *et al.*, (2011) processed temperature (30, 40 and 50 °C), syrup concentration (50, 60 and 70 °Brix) and process time (4, 5 and 6 h) for osmotic dehydration of papaya (*Carica papaya)* cubes were optimized for the maximum water loss and optimum sugar gain by using response surface methodology. The peeled and pre-processed papaya cubes of 1 cm size were immersed having syrup to papaya cubes ratio of 4:1 (w/w). The cubes were removed from bath at predecided time, rinsed with water and weighed.

Farzaneh *et al.*, (2011) affected the edible coat (carboxyl methyl cellulose) before osmotic dehydration and different drying methods on sensory and physical properties of dried apple (V. *Golden delicious*) rings were investigated. The coated and non-coated samples pretreated with 50% sucrose osmotic solution and dried in freeze drier (-40 to -50°C, 0.026-0.017 mbar, 24 hr), vacuum drier (70°C, 200 mbar, 8-10 hr), Air dryer (60°C, 1.5 m/s, 2-3 hr). Sensory evolutions, Rehydration ratio (RR), color changes (ΔE), shear strength (SS), true density and shrinkage present of dried samples were determined. Effect of using edible coats before osmotic process was significant on the SS, RR and color changes. As the lowest shrinkage, color changes, RR, and highest SS were found in freeze dried apples. The air and vacuum dried samples had the highest RR and true density, respectively. The best sample in sensory evolutions was coated and freeze dried samples.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Maneepan and Yuenyongputtakal (2011) revealed that the effects of vacuum pressure pre-treatment on the osmotic dehydration of coconut pieces and on mass transfer parameters and some physical characteristics. The coconut pieces were immersed in sucrose solution (60% (w/w)) for 8 hr. at room temperature. Samples were subjected to vacuum pressure at 50 and 65 mbar with different pretreatments: 1) vacuum pressure for 20min, then atmospheric pressure and 2) vacuum pressure for 10 min, atmospheric pressure for 10 min, vacuum for 10 min, then atmospheric pressure. Microscopic observations revealed that the integrity of the cellular matrix associated with mass transport behavior and mechanical properties.

Eroglu and Yildiz (2010) concerned that osmotic dehydration is an operation used for partial removal of water from foods such as fruits and vegetables. In this process, foods are placed in hypertonic (osmotic) solution. Three different mass transfer mechanisms occur in the osmotic dehydration; (i) water migration from food to the solution, (ii) solute migration from solution to food, and (iii) solute concerning product extracted to solution. Osmotically dehydrated fruits and vegetables are generally dried by hot air flow. In recent years, osmotic dehydration has been combined with various methods such as the high hydrostatic pressure, high electrical field pulses, gamma irradiation, ultrasound, vacuum and centrifugal force. These new combination methods increase mass transfer and drying rate and foods by increasing the cell membrane permeability. The operation time in the combined methods is shorter than that in traditional osmotic dehydration, causing further energy saving. In this study, recent advances in osmotic dehydration will be reviewed.

Tortoe (2010) experimented on osmotic dehydration was not receiving much attention in the food industry due to the poor understanding of the counter current flow phenomena

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

associated with it. Therefore, it is very important to investigate the underlying principles of the counter current flow to improve industrial implementation of the technology. Osmotic dehydration experiments had been reported plant and animal materials. Minimal improvement on amount and rate of water loss and corresponding solid gain had been reported in the presence of sodium chloride and agitation especially for the first thirty minutes of osmotic dehydration. Simulation of cell membrane using artificial cell had showed that the presence of starch in food materials retards the diffusion of water.

Yetenayet and Hosahalli (2010) revealed that Dehydration of food stuffs by immersion in osmotic solutions before convective air-drying improves the quality of the final product since it prevents oxidative browning and/or loss of volatile flavoring constituents, reduces the fruit acidity.

Mosayebi (2010) were designed according to Central Composite Design with six factors each at five different levels. Response Surface Methodology (RSM) was used to determine the optimum processing conditions that yield maximum water loss and rehydration ratio and minimum solid gain and shrinkage in osmotic-convective drying of edible button mushrooms.

Aminzadeh *et al.*, (2010) were investigated the effect of different osmotic solution concentrations 30, 40 and 50% (w/w) of sucrose with 10% NaCl salt and fruit to solution ratios 1:4, 1:5 and 1:6 on the mass transfer kinetics during osmotic dehydration of melon in ternary solution namely sucrose salt- water followed by air-drying were studied. The diffusivity of water during air-drying was enhanced after the fruit samples were immersed in the osmotic solution after 60 min.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Marzec (2009) research was to analyzed mechanical and acoustic properties of apples which were dried using different methods. The porosity of material correlated with the compression force, as well as the acoustic energy and the number of events.

Nunes and Moreira (2009) revealed that the best mango chip in vacuum frying was produced with an osmotic solution concentration of 65% (w/v) and temperature of 40°C, which resulted in the highest water loss to sugar gain and provided a good texture characteristic.

Khan *et al.*, (2009) carried out on the Osmotic dehydration of apple was using aqueous solutions of sucrose, fructose and maltodextrin of different concentrations (40, 50 and 60 %) as osmotic media, at different temperature levels (40, 50 and 60 0C) and solution to sample ratio 5:1 with agitation. The experiments were carried out up to 240 min and samples were taken for analysis at an interval of 10 min up to first 60 min, followed by intervals of 30 min for the next 180 min to evaluate moisture loss and solid gain during osmotic dehydration.

Azoubel and Silva (2008) influenced the temperature (30–50˚C), immersion time (60–150min) and solution concentration (40–60% w/w) was studied through response surface methodology. Responses of water loss and solid gain were fitted to polynomials, with multiple correlation coefficients ranging from 0.72 to 0.95, respectively. The fitted functions were optimized for maximum water loss and minimized incorporation of solids in order to obtain a product resembling non-processed fruit. Optimum conditions to obtain water removal >25% with solid uptake lower than 6% could be obtained using a 44% (w / w) sucrose solution concentration, temperatures up to 38˚C and immersion times up to 80 min.

Kowalska *et al.*, (2007) analyzed the influence of microwave heating on mass transfer during osmotic dehydration of apples. The samples in 10 mm-cube shape were pre-dried at

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

200 and 300W microwave power for 10 min. After that, osmotic dehydration of apples was carried out in a glucose solution of 49% concentration at 30 and 50°C temperature. Osmotic process time was 15 and 30 min. Microwave treatment before osmotic dehydration caused slightly more darkness of apples in comparison with non-treated samples.

Nurul *et al.*, (2007) concluded that microwave power intensity influenced the drying characteristics of papaya fruit. As microwave power increased, the drying rate increased. As to achieve final moisture content below 10% during microwave-vacuum drying of papaya, increase in power intensity resulted in shorter drying time. Meanwhile, the effect of system pressure on the drying time was not as significant as that of microwave power level. It is obvious that the entire drying process for the samples occurred in the range of falling rate period.

Birthal *et al.*, (2007) conducted throughout equilibrium in osmotic dehydration were analyzed and modeled. Results showed that, by the time osmoses samples reached the maximum weight and volume loss, solute concentration of the fruit liquid phase was higher than that of the osmotic solution. The reported overconcentration could be explained in terms of the apple structure shrinkage that occurred during the osmotic dehydration with highly concentrated osmotic solutions due to the elastic response of the food structure to the loss of water and intake of solutes. The fruit liquid phase overconcentration rate was observed to depend on the concentration of the osmotic solution, the processing temperature, the sample size, and shape of the cellular tissue.

Moura *et al.*, (2005) were evaluated in three apple varieties Gala, Gold and Fuji. The study was undertaken to collect information in order to identify the effects of initial tissue properties on mass transport phenomena in general and osmotic processing responses in

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

particular. The apples, obtained from the local market, were washed, peeled and cut into 10 mm cube. After this, the samples were dehydrated in sugar osmotic solution (50% w/w) at 30 °C and 110 rpm of agitation. The ratio of foodstuff to osmotic solution was greater than 1:20. The mass transfer kinetics was measured in intervals of 20 minutes during 3 hours. The mass transfer kinetics of the different apple varieties has presented different behavior during the osmotic dehydration.

Ramallo and Rodolfo. (2005) presented the water loss, sucrose gain and the variation in concentration of other natural fruit sugars (glucose and fructose) were studied during osmotic dehydration of pineapple slices (0.6 mm thick) in sucrose solution (60 % w/w) at three temperatures (30, 40 and 50°C). As temperature increased from 30 to 50°C, the apparent moisture and sucrose diffusivities (Dw and Ds) increased 3.8 and 2.8 times, respectively; therefore, the dehydration efficiency index (Dw/Ds) increased with temperature. The loss of glucose and fructose increased with temperature.

Falade and Aworh (2005) reported that the sensory evaluation and consumer acceptance of osmosed star apple and African mango, Osmotic dehydration was evaluated by the water loss (g water/g initial mass) and solids gain (g solids/g initial mass). Results obtained that the water loss and solids gain increased with increasing degree of fruit ripeness, immersion time, concentration and temperature of sucrose solution. Water loss and solids gain increased with decreasing slice thickness of African mango.

Tiwari (2005) reported that an optimum ratio since large ratios offer practical difficulties in handling the syrup fruit mixture for processing. A ratio of 1:2 or 1:3 is optimum for practical purposes. The literature on osmotic dehydration of pineapple slices has been found to be scanty. Therefore, the present investigation on osmotic dehydration of pineapple slices

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

with variation in some important parameters has been planned.

Alves *et al.*, (2005) found that the osmotic dehydration of frozen mature acerolas in an incubator at temperature 25–60°C and constant agitation. They performed an experiment in which acerolas were blanched in water (80°C for 3 min) and dehydrated using binary (water + sucrose) and ternary (water + sucrose + salt) solutions. Results were found at 60°C for both the solutions but 60% (w/w) sucrose in binary solution and 50% (w/w) sucrose with 10% (w/w) salt in ternary mixture provides optimum result.

Azoubel and Murr (2003) reported the Osmotic dehydration of cashew apple in sucrose and corn syrup solids solutions as influenced by temperature (30–50˚C), sugar syrup concentration (40–60% w/w) and immersion time (90–240 min) was studied through response surface methodology. Responses of water loss (%) and solid gain (%) were fitted to polynomials, with multiple correlation coefficients ranging from 0.92 to 0.99. The fitted functions were optimized for maximum water loss and minimized incorporation of solids in order to obtain a product resembling non-processed fruit. Three optimum sets were selected for each solute and the ascorbic acid content was determined. The ascorbic acid losses were similar to those reported for osmotic dehydration processes.

El-Aouar *et al.*, (2003) studied that the drying kinetics of fresh and osmotically pre-treated papaya cubes (*Carica papaya* L.) using the diffusion model (Fick's second law) adapted to a cubic geometry, and an empirical two parameters model. The osmotic pre-treatment was carried out in an incubator at constant temperature and agitation. The drying process was carried out in a fixed bed dryer at two different temperatures and air velocities. At the beginning of the drying process of fresh papaya, drying rate was influenced by both air velocity and air temperature. But lose to the equilibrium condition; the drying rate was affected only by the air

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

temperature. The physico-chemical changes in the papaya cubes during osmotic pre-treatment caused differences in the drying rate in the subsequent air drying process when compared to fresh papaya cubes. The effective diffusivities of water, calculated by diffusion model was of the order of 10.9 m^2/s.

Prothon *et al.*, (2001) were compared to the samples that did not undergo any pre treatment. A puncture test and confocal laser scanning microscopy (CLSM) were used to analyze the effects of these processes on texture and microstructure. Rehydration in water and in yoghurt were studied and compared. The rehydration capacity in water was significantly higher for non-treated samples than for the pre-treated ones ~ although rehydration in yoghurt reduced this deference.

Prothon *et al.*, (2000) studied on the Osmotic pre-treatment in sucrose solution was followed by microwave-assisted air-dehydration at deferent temperatures (50, 60 and 70 3C). The products were compared to the samples that did not undergo any pretreatment. A puncture test and confocal laser scanning microscopy (CLSM) were used to analyze the effects of these processes on texture and microstructure. Rehydration in water and in yoghurt were studied and compared. Results showed that osmotic pre-treatment before microwave-assisted air-drying increased the overall quality of the product.

Panagiotou *et al.*, (1998) observed that the size of fruit samples had a negative effect on water loss during osmotic treatment. In general, a sample size of 3 mm to a maximum of 10 mm in rectangle, ring or cube shape was suggested for the use in osmotic dehydration process.

Krokida *et al.*, (1998) studied mechanical properties of osmo-convectively dried bananas and apples. They found that osmo-convectively dried samples were more resistant to rupture than those convectively dried. These properties were explained by the more plastic

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

structure caused by the sugar uptake during the osmotic treatment. Mechanical properties of fruits are determined by the characteristics of the cells. Exposing fruits to fluids of high-temperatures causes the chemical changes that affect the structure of the fruit tissue. Water loss decreases the pressure in the cell thus decreasing the firmness of fruit tissues.

Valle *et al.*, (1998) proved that HTST (High Temperature Short Time) blanching of apple pieces caused PPO (Poly Phenol Oxidase) inactivation and softening. PPO inactivation was minimal during immersion in water at 40°C, but it increased with temperature after 15 min exposure at 55–65°C. Softening decreased with adding 0.6% $CaCl_2$ is added to the blanching medium. Vacuum infiltration of apple pieces caused cellular damage that increased with applied pressure. Texture improved by the use of aqueous $CaCl_2$ solution instead of distilled water. HTST blanched apple pieces showed extensive material loss and poor texture on osmotic dehydration.

Lazarides (1994) reported substantial higher sugar gains (up to ca.55%) compared to room temperature conditions during osmotic dehydration of apples at process temperature between 30 and 50°C. The higher uptake values of treatments above 20°C were probably due to the membrane swelling and plasticizing effect, which improved the cell membrane permeability to sugar molecules.

Shi and Maupoey (1993) concluded that the vacuum Osmotic dehydration leads to more water loss but had no effect on solid uptake since vacuum treatment intensify the capillary flow function. Vacuum treatment was suitable in high porous fruit such as pineapple.

Sharma *et al.*, (1991) observed that the caned apple rings pretreated with 70% sugar solution at 50°C for half an hour resulted in weight loss, increase in sugar penetration and increase in shrinkage.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Chapter-3

MATERIALS AND METHODS

The present investigation entitled "**Study on Osmo-Convective Dehydration of Papaya (Carica papaya L.) Slices and Evaluation of Quality During Storage.**" the work was carried out in the Department of Agricultural Engineering, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, (U.P.) during December (2017) to May (2018). The practices used and techniques adopted during the course of investigation are presented in this chapter.

3.1 To study the effect of pretreatments on osmotic dehydration of papaya slices.

The experiment for pretreatments and osmotic dehydration kinetics involves various steps as mentioned below:

3.1.1 Procurement of Raw Material

Papaya (*Carica Papaya* L.) fruits of average size and shapes were procured from the local market of Meerut on daily basis prior to each set of experiment. Commercial sugar which is used as osmotic agent was purchased from the local market. While purchasing the fruits all precautions were taken to select the healthy and well-matured fruits. The individual fruit of pineapple was weighed in order to select an average grade of the fruit for the experimentation.

3.1.2 Experimental Plan

Papaya slices were first selected for pretreatments (T_1 Control or Untreated, T_2 Potassium metabisulphate, T_3 Sodium bisulphate and T_4 Blanching) osmotic solution at selected osmotic solution temperature at 50°C. Then the samples were dried under tray drier and hot air oven drier at 60°C temperature. The dried samples from each experiment were packed, sealed properly and kept at ambient temperature for quality analysis. An Experiment

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

was conducted to investigate different drying characteristics of papaya slices under different drying condition of osmotic dehydration after standardizing the pretreatment of papaya slices. During the process, osmosis was carried out in sucrose solution at a varying concentration of 55° and 65°B Osmosis was conducted manually at regular intervals to maintain uniform temperature. At each experimental condition osmotic dehydration was carried out for 180 minutes and at each design time (after every 30 min intervals), samples were analyzed for moisture content, and the solid gain which were calculated based on mass balance.

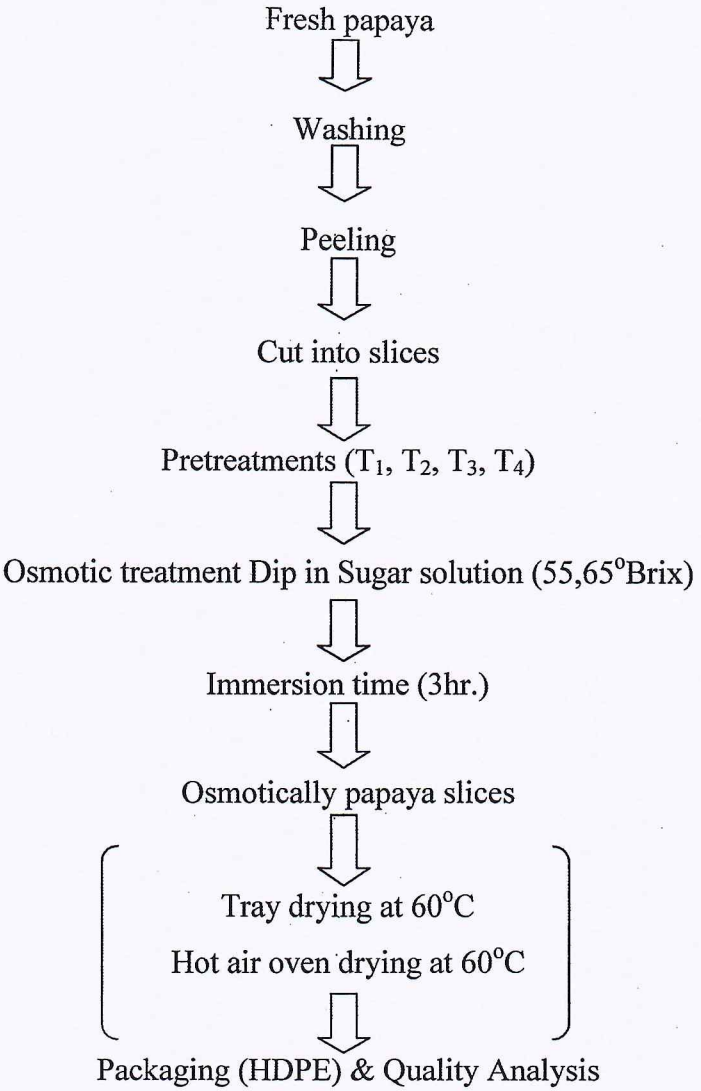


Fig. 3.1 Flow chart of osmotic dehydration process

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Table 3.2 Experimental layout for drying of papaya slices.

Experimental Parameters	Levels	Description	Quality Evaluation Parameters
Papaya	1	Papaya Slices	
Sample size	3	200 gm	**Physico-chemical Analysis** Moisture content, Water loss, Solid gain, Mass Reduction, Rehydration Ratio, Drying Rate **Sensory** Color, Taste, Flavor and over all acceptability
Pretreatments	4	**T_1:** Control (untreated) **T_2:** KMS(Potassium metabisulphate) 1% **T_3:** $NaHSO_4$ (Sodium bisulphate) 1% **T_4:** Blanching	
Sugar Concentration	2	55°Brix, 65°Brix	
Drying Methods	2		
Temperature of syrup	1	50°C	
Solution to product ratio	1	6:1	
Immersion time	1	3 hr.	
Packaging material	1	HDPE	
Storage	1	Room Temperature	
Storage Period	4	0, 30, 60 and 90 days	
Replication	3		
Design	1	RBD	
Size and Shape	2	2.5×2.5×2.5(cm) and Cube	

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

3.3 Experimental setup

3.3.1 Electronic balance

Electronic balance is a measuring instrument used for determining the weight or mass of an object. An electronic balance (model no GEFTT) was used to weigh all the ingredients required for the osmotic dehydration of Papaya. A measuring pan of 1 g precision was placed inside. The maximum limit of the balance was 10 kg.

3.3.2 Hot air oven

Hot air oven was used for the determination of the moisture content. It is operated within a temperature range of 50°C to 300°C. The temperatures are digitally controlled using a thermostat. The double walled insulation keeps the heat in and conserves energy). The inner layer is a poor conductor whereas outer layer is metallic. An air filled space aids in insulation. The samples can be placed inside the inner cavity which is fitted with adjustable aluminum trays.

3.3.3 Water bath

Water bath was used to maintain the temperature of the osmotic solution. It was operated within a temperature range of 10°C to 110°C. The temperatures are digitally controlled using a thermostat, the heating rods underneath heat the water in the water bath and desired temperature was maintained by thermostat.

3.3.4 Desiccator

Desiccator was used to keep the hot Petri plates for cooling. Keeping the hot Petri plates in desiccator it avoids fluctuation in measuring the weight. Desiccators were sealable enclosures containing desiccants used for preserving moisture-sensitive items. A common use

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

for desiccators was to protect chemicals which were hygroscopic or which react with water from humidity.

3.3.5 Tray dryer

A cabinet type mechanical tray dryer was used to conduct drying experiment. Main Drive Motor 1.5 KW/ 2 H.P., 960 RPM , 3 Phase , 415 Volts, 50 Hz.

The dryer had drying chamber, heating unit and a fan. Drying chamber was an insulated box with a single door opening at front. Six aluminum trays were placed in drying chamber. Six heating units were provided to increase the temperature inside the drying chamber. Control and osmosis papaya slices samples were spread uniformly for thin layer drying in the dryer, the drying air temperature ranged from 50 to 250°C and the air velocity kept as constant 28 m/s.

3.4 Experimental procedure

The papaya was procured from the local market of Meerut. The papaya was then washed, and cut into 2.5x2.5x2.5 cm slices. The papaya slices were put in to the chemical solution for 30 minutes and after 30 minutes the sample were removed in to the chemical solution and put in room temperature for 15 minutes and then weighted by electrical balance. After give the pretreatments of samples, i was make the osmotic solution 55°Brix and 65°Brix, and the slices were put in osmotic solution having sugar concentration ranging from 55 to 65°Brix at 50°C temperature for 180 minute. After the osmotic treatment the slices were wiped by using the blotting paper and were dried in Cabinet tray drier at 60°C temperature and Hot air oven at 60°C temperature. The dried papaya slices after drying were packed in HDPE (high density polyethylene) for quality evaluation.

3.4.1 Preparation of osmotic solution

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Osmotic solution was prepared with distilled water by blending the desired solute (w/b) basis). Sugar was used as osmotic agent. Selected quantities of sugar were added with osmotic solution to improve the osmotic dehydration process and quality of samples. A stirrer was used to dissolve the solute content. An electronic balance was used to weigh sugar. Based on the preliminary trials and review of literatures, two concentrations each of sugar (55°Brix and 65°Brix) at temperature levels of 50°C were used to carry out the experiments Concentrations were checked by HRN-18 Hand Refractometer.

3.4.2 Preparation of the samples

Good quality papaya of was procured from the local market of Meerut. Procured papaya was washed with water and unwanted material like dust, dirt, and surface adhering were removed. The fruits were then peeled off with the help of a stainless steel knife and both the ends of the fruits were trimmed off using a stainless steel knife and cut into slices of 2.5x2.5x2.5 cm thickness. The thickness was measured with Verniercaliper having least count of 0.001 mm.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Fig. 3.4.2 Preparation of sample

3.4.3 Osmotic dehydration of papaya slices

In osmotic dehydration the prepared samples (papaya slices) were weighed approximately 200gm for every experiment and immersed in sugar solution (55°Brix and 65°Brix) contained in a 1500 ml glass beaker. The beakers were placed inside the constant temperature water bath. The solution in the beakers were manually stirred at regular intervals to maintain uniform temperature 50°C and kept for 3 hrs. The beakers were removed one by one from water bath at designed time, samples were taken out and placed on absorbent paper for 5 minute or were immediately rinsed in flowing water and placed on tissue paper to remove the surface moisture to eliminate excess solution from the surface before weighing. Finally the samples were weighted and their moisture contents were determined. After the osmotic treatment the slices were wiped by using the blotting paper and were dried in Cabinet tray drier at the temperature of 60°C and Hot air oven at of temperature 60°C.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

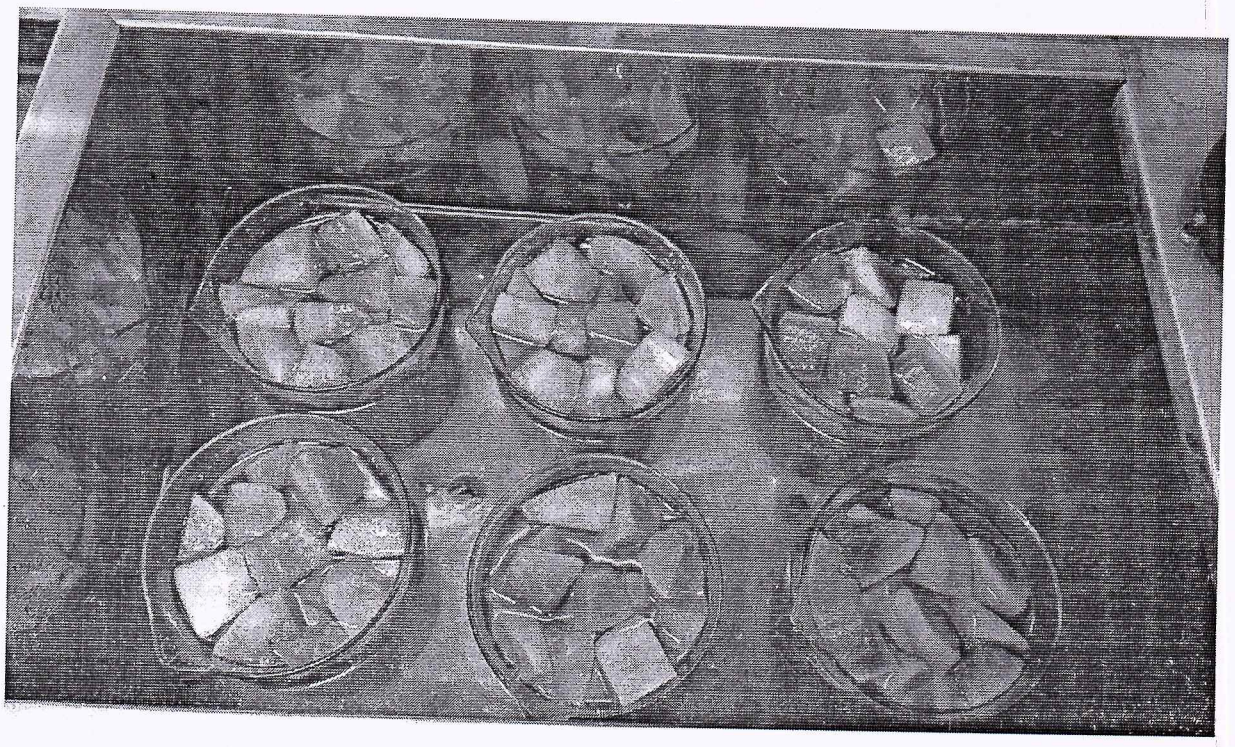


Fig. 3.4.3 Osmotic dehydration of papaya slices.

Fig. 3.4.4 Packaging of dried papaya slices in HDPE.

3.4.4 Packaging of dried products

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

The dried papaya slices were packed in polythene pouches and were again kept in moisture proof pouches and heat-sealed. The samples were stored at ambient condition for further quality analysis.

3.5 PHYSICO- CHEMICAL PARAMETERS

3.5.1 Moisture content

Moisture content of the sample was determined by standard air oven method **(Ranganna, 2010).** Test sample of 5 g was kept for 24 h in a hot air electric oven maintained at 105°C. After 24 h, sample was drawn from the oven and placed in a desiccator for cooling. After cooling the weight of the sample was taken precisely. The loss in weight was determined and moisture content was calculated using the following expression:

The moisture content of sample calculated by using following equation:

$$\mathbf{M\ C\%\ (w.b)} = \frac{\mathbf{(initial\ weight - final\ weight)}}{\mathbf{initial\ weight}} \times \mathbf{100} \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$\mathbf{M\ C\%\ (d.b)} = \frac{\mathbf{(initial\ weight - final\ weight)}}{\mathbf{final\ weight}} \times \mathbf{100} \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Total solids in per cent will be obtained after subtracting the moisture content from 100.

3.5.2 Determination of water loss (WL) and solid gain (SG).

Osmotic dehydrated samples were blotted with tissue paper and later weighed for determination of WL and SG as shown by the following equation **(Aktas *et al.*, 2007)**

$$WL = \frac{Wwo - Ww}{Wo} \times 100$$

$$SG = \frac{Ws - Wso}{Wo} \times 100$$

$$MR = WL - SG$$

Where, WL, SG and MS are Water Loss, Solid Gain and Mass Reduction in %, respectively.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

W_{wo} is the initial water mass,

W_w is the mass of water at time t,

W_S is the solid mass at time t,

W_{so} is the initial solid mass

3.5.3 Rehydration ratio

Rehydration tests for dehydrated samples were carried out by immersing 5 g sample in 50 ml distilled water at 35°C in a 100 ml beaker kept in a hot water bath to maintain a water temperature of 35°C for 5 hr **(Nsonzi and Ramaswamy, 1998).** Dehydrated samples were evaluated for rehydration ratio, from the weight before and after the rehydration.

$$Rehydration\ Ratio\ (RR)\frac{C}{D}$$

Where,

C =drained weight of rehydrated sample (g)

D = test weight of dehydrated samples (g)

3.6 SENSORY EVALUATION

Sensory evaluation is important to access the consumer's requirements. It is difficult to classify 100% by machine because it was a subjective factor. Dehydrated product should have a typical taste, flavor, and texture. To test these organoleptic characteristics, sensory evaluation was done on the basis of 9 points hedonic scale. The sensory evaluation was carried out for taste, color and overall acceptability. A sample of dehydrated product was served for the evaluation to a 10 panelists at a time. The score sheet was provided with product and of all the panelists was computed on 9 point hedonic scale.

Table 3.6.1: Point hedonic scale for sensory evaluation

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Sr. No.	Feeling	Rating
1	Like extremely	9
2	Like very much	8
3	Like moderately	7
4	Like slightly	6
5	Neither like nor dislike	5
6	Dislike slightly	4
7	Dislike moderate	3
8	Dislike very much	2
9	Dislike extremely	1

3.7 Statistical analysis and interpretation of data

The data collected growth and yield were suggested to statically analysis as for method of "Analysis of Variance. The results have been interpreted on the basis of "F "test and C.D. at 5% level between two means. The significant effect at treatment have been summarized in tables and illustrated by suitable diagrams. The observations on the morphological characters at the successive stage of growth have been shown by curves.

3.7.1 Critical difference

The data obtained was subjected to statistical analysis. The treatment means were compared using transformed means. The treatment differences were tested by least significant difference at 5 per cent of probability, calculated by the following formula:

$$CD = \sqrt{\left(\frac{2 \times erroe\ mean\ square}{r} \times t0.05\right)}$$

Where,

CD = Critical difference

r = Number of replications of the factor for which C.D. is to be calculated.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

t0.05 = Value of percentage point of 't' distribution for error degree of freedom at 5 per cent level of significance.

Chapter-4

RESULTS AND DISCUSSION

In this present study, on osmo-convective dehydration was carried out "**Study on Osmo-Convective Dehydration of Papaya (carica papaya L.) Slices and Evaluation of Quality During Storage"** Further the process parameters, osmotic solution concentration, and osmotic solution temperature, solution to fruit product ratio and immersion time. For each osmotic agent and shape of papaya were optimized by multiple response optimization technique for the response namely water loss, solid gain, rehydration ratio, mass reduction. In addition to the optimization of osmotic dehydration process, physical characteristics, osmo-convective and convective drying kinetics and impact of various treatments on quality of

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

papaya fruit were also investigated. The results of the study along with relevant discussion are included in this chapter.

4.1 To study the effect of pretreatments on osmotic dehydration of papaya slices.

This experiments were conducted in sugar solution having different concentrations (55°Brix and 65°Brix and solution to product ratio is 5:1 and 55°C at the solution temperature the detailed description of the experiments is given in table 3.2 in order to follow adequately the osmotic dehydration kinetics, individual analysis for each sample were carried out and from these; water loss, solid gain, mass reduction were obtained. The data pertaining to osmotic dehydration kinetics of cube shaped papaya are given in appendix-A. The effect of process parameters on osmotic dehydration kinetics were discussed below:

4.1.1. Effect on water loss, solid gain and mass reduction.

The effects of various process parameters on water loss, solid gain, and mass reduction are given bellow.

The effect of sugar concentration and time on water loss, solid gain, mass reduction at constant temperature of 55°C and solution to product ratio 5:1 during osmotic dehydration for Treatments T_2, T_3 and T_4 are shown in fig. 4.1.1.0 to 4.1.1.8 The figure clearly shown that the complete results for osmotic dehydration kinetics of cube shaped papaya have been presented in appendix -A.

4.1.1.0 Effect of osmotic solution concentration and time on water loss for T_2.

In osmotic papaya sample (T_2) the water loss were found 5.055% and 5.71% at 55°Brix and 65°Brix respectively on 30 minutes difference. On each 30 minutes difference, the values of water loss for 55°Brix were found 7.634%, 10.20%, 11.92%, 13.19% and 14.51% respectively. While the water loss for 65°Brix on 30 minutes difference were found 8.82%,

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

11.86%, 16.15%, 19.15% and 21.63% respectively. The data shown that after 30 minutes of osmosis papaya cubes at 55°Brix was found the lowest water loss, while the highest value was found 14.51% after 180 minutes, and 65°Brix the minimum water loss was found 5.71% after 30 minutes and the maximum value was found 21.63% after 180 minutes of osmosis.

Water loss in osmosis increased with increase in sugar concentration, this was because as increase in the concentration of sugar solution resulted in osmotic gradient, which increased the driving force for water remove between solution and fruit and thereby giving higher mass transfer rates.

4.1.1.1 Effect of osmotic solution concentration and time on mass reduction for T_2.

The values mass reductions were found 4.33%, 6.67%, 8.83%, 10.17%, 11.17% and 12.17% at 55°Brix. While the values at 65°Brix were found 5.33%, 8.0%, 10.5%, 13.83%, 16.17% and 17.67 % for T_2 sample after 30 minutes of intervals.

Mass reduction in osmosis increased with increase in syrup temperature and concentration of solution. At initial stage increasing temperature and sugar concentration of solution raises water loss more than solid gain which causes an increase in mass reduction. However later increase in solid gain blocks layers of the product, which reduce the concentration gradient between the product and osmotic solution, posing an additional resistance to mass exchange and lowering the rates of water loss and consequently mass reduction.

4.1.1.2 Effect of osmotic solution concentration and time on solid gain for T_2.

Solid gain values showed variability among the treatments. Solid gain in osmosis decrease with the increase in the sugar concentration and syrup temperature, it might be due to

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

penetration at solution and gel interface. The solid gain values were found 0.72%, 0.968%, 1.37%, 1.76%, 2.032% and 2.341% for T_2 sample after each 30 minute intervals at 55°Brix. While the values of solid gain were found 0.393%, 0.823%, 1.364%, 2.32%, 3.15% and 3.96% at 65°Brix after each 30 minutes of intervals.

The value of solid gain were much lower than the water loss for all the process parameters during osmotic dehydration, because sucrose having larger ionic radius could not diffuse easily through the cell membrane and thus the approach to osmotic equilibrium was achieved primarily by flow of water from cell. It was observed that solid gain goes on decreasing as sugar concentration goes on increasing.

4.1.1.3 Effect of osmotic solution concentration and time on water loss for T_3.

In osmotic papaya sample (T_3) the water loss were found 6.37% and 7.17% at 55°Brix and 65°Brix respectively on 30 minutes difference. On each 30 minutes difference, the values of water loss for 55°Brix were found 9.87%, 14.35%, 18.49%, 22.29% and 27.291% respectively. While the water loss for 65°Brix on 30 minutes difference were found 12.402%, 16.63%, 20.31%, 23.11% and 26.798% respectively.

4.1.1.4 Effect of osmotic solution concentration and time on Mass Reduction for T_3.

The values mass reductions were found 4.0%, 7.17%, 11.83%, 15.00%, 17.67% and 20.83% at 55°Brix. While the values at 65°Brix were found 6.8%, 10.67%, 14.00%, 16.17%, 18.5% and 20.67% for T_3 sample after 30 minutes of intervals.

4.1.1.5 Effect of osmotic solution concentration and time on Solid Gain for T_3.

The solid gain values were found 2.374%, 2.701%, 2.512%, 3.497%, 4.627% and 6.46% for T_3 sample after each 30 minute intervals at 55°Brix. While the values of solid gain

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

were found 0.667%, 1.73%, 2.63%, 3.64%, 4.43% and 6.131% at 65°Brix after each 30 minutes of intervals.

4.1.1.6 Effect of osmotic solution concentration and time on water loss for T_4.

In osmotic papaya sample (T_4) the water loss were found 10.123% and 8.93% at 55°Brix and 65°Brix respectively on 30 minutes difference. On each 30 minutes difference, the values of water loss for 55°Brix were found 17.33%, 19.26%, 22.86%, 25.76% and 27.58% respectively. While the water loss for 65°Brix on 30 minutes difference were found 14.22%, 20.35%, 21.83%, 26.54% and 30.32% respectively.

4.1.1.7 Effect of osmotic solution concentration and time on mass reduction for T_4.

The values mass reductions were found 8.67%, 13.83%, 15.17%, 17.5%, 19.5% and 20.67% at 55°Brix. While the values at 65°Brix were found 7.5%, 11.83%, 16.17%, 17.17%, 20.17% and 22.33% for T_4 sample after 30 minutes of intervals.

4.1.1.8 Effect of osmotic solution concentration and time on Solid Gain at 55°C temperature for T_4.

The solid gain values were found 1.7113%, 3.501%, 4.1%, 5.36%, 6.26% and 6.912% for T_4 sample after each 30 minute intervals at 55°Brix. While the values of solid gain were found 1.43%, 2.39%, 4.19%, 4.66%, 4.37% and 7.99% % at 65°Brix after each 30 minutes of intervals.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

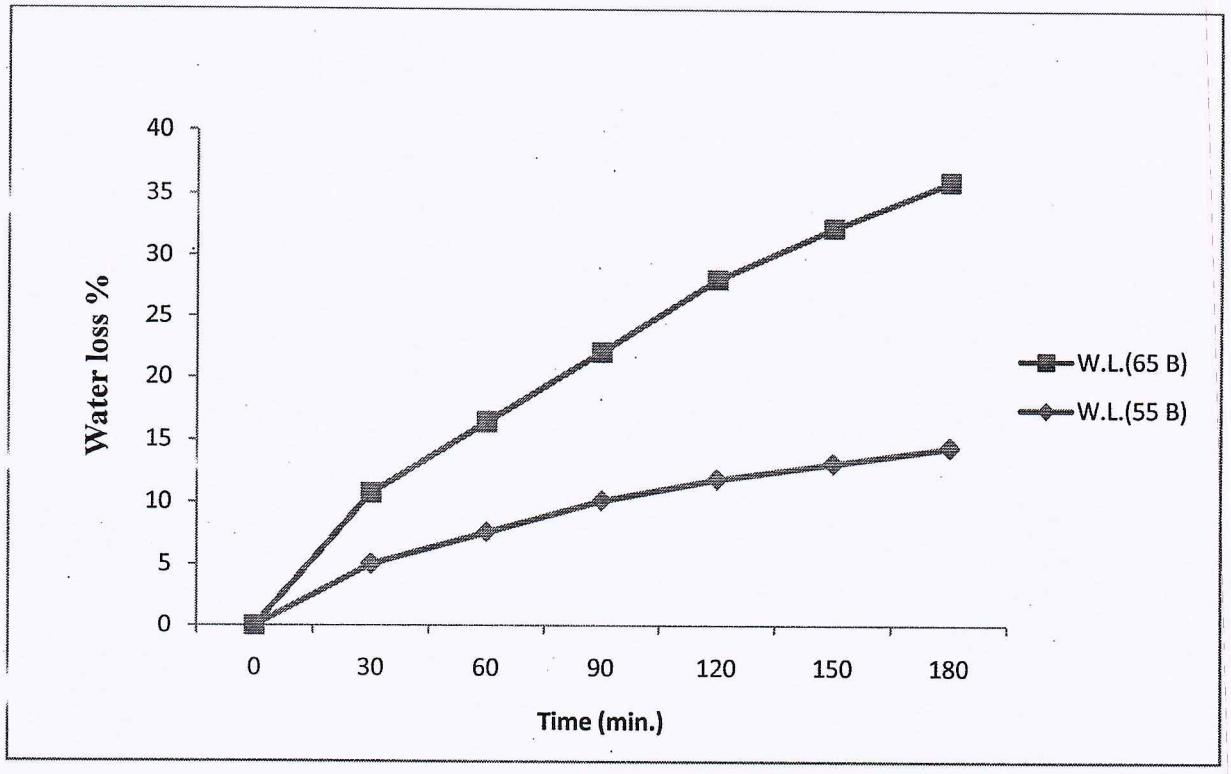


Fig. 4.1.1.0 Effect of osmotic solution concentration and time on water loss for T_2.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

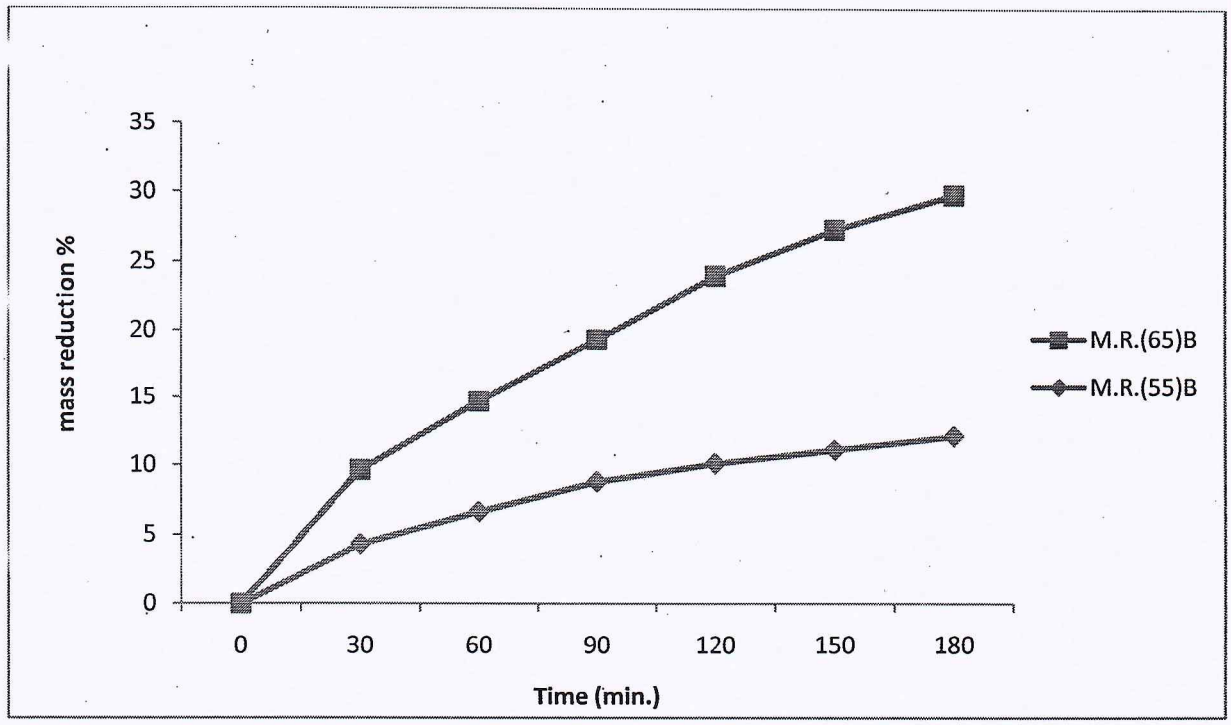


Fig. 4.1.1.1 Effect of osmotic solution concentration and time on mass reduction for T_2.

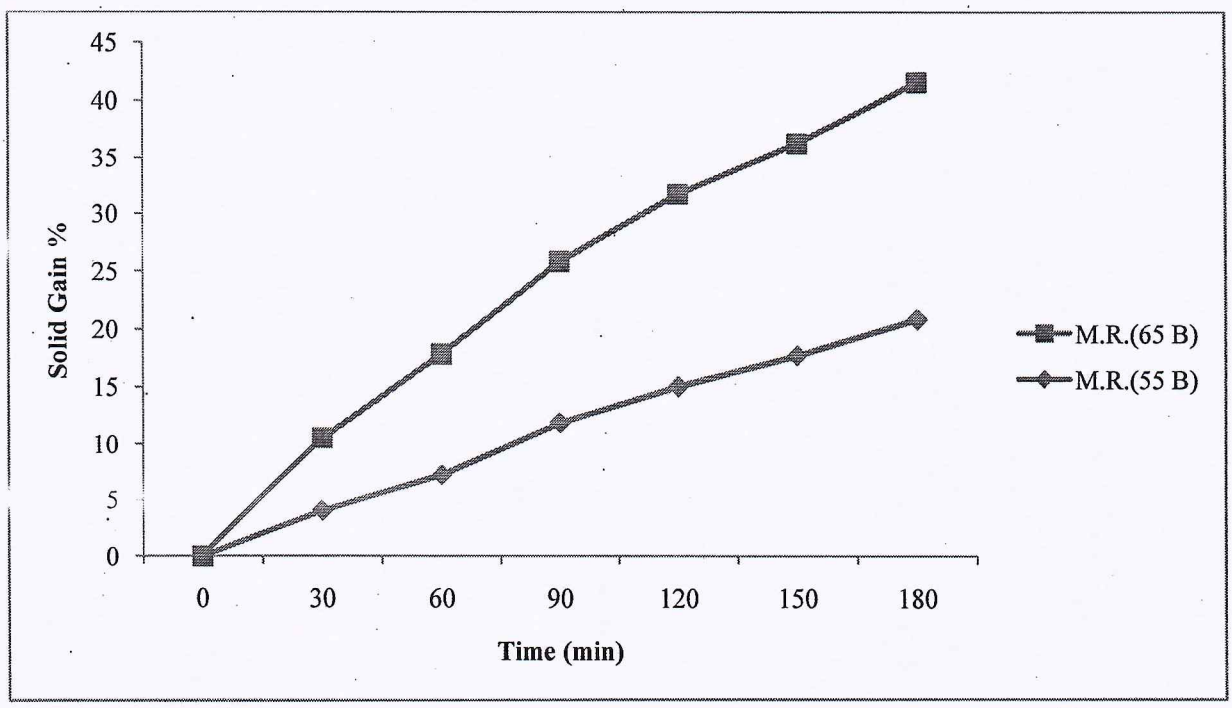


Fig. 4.1.1.2 Effect of osmotic solution concentration and time on solid gain for T_2.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

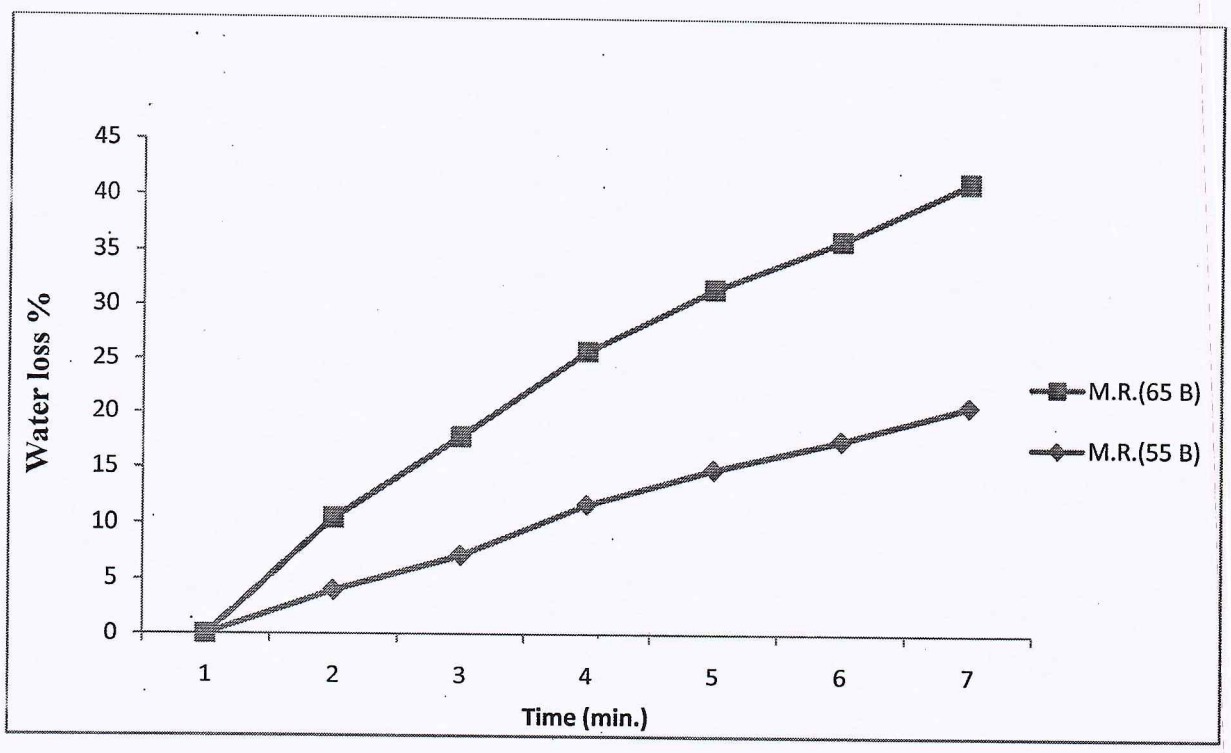


Fig. 4.1.1.3 Effect of osmotic solution concentration and time on water loss for T_3.

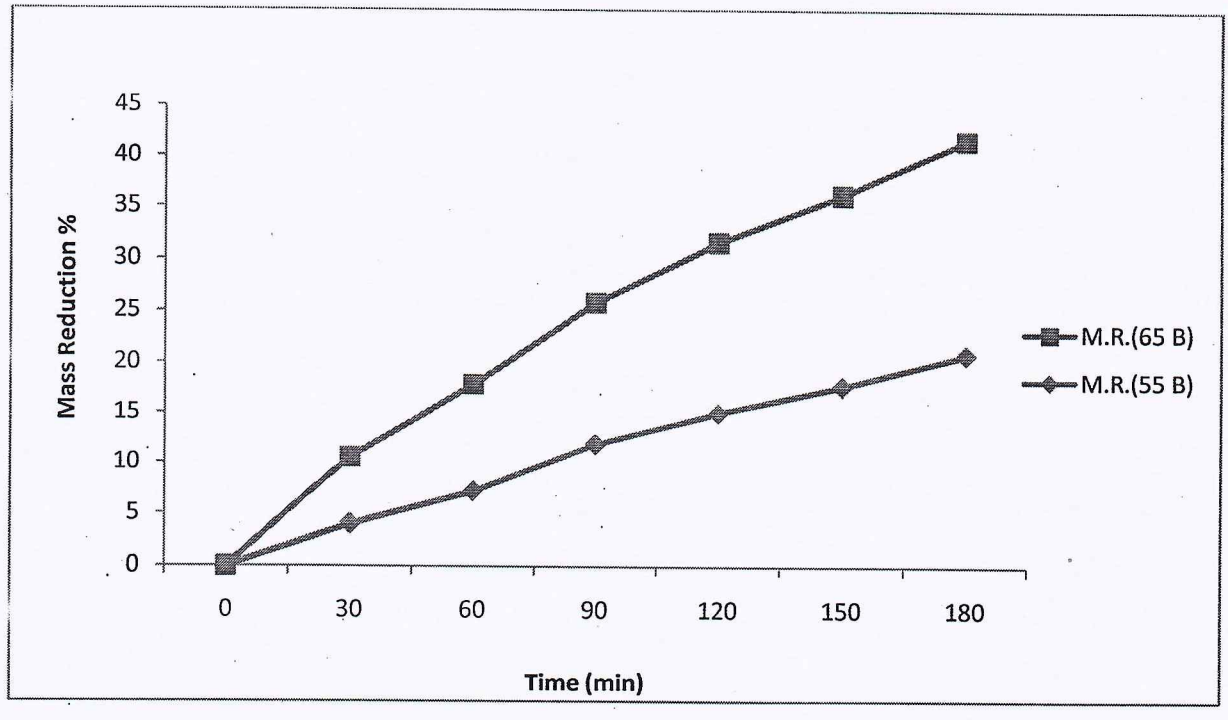


Fig. 4.1.1.4 Effect of osmotic solution concentration and time on Mass Reduction for T_3.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

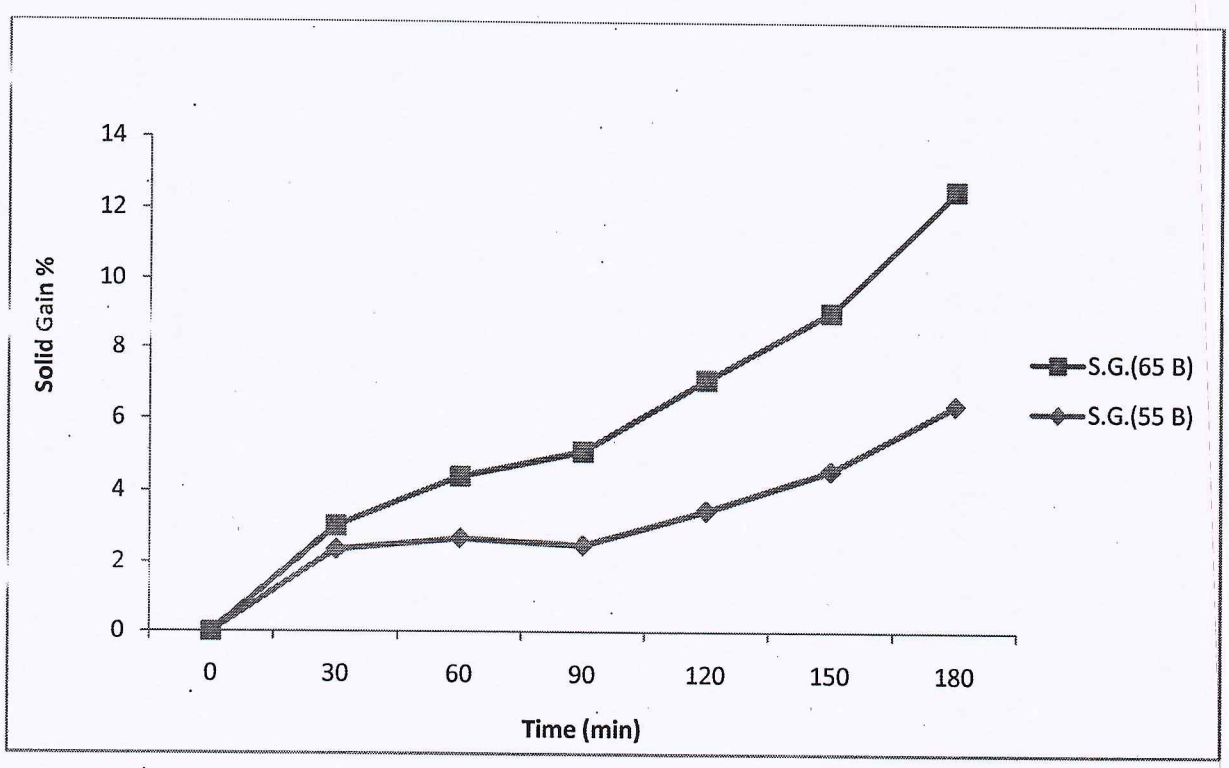


Fig. 4.1.1.5 Effect of osmotic solution concentration and time on Solid Gain for T_3.

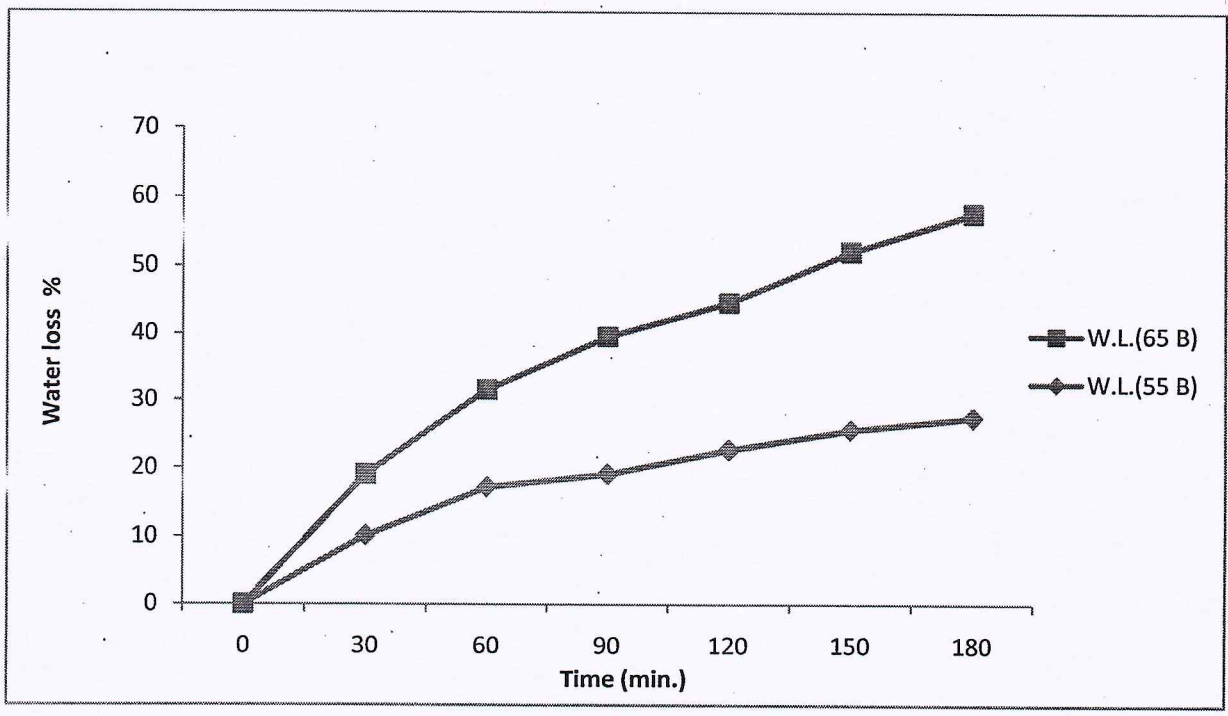


Fig. 4.1.1.6 Effect of osmotic solution concentration and time on water loss for T_4.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

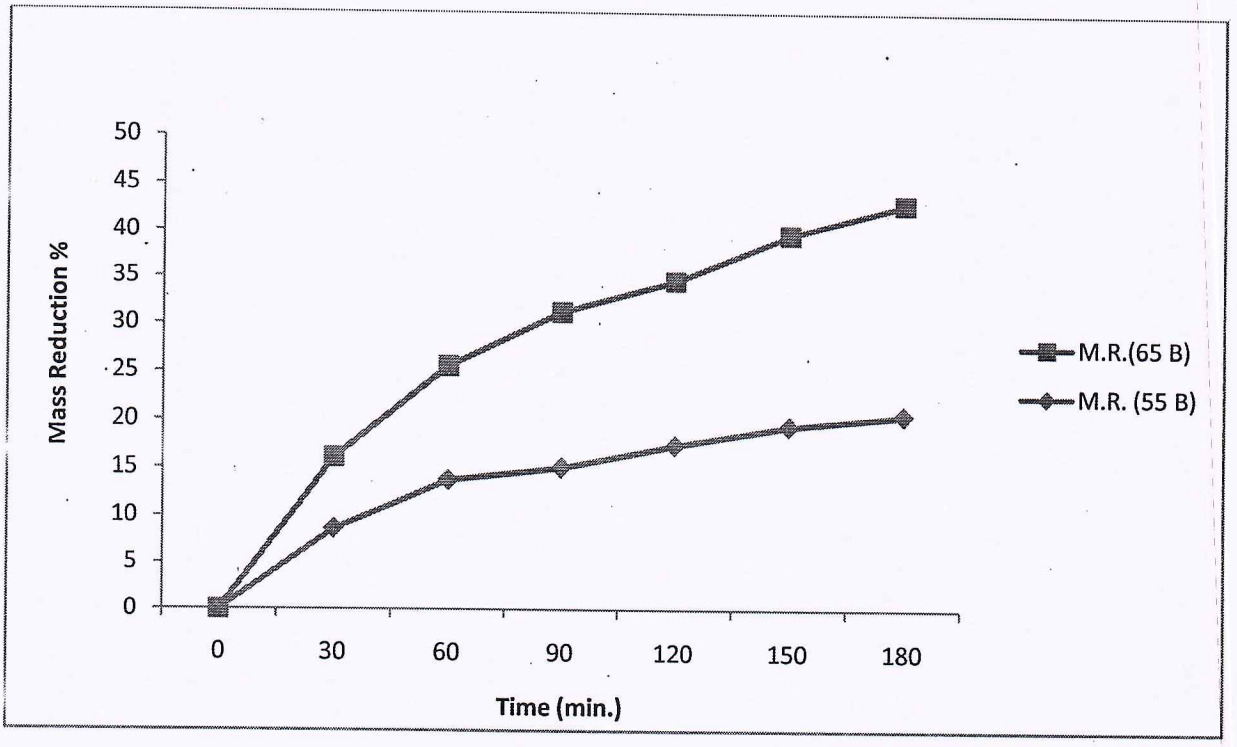


Fig. 4.1.1.7 Effect of osmotic solution concentration and time on Mass Reduction for T_4.

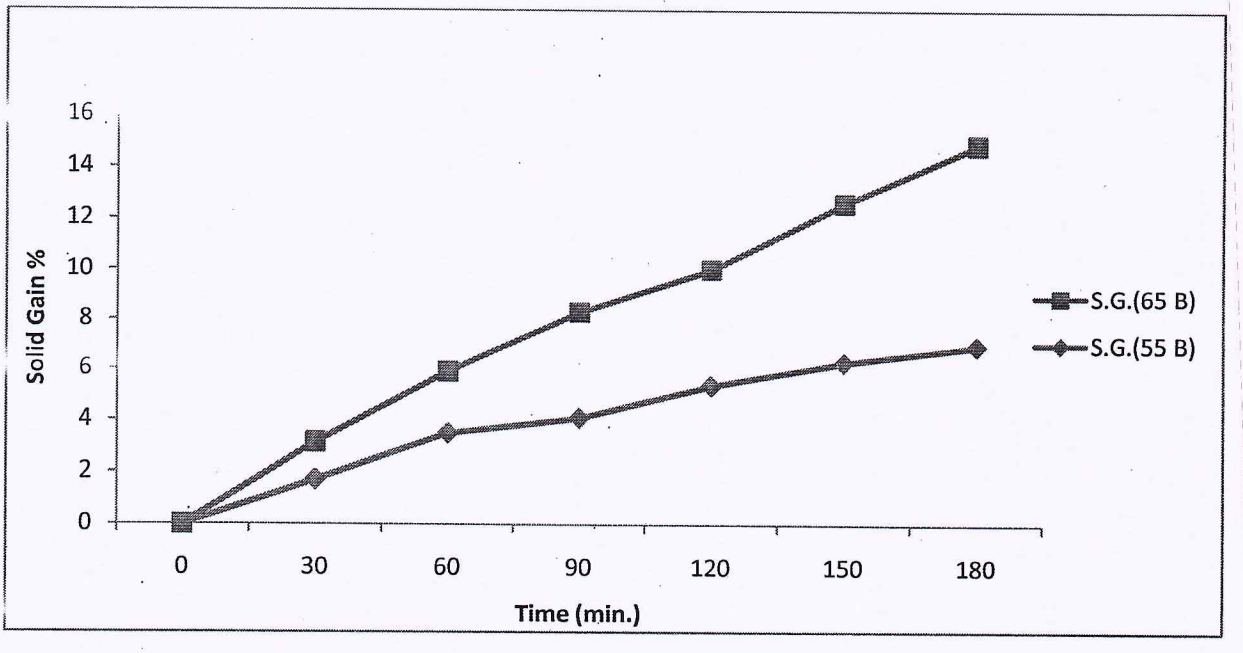


Fig. 4.1,1.8 Effect of osmotic solution concentration and time on Solid Gain for T_4.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

4.2.0 Drying kinetics of papaya slices at 55°Brix and 65°Brix in Tray dryer (60°C).

The drying behavior of papaya slices was analyzed using the experimental data of moisture of product Time interval varies from 0 to 540 minutes at 60°C temperature. The experimental data of the drying behavior of dried papaya slices with relation to moisture content, and drying rate are given in Appendix-B. It was observed from the curves that the drying rate was higher in the initial period of drying and subsequently it was reduced with decrease in moisture content. The drying in falling rate period indicates that internal mass transfer occurred by diffusion. Similar results have been reported for the drying studies on onion slices (**Rapusas and Driscoll, 1995**) and apricots (**Doymaz, 2004**). The higher drying rate at the start of drying is due to high surface moisture availability, which evaporates rapidly. Further decrease in drying rate is owed to decrease in available moisture due to low driving force and low moisture diffusion from center to surface of the dried product. Similar results were found by (**Rocha et al., 1992**). During the drying process the fig. 4.2.1 to 4.3.6 show that the complete results of moisture content on dry basis and wet basis at different drying methods.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

4.2.1. Effect of moisture content (db) at 55°Brix (Tray Dryer)

The T_1 sample was dried under cabinet tray dryer at 60°C and it was found that the maximum to minimum moisture content on (db%) ranged from 720.8 to 9.6, and in T_2 sample it was found that maximum to minimum moisture content were ranged from 236.2 to 2.4 while in T_3 and T_4 samples the moisture content varies from 254.1 to 5.3 and 166.9 to 1.7 respectively.

Table 4.2.1 Effect of moisture content (db) at 55°Brix (Tray Dryer).

Time (min.)	T_1	T_2	T_3	T_4
0	720.8	236.2	254.1	166.9
60	470.3	194.8	228.9	121.9
120	335.4	111.6	158.0	99.0
180	254.2	83.8	120.5	75.0
240	115.4	41.9	78.5	36.9
300	78.3	28.5	47.2	27.9
360	53.6	20.5	33.4	19.0
420	24.8	9.7	12.2	9.3
480	15.8	5.7	7.5	5.7
540	9.6	2.4	5.3	1.7

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

4.2.2 Effect of moisture content (wb) at 55°Brix (Tray Dryer)

The T_1 sample dried under cabinet tray dryer at 60°C and it was found that the maximum to minimum moisture content on (w.b.%) ranged from 87.7 to 8.6, and in T_2 sample it was found that maximum to minimum moisture were ranged from 69.5 to 2.4 while in T_3 and T_4 samples the moisture content varies ranged from 71.1 to 4.9 and 61.3 to 1.7 respectively.

Table 4.2.2: Effect of moisture content (wb) at 55°Brix (Tray Dryer).

Time (min.)	T_1	T_2	T_3	T_4
0	87.7	69.5	71.1	61.3
60	81.9	65.3	68.7	54.6
120	74.3	51.7	60.1	49.3
180	67.2	44.7	52.9	42.4
240	51.4	29.1	43.7	26.9
300	42.5	21.7	31.6	21.7
360	33.9	168	24.7	15.9
420	19.4	8.8	10.7	8.4
480	13.4	5.4	6.9	5.5
540	8.6	2.4	4.9	1.6

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

4.2.3 Effect of drying rate at 55°Brix (Tray Dryer)

The drying rate of T_1 sample was found maximum 4.84% after one hour and the minimum drying rate was found 0.03901 % after Nine hours. While in T_2, T_3, and T_4 samples the drying rate in tray dryer were found the maximum ranged from 0.69912, 0.52114 and 0.74889 while these treatments were found after Nine hours the minimum drying rate were observed from 0.00607, 0.00413 and 0.00732 % respectively.

Table 4.2.3 Effect of drying rate at 55°Brix (Tray Dryer).

Time	T_1	T_2	T_3	T_4
0	0	0	0	0
60	4.83659	0.69912	0.52114	0.74889
120	2.19534	0.68385	0.49052	0.19061
180	1.48911	0.17438	0.20857	0.15346
240	1.37252	0.15412	0.17482	0.13903
300	0.42216	0.04487	0.10422	0.03003
360	0.47049	0.02518	0.05837	0.02457
420	0.22453	0.02268	0.03046	0.02311
480	0.08917	0.00836	0.00985	0.00753
540	0.03901	0.00607	0.00413	0.00732

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

4.2.4 Effect of moisture content (db) at 65°Brix (Tray Dryer)

The T_1 sample was dried under cabinet tray dryer at 60°C was it was found that the maximum to minimum moisture content on (db%) ranged from 791.331 to 7.631, and in T_2 sample it was found that maximum to minimum moisture content were ranged from 205.34 to 3.67 while in T_3 and T_4 sample moisture content varies from 259.72 to 3.123 and 198.724 to 5.96 respectively.

Table 4.2.4: Effect of moisture content (db) at 65°B (Tray Dryer).

Time	T_1	T_2	T_3	T_4
0	791.331	205.336	259.721	198.724
60	588.364	145.147	177.008	152.367
120	454.38	106.171	129.017	117.293
180	352.758	83.3907	101.525	96.3254
240	195.411	45.2591	56.7572	62.4065
300	135.888	33.1735	44.6625	54.2215
360	96.088	26.7732	29.1923	35.5011
420	36.8722	13.0676	18.2058	24.5575
480	16.8483	6.87411	10.3633	14.1486
540	7.63128	3.66656	3.12345	5.96059

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

4.2.5 Effect of moisture content (wb) at 65°Brix (Tray Dryer).

The T_1 sample was dried under cabinet tray dryer at 60°C found the maximum to minimum moisture content on (w.b.%) ranged from 88.667 to 7.032, and in T_2 sample was found maximum to minimum moisture ranged from 66.397 to 3.153 while in T_3 and T_4 sample were found moisture content ranged from 70.97 to 3.008 and 66.043 to 5.583 respectively.

Table 4.2.5: Effect of moisture content (wb) at 65°Brix (Tray Dryer).

Time	T_1	T_2	T_3	T_4
0	88.6667	66.3967	70.97	66.0433
60	85.2233	58.3433	63.1667	60.14
120	81.56	50.77	55.3867	53.36
180	76.8617	44.53	48.9833	48.2033
240	64.5267	30.9133	36.0233	35.43
300	55.3943	24.71	30.5633	31.4767
360	45.9267	20.93	22.4233	24.14
420	25.76	11.5033	14.8267	18.4933
480	14.1233	6.41067	9.12	12.03
540	7.03167	3.51333	3.008	5.58333

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

4.2.6 Effect of drying rate at 65°Brix (Tray Dryer).

The drying rate of T_1 sample was found maximum drying rate 3.383 % after one hour. And the minimum drying rate was found 0.01707 % after 9 hours. While in T_2, T_3, and T_4 the drying rate were found maximum ranged from 1.0032, 1.379 and 0.77 % at 60 minutes duration. And these treatments were found minimum drying rate after 9 hours from 0.00594, 0.01341 and 0.01516 % respectively.

Table 4.2.6: Effect of drying rate at 65°Brix (Tray Dryer).

Time	T_1	T_2	T_3	T_4
0	0	0	0	0
60	3.38279	1.00315	1.379	0.77261
120	1.11653	0.32479	0.39992	0.29228
180	0.66456	0.15656	0.18273	0.14649
240	0.55561	0.14888	0.15653	0.11133
300	0.19841	0.2029	0.04232	0.05728
360	0.14056	0.03778	0.04097	0.02601
420	0.11099	0.02263	0.02616	0.02206
480	0.04172	0.0129	0.01634	0.02169
540	0.01707	0.00594	0.01341	0.01516

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

4.3.0 Effect of moisture content (wb), (db) and drying rate of the sample (HOT 60°C).

4.3.1 Effect of moisture content (db) at 55°Brix (Hot air oven)

The T_1 sample was dried under hot air oven at 60°C and it was found that maximum to minimum moisture content on (db%) ranged from 750.794 to 6.92, and in T_2 sample it was found that the maximum to minimum moisture content were ranged from 223.674 to 4.84 while in T_3 and T_4 samples found moisture content varies from 245.52 to 7.19 and 235.93 to 2.79 respectively.

Table 4.3.1 Effect of moisture content (db) at 55°Brix (Hot air oven).

Time	T_1	T_2	T_3	T_4
0	750.794	223.674	245.521	235.928
60	693.107	192.081	211.71	179.933
120	644.87	150.099	172.269	145.531
180	457.556	109.918	137.12	98.2839
240	337.358	82.46	105.985	65.694
300	207.882	63.0009	80.1418	49.9151
360	155.705	48.4005	60.6738	39.2297
420	86.2215	36.7031	48.4046	31.3507
480	58.5348	27.1505	34.6726	23.5977
540	30.8531	21.7458	28.9341	16.2551
600	15.1898	14.5062	19.4922	9.1887
660	6.91823	4.83995	7.18553	2.78857

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

4.3.2 Effect of moisture content (wb) at 55°Brix (Hot air oven)

The T_1 sample was dried under hot air oven dryer at 60°C were found the maximum to minimum moisture content on (wb%) ranged from 88.17 to 6.37, and in T_2 sample it was found that maximum to minimum moisture content were ranged from 69.05 to 4.61 while in T_3 and T_4 samples the moisture content varies from 70.88 to 6.697 and 70.003 to 2.71 respectively.

Table 4.3.2: Effect of moisture content (wb) at 55°Brix (Hot air oven).

Time	T_1	T_2	T_3	T_4
0	88.1667	69.05	70.8767	70.0033
60	87.33	65.7313	67.7967	63.98
120	86.51	59.975	62.96	59.0167
180	81.5	51.9467	57.4833	48.4433
240	75.0433	44.8317	51.3033	39.3033
300	66.76	38.1933	44.1667	33.1
360	60.4433	32.1667	37.4233	28.07
420	44.5067	26.4267	32.3333	23.8033
480	36.1533	21.16	25.5567	19.0033
540	23.5667	17.7067	22.26	13.98
600	13.1267	12.64	16.2233	8.41
660	6.36667	4.614	6.69667	2.70667

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

4.3.3 Effect of drying rate at 55°Brix (Hot air oven).

The drying rate of T_1 sample was found maximum 1.6144 % after one hour and the minimum drying rate was found 0.00961 % after 11 hours. While in T_2, T_3, and T_4 Samples the drying rate were found that maximum ranged from 0.53, 0.564 and 0.933 % at 60 minutes duration while these treatments were found after 11 hours the minimum drying rate were observed from 0.007, 0.00998 and 0.0039 % respectively.

Table 4.3.3: Effect of drying rate at 55°B (Hot air oven).

Time	T_1	T_2	T_3	T_4
0	0	0	0	0
60	1.6144	0.52655	0.56351	0.9333
120	0.90198	0.34985	0.32867	0.2867
180	0.54063	0.22323	0.19527	0.2625
240	0.50083	0.11441	0.12973	0.1358
300	0.43159	0.06486	0.08614	0.0526
360	0.16494	0.04056	0.05408	0.0297
420	0.14544	0.02785	0.02921	0.0188
480	0.05768	0.01990	0.02861	0.0162
540	0.05126	0.01401	0.01863	0.0136
600	0.02611	0.01207	0.01574	0.0118
660	0.01253	0.01065	0.01065	0.0097
720	0.00961	0.007	0.00998	0.0039

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

4.3.4 Effect of moisture content (db) at 65°Brix (Hot air oven)

The T_1 sample was dried under hot air oven at 60°C and it was found that maximum to minimum moisture content on (db%) ranged from 772.73 to 16.303 and in T_2 sample it was found that maximum to minimum moisture content were ranged from 251.814 to 4.12. While in T_3 and T_4 samples the moisture content varies from 371.89 to 9.32 and 297.36 to 9.76 respectively.

Table 4.3.4: Effect of moisture content (db) at 65°Brix (Hot air oven).

Time (min.)	T_1	T_2	T_3	T_4
0	772.73	251.814	371.893	297.36
60	717.014	204.029	265.386	223.055
120	661.43	164.984	192.958	177.847
180	569.834	117.122	153.733	116.904
240	456.806	76.4046	104.066	78.4525
300	312.347	56.3851	67.1157	62.9765
360	243.708	47.3862	52.293	47.4985
420	156.356	35.4526	37.4874	36.0728
480	113.161	28.2689	30.3976	29.0476
540	71.2687	18.9684	22.3196	22.8556
600	53.6365	11.2199	16.4158	16.6661
660	16.3039	4.11503	9.32241	9.76178

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

4.3.5 Effect of moisture content (wb) at 65°Brix (Hot air oven)

The T_1 sample was dried under hot air oven at 60°C was found the maximum to minimum moisture content on (wb%) ranged from 88.5 to 13.29 and in T_2 sample it was found that maximum to minimum moisture content were ranged from 71.05 to 3.94. while in T_3 and T_4 samples moisture content varies from 78.35 to 8.33 and 74.36 to 8.68 respectively.

Table 4.3.5: Effect of moisture content (wb) at 65°Brix (Hot air oven).

Time (min.)	T_1	T_2	T_3	T_4
0	88.5	71.05	78.3467	74.3567
60	87.72	67.0567	72.5133	68.8367
120	86.8367	62.2467	65.65	63.5667
180	84.9633	53.4367	60.2567	53.59
240	81.8733	43.0833	49.8667	43.2467
300	74.8767	35.9467	39.0867	37.9667
360	69.5533	32.13	33.8533	31.7867
420	56.12	26.17	26.8067	26.29
480	47.89	22.0233	22.95	22.34
540	37.2533	15.8933	17.91	18.4933
600	30.43	10.07	13.78	14.2233
660	13.2933	3.93667	8.32667	8.68333

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

4.3.6 Effect of drying rate at 65°Brix (Hot air oven)

The drying rate of T_1 sample was found maximum 0.93 % after one hour and the minimum drying rate was found 0.02264 % after 12 hours. While in T_2, T_3, and T_4 samples the drying rates were found that maximum ranged from 0.796, 2.65 and 1.24at 60 minutes duration while these treatments were found after 12 hours the minimum drying rate were observed from 0.00572, 0.0129 and 00.01032 % respectively.

Table 4.3.6: Effect of drying rate at 65°Brix (Hot air oven).

Time(min.)	T_1	T_2	T_3	T_4
0	0	0	0	0
60	0.92855	0.79642	2.6522	1.23842
120	0.56321	0.32537	0.8629	0.37673
180	0.48887	0.26590	0.4187	0.33857
240	0.47195	0.16966	0.2784	0.16022
300	0.47053	0.06673	0.1696	0.05159
360	0.29066	0.02800	0.0648	0.04299
420	0.20798	0.02641	0.0478	0.02720
480	0.08999	0.01797	0.0278	0.01464
540	0.07758	0.01422	0.0221	0.01147
600	0.05939	0.01291	0.0208	0.01056
660	0.02656	0.01076	0.0187	0.01046
720	0.02264	0.00572	0.0129	0.01032

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

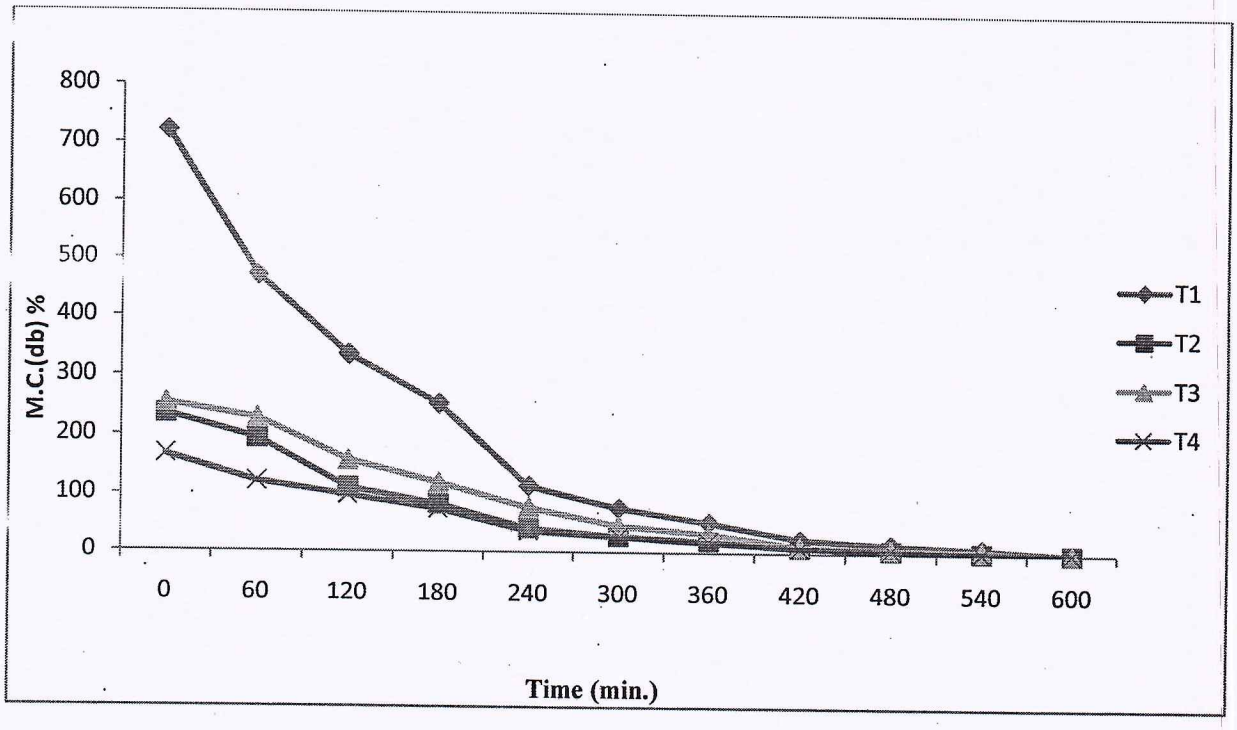


Fig. 4.2.1. Effect of moisture content (db) at 55°B (Tray Dryer).

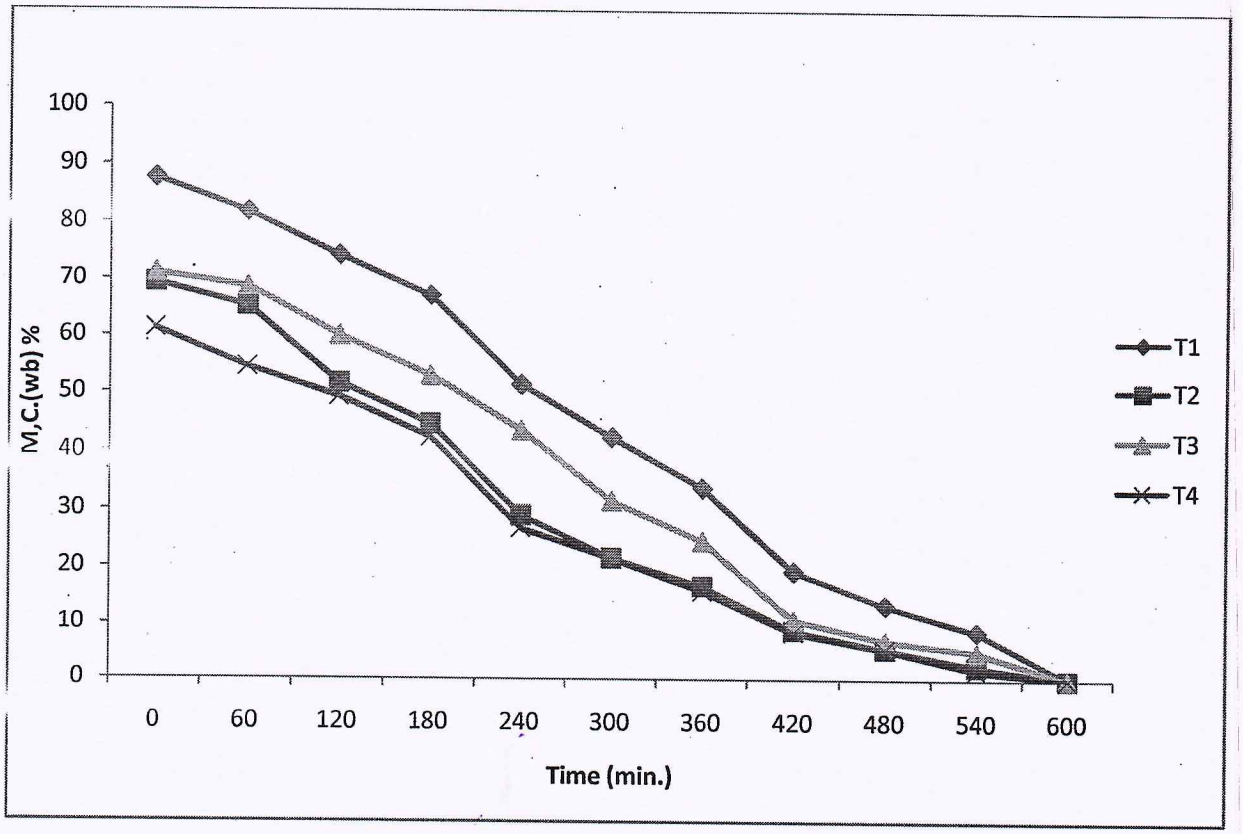


Fig. 4.2.2 Effect of moisture content (wb) at 55°B (Tray Dryer).

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

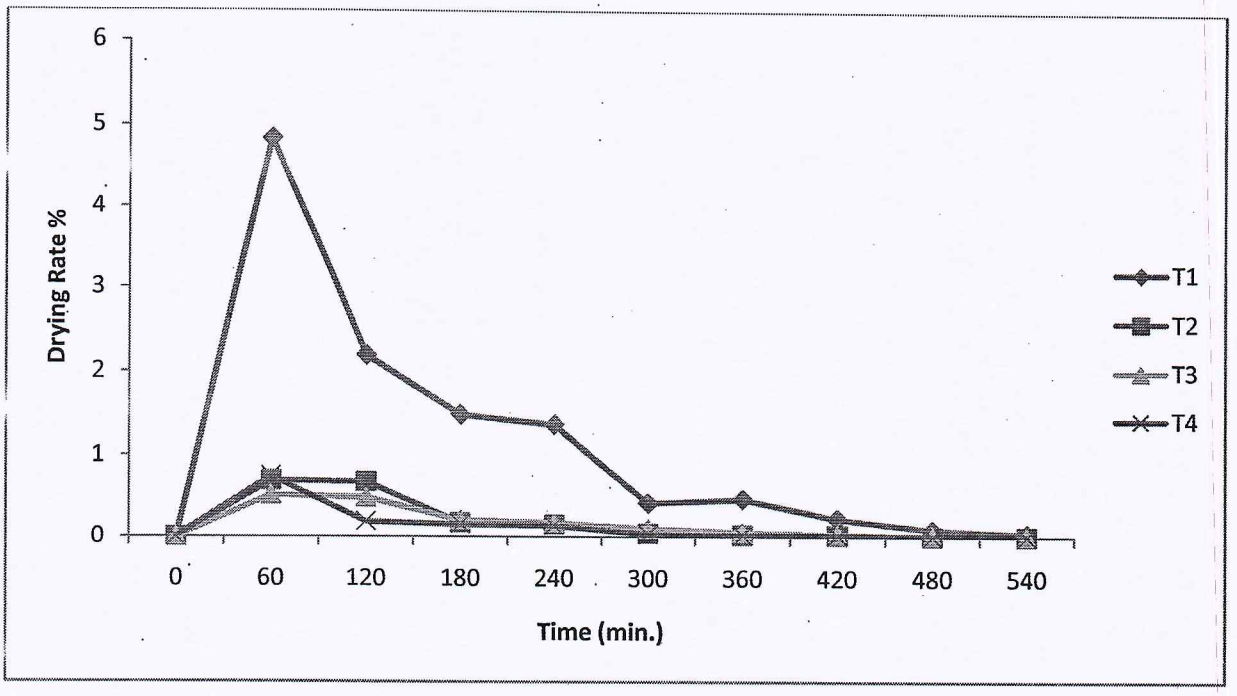


Fig. 4.2.3 Effect of drying rate % at 55°B (Tray Dryer).

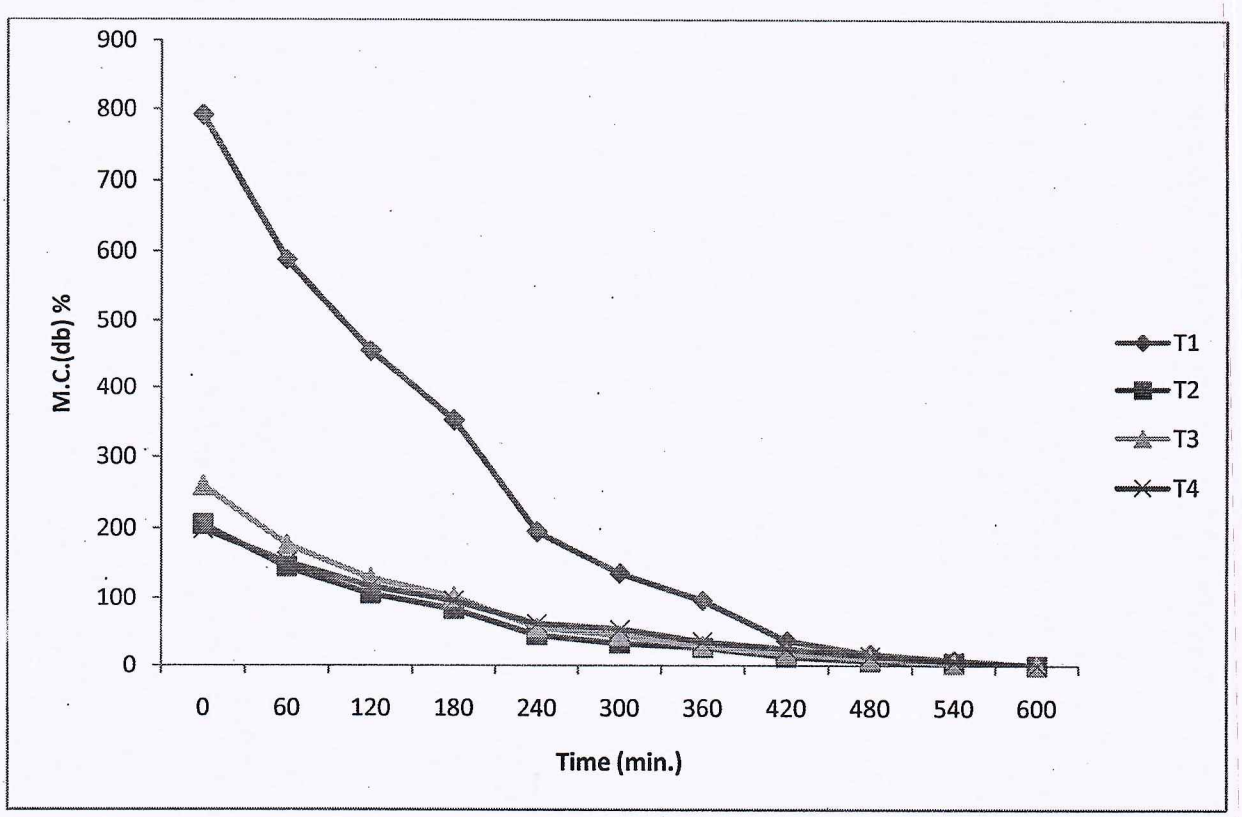


Fig. 4.2.4 Effect of moisture content (db) at 65°Brix (Tray Dryer).

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

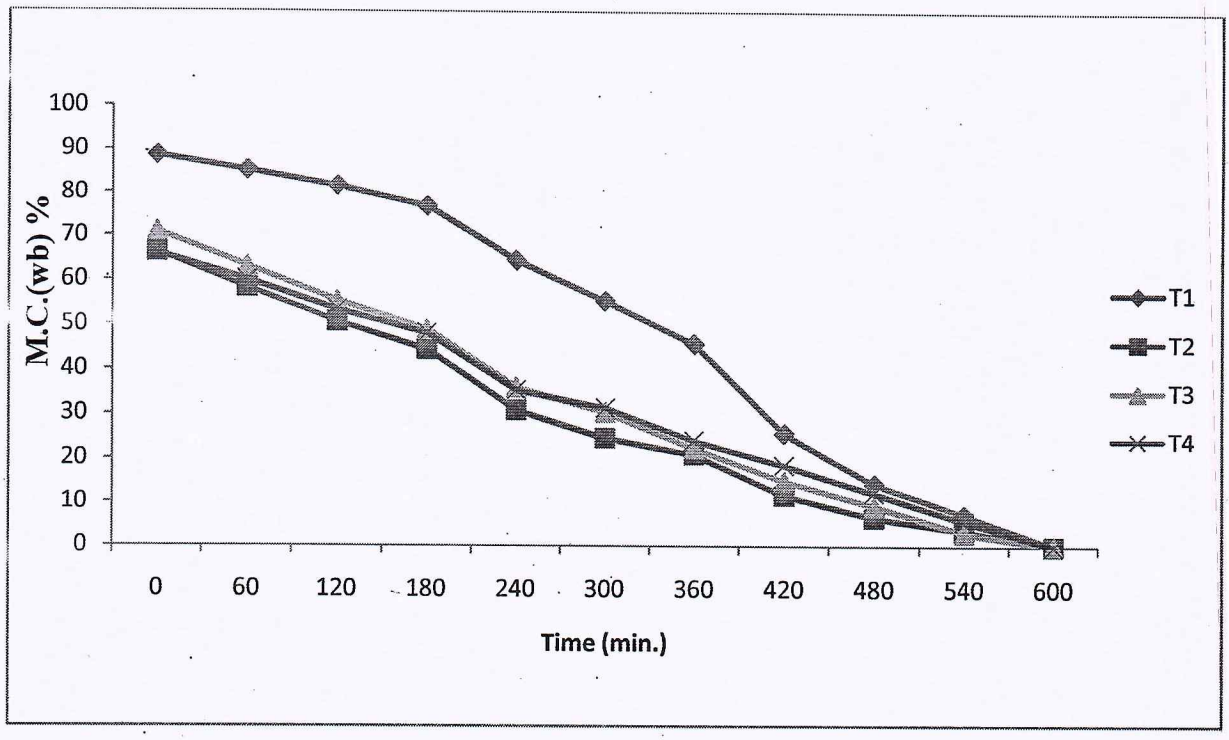


Fig. 4.2.5 Effect of moisture content (wb) at 65°B (Tray Dryer).

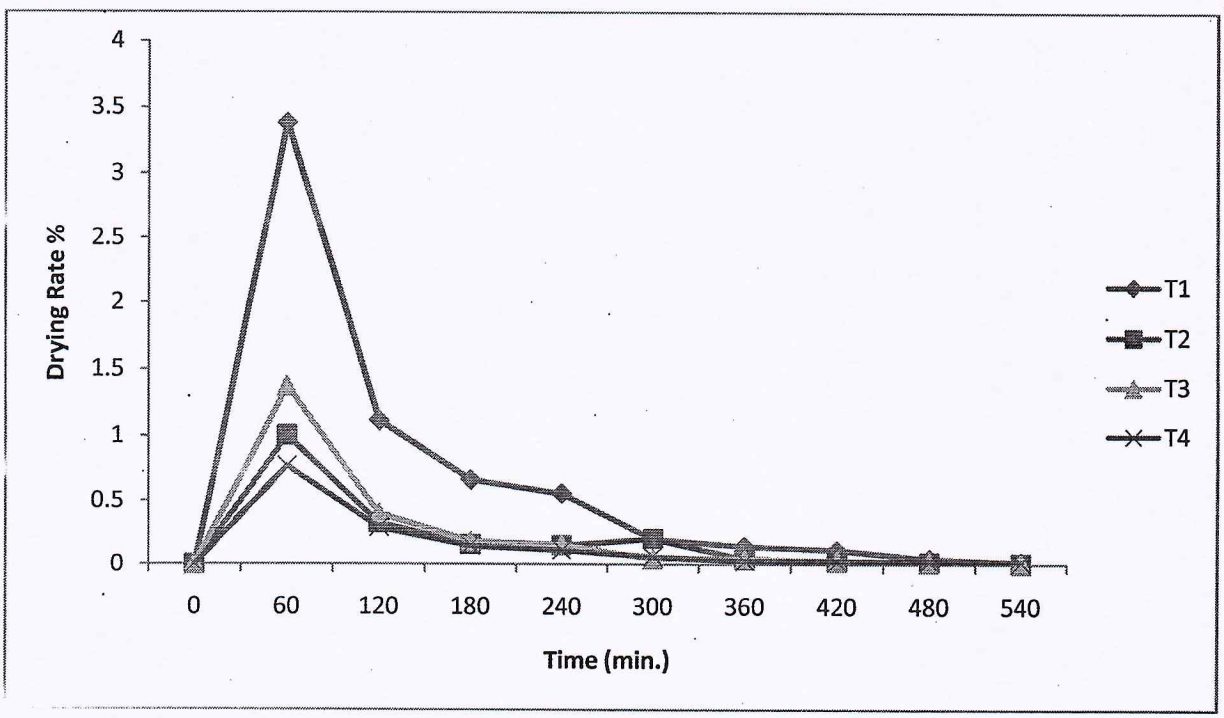


Fig. 4.2.6 Effect of drying rate % at 65°Brix (Tray Dryer).

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

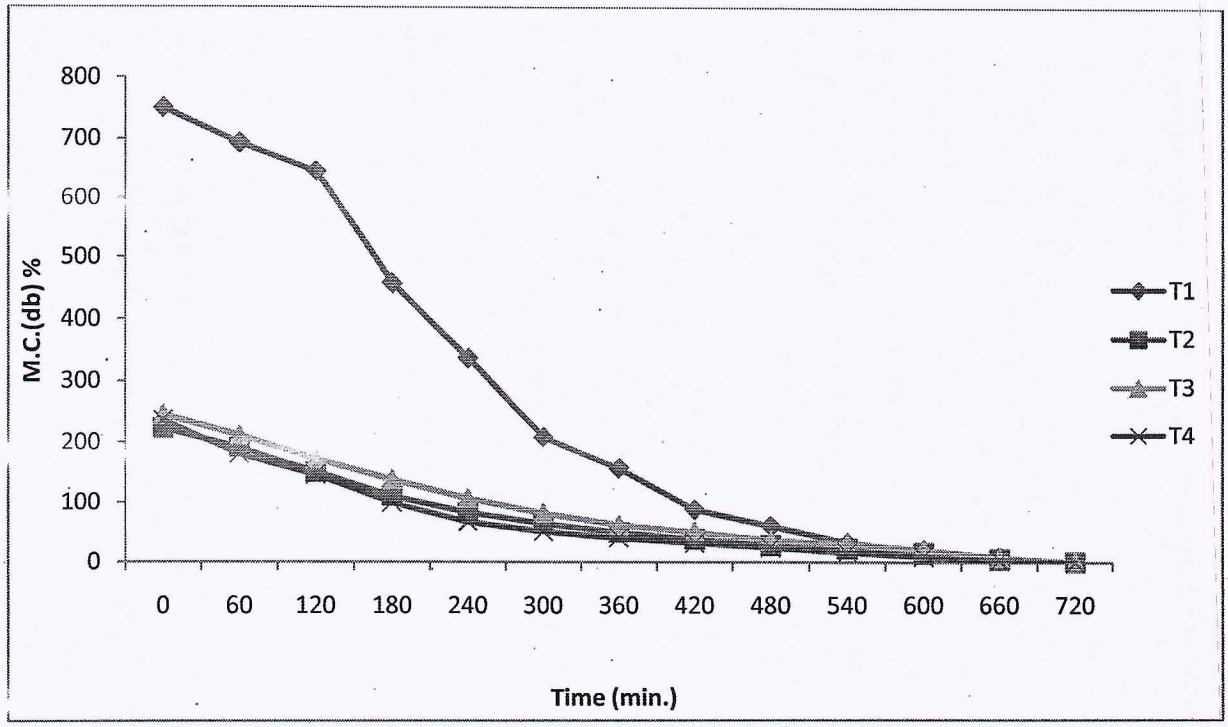


Fig. 4.3.1 Effect of moisture content (db) at 55°Brix (Hot air oven).

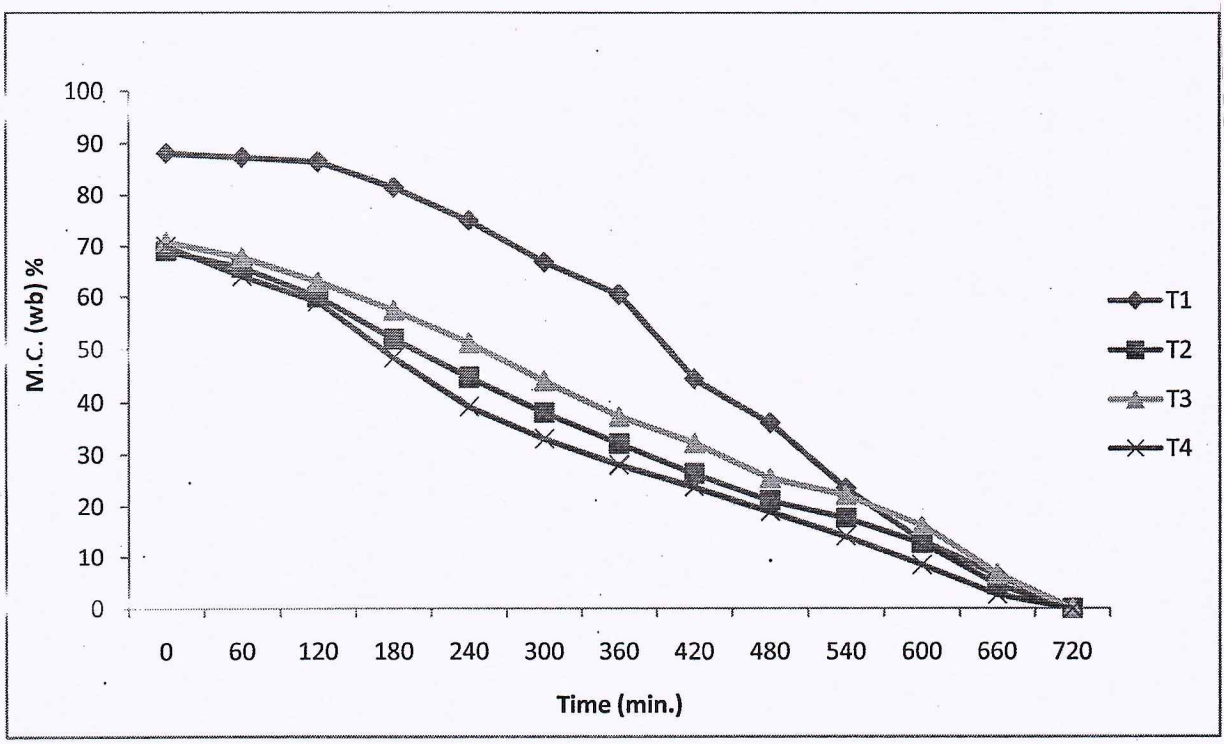


Fig. 4.3.2 Effect of moisture content (wb) at 55°Brix (Hot air oven).

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

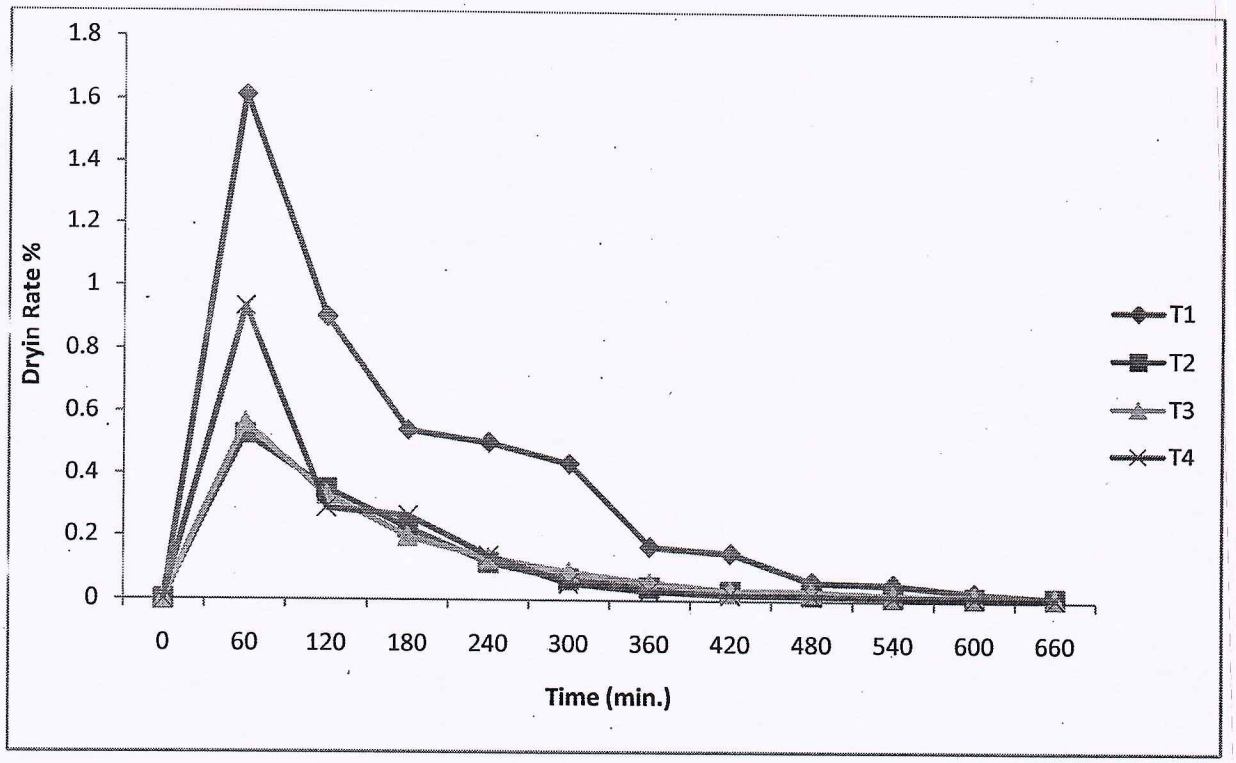


Fig. 4.3.3 Effect of drying rate at 55°B (Hot air oven).

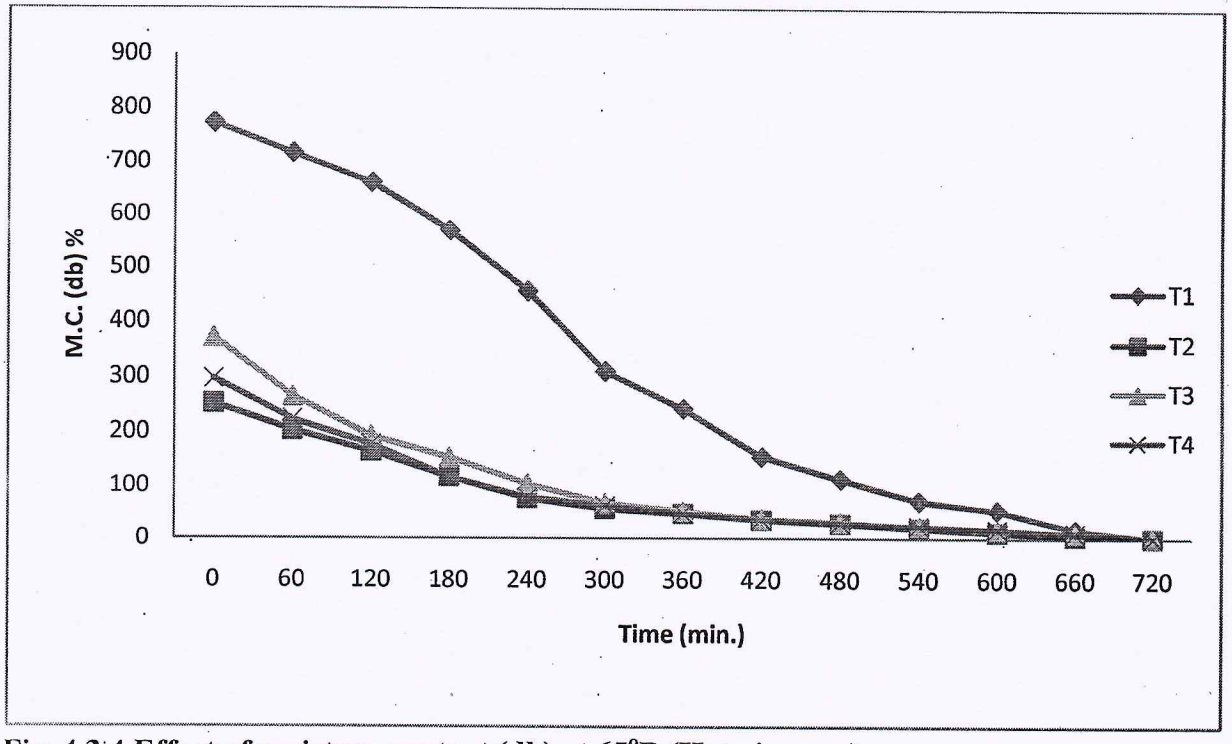


Fig. 4.3.4 Effect of moisture content (db) at 65°B (Hot air oven).

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

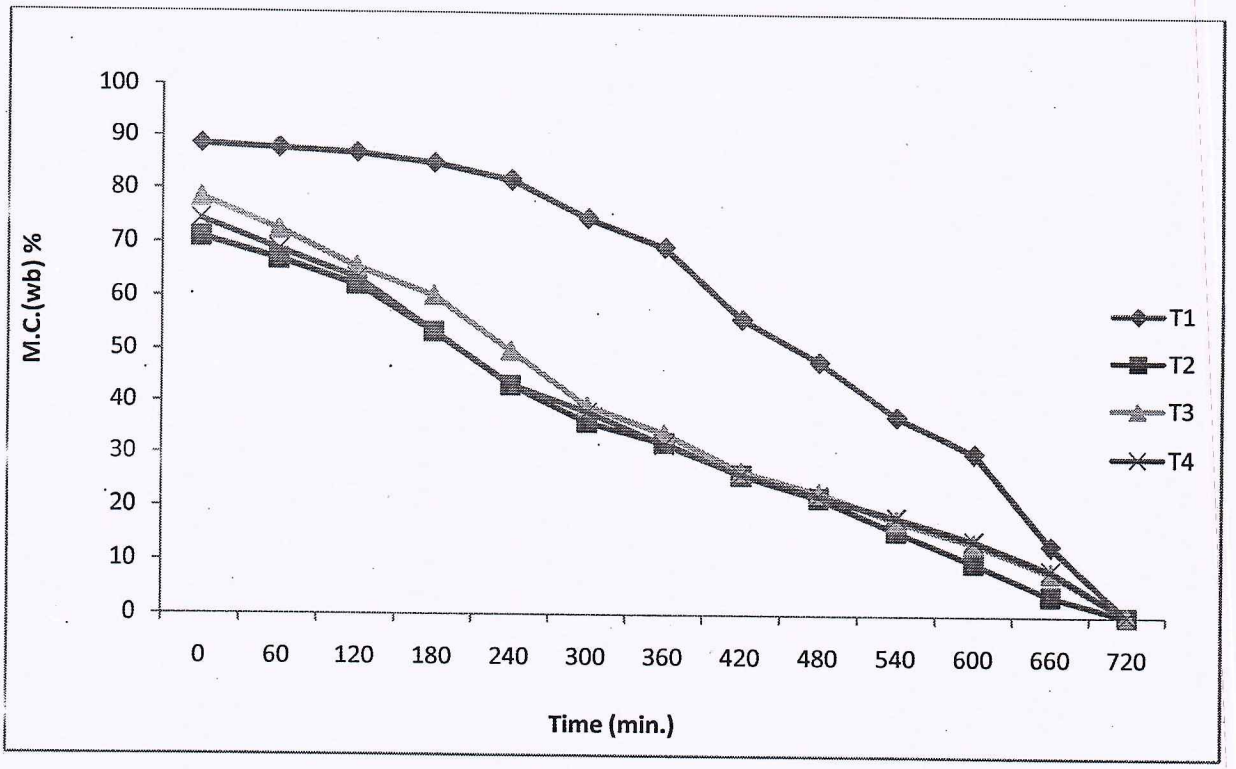


Fig. 4.3.5 Effect of moisture content (wb) at 65°B (Hot air oven).

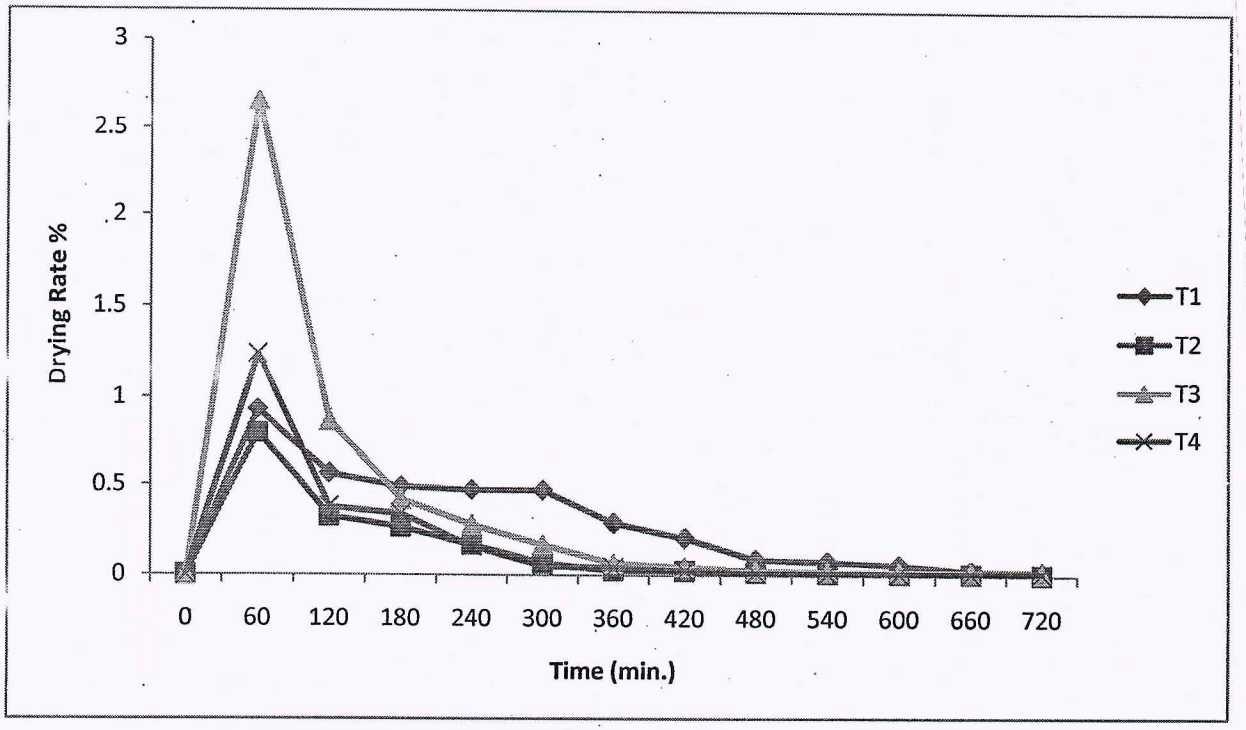


Fig. 4.3.6 Effect of drying rate at 65°B (Hot air oven).

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

4.4.0 Effect of Rehydration ratio on osmo dried papaya slices for 55°Brix and 65°Brix (Tray dryer) and different storage periods.

Rehydration Ratio:

Rehydration is a complex phenomenon affected by numerous factors. Important factor that would affect the rehydration is the changing of cell structure during the drying process. In most cases, the changing of cell structure is related to drying product temperature.

The rehydration ratio of tray dried papaya slices were immersed in syrup concentration of 55°Brix & 65°Brix for different storage on 0, 30, 60 and 90 days time periods. The Effect of Rehydration Ratio on Osmo-convective dehydration papaya slices clearly show in fig. 4.4.1 to 4.4.4 and the data was analyzed by online OPSTAT which have been show in appendix-D.

4.4.1. Effect of Rehydration Ratio on Tray dried papaya slices for 55°Brix during storage period.

It was observed that the rehydration ratio of T_1 sample 4.814, 4.819, 4.82 and 4.821 after 0, 30, 60 and 90 days of storage period respectively. The T_2 sample was observed that the rehydration ratio 3.06, 3.08, 3.1 and 3.12 after same storage period respectively. The T_3 was observed that the rehydration ratio2.42, 2.46, 2.47 and 2.47 on same storage period. And the T_4 samples was observed that the rehydration ratio3.44, 3.45, 3.45 and 3.45 after 0, 30, 60 and 90 days of storage period respectively.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Table: 4.4.1 Effect of Rehydration Ratio on Tray dried papaya slices for 55°Brix during storage period.

Treatments	Rehydration Ratio (R.R.)			
	0 (day)	30 (day)	60 (day)	90 (day)
T_1	4.814	4.819	4.82	4.821
T_2	3.06	3.08	3.1	3.11
T_3	2.42	2.46	2.47	2.47
T_4	3.44	3.45	3.45	3.45

4.4.2 Effect of Rehydration Ration on tray dried papaya slices for 65°Brix during storage periods.

It was observed that the rehydration ratio of T_1 sample 4.92, 4.93, 4.96 and 4.96 after 0, 30, 60 and 90 days of storage period respectively. The T_2 sample was observed that the rehydration ratio 2.62, 2.64, 2.67 and 2.69 after same storage period respectively. The T_3 was observed that the rehydration ratio 2.94, 2.95, 2.96 and 2.98 on same storage period. And the T_4 samples was observed that the rehydration ratio 1.8, 2.0, 2.05 and 2.1 after 0, 30, 60 and 90 days of storage period respectively.

Table 4.4.2 Effect of Rehydration Ration on tray dried papaya slices for 65°Brix during storage periods.

Treatments	Rehydration Ratio (R.R.)			
	0 (day)	30 (day)	60 (day)	90 (day)
T_1	4.92	4.93	4.96	4.96
T_2	2.62	2.64	2.67	2.69
T_3	2.94	2.95	2.96	2.98
T_4	1.8	2	2.05	2.1

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

4.4.3 Effect of Rehydration Ratio on hot air oven dried papaya slices for 55°Brix during storage period.

It was observed that the rehydration ratio of T_1 sample 5.04, 5.06, 5.07 and 5.08 after 0, 30, 60 and 90 days of storage period respectively. The T_2 sample was observed that the rehydration ratio 2.04, 2.27, 2.29 and 2.30 after same storage period respectively. The T_3 was observed that the rehydration ratio 3.02, 3.05, 3.07 and 3.07 on same storage period. And the T_4 samples was observed that the rehydration ratio 2.48, 2.54, 2.55 and 2.56 after 0, 30, 60 and 90 days of storage period respectively.

Table 4.4.3 Effect of Rehydration Ratio on hot air oven dried papaya slices for 55°Brix during storage periods.

Treatments	Rehydration Ratio (R.R.)			
	0 (day)	30 (day)	60 (day)	90 (day)
T_1	5.04	5.06	5.07	5.08
T_2	2.24	2.27	2.29	2.3
T_3	3.02	3.05	3.07	3.07
T_4	2.48	2.54	2.55	2.56

4.4.4 Effect of Rehydration Ratio on hot air oven dried papaya slices for 65°Brix during storage periods.

It was observed that the rehydration ratio of T_1 sample 4.88, 4.9, 4.91 and 4.95 after 0, 30, 60 and 90 days of storage period respectively. The T_2 sample was observed that the rehydration ratio 2.56, 2.57, 2.59 and 2.61 after same storage period respectively. The T_3 was observed that the rehydration ratio 3.0, 3.02, 3.04 and 3.05 on same storage period. And the T_4

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

samples was observed that the rehydration ratio 2.80, 2.83, 2.85 and 2.89 after 0, 30, 60 and 90 days of storage period respectively.

Table 4.4.4 Effect of Rehydration Ratio on hot air oven dried papaya slices for 65°Brix during storage periods.

Treatments	Rehydration Ratio (R.R.)			
	0 (day)	30 (day)	60 (day)	90 (day)
T_1	4.88	4.9	4.91	4.95
T_2	2.56	2.57	2.59	2.61
T_3	3	3.02	3.04	3.05
T_4	2.8	2.83	2.85	2.89

4.5.0 Effect of moisture content on osmo convective dehydration of papaya slices at different storage periods.

Moisture content followed a slight increasing trend as the storage period increases and this is due to the storage of samples at ambient temperature These results are agreed with **(Alamzeb *et al.*, 1994)** they found decrease of moisture content in osmotic solution increase The variations in moisture content of Tray dried papaya slices with storage period for experimental range of syrup concentrations (30-50°Brix) and control. The effect of moisture content on osmo convective dehydration papaya slices was clearly showed in fig. 4.5.1 to 4.5.4.

4.5.1 Effect of Moisture content on Tray dried papaya slices for 55°Brix during storage periods.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

The treatments have added the moisture content at the storage period of 0, 30, 60, 90 days. The moisture of T_1 was 8.59, 8.56, 8.72 and 8.88 % respectively. While in T_2, T_3 and T_4 treatments were added the moisture from 2.38 to 2.63, 4.95 to 5.21 and 1.65 to 2.20 respectively.

Table 4.5.1: Effect of Moisture content on Tray dried papaya slices for 55°Brix during storage periods.

Treatments	Storage period (days)			
	0	30	60	90
T_1	8.59	8.65	8.72	8.88
T_2	2.38	2.47	2.54	2.63
T_3	4.95	5.05	5.12	5.21
T_4	1.65	1.95	2.14	2.20

4.5.2 Effect of Moisture content on Tray dried papaya slices for 65°Brix during storage periods.

The treatments have added the moisture content at the storage period of 0, 30, 60, 90 days. The moisture of T_1 was 7.032, 7.051, 7.089 and 7.096 % respectively. While in T_2, T_3 and T_4 treatments were added the moisture from 3.513 to 3.635, 3.008 to 3.037 and 5.583 to 5.62 % respectively.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Table 4.5.2: Effect of Moisture content on Tray dried papaya slices for 65°Brix during storage periods.

Treatments	Storage period (days)			
	0	30	60	90
T_1	7.032	7.051	7.089	7.096
T_2	3.513	3.614	3.626	3.635
T_3	3.008	3.012	3.025	3.037
T_4	5.583	5.597	5.610	5.62

4.5.3 Effect of Moisture content on hot air oven dried papaya slices for 55°Brix during storage periods.

The treatments have added the moisture content at the storage period of 0, 30, 60, 90 days. The moisture of T_1 was 6.37, 6.45, 6.67 and 6.74 % respectively. While in T_2, T_3 and T_4 treatments were added the moisture from 4.61 to 4.92, 6.70 to 6.98 and 2.71 to 2.91 % respectively.

Table 4.5.3: Effect of Moisture content on hot air oven dried papaya slices for 55°B during storage periods.

Treatments	Storage period (days)			
	0	30	60	90
T_1	6.37	6.45	6.67	6.74
T_2	4.61	4.73	4.86	4.92
T_3	6.70	6.83	6.92	6.98
T_4	2.71	2.79	2.84	2.91

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

4.5.4 Effect of Moisture content on hot air oven dried papaya slices for 65°Brix during storage periods.

The treatments have added the moisture content at the storage period of 0, 30, 60, 90 days. The moisture of T_1 was 13.29, 13.37, 13.46 and 13.59 % respectively. While the T_2, T_3 and T_4 treatments were added the moisture from 3.94 to 4.23, 8.33 to 8.63 and 8.68 to 8.93 % respectively.

Table 4.5.4: Effect of Moisture content on hot air oven dried papaya slices for 65°B during storage periods.

Treatments	Storage period (days)			
	0	30	60	90
T_1	13.29	13.37	13.46	13.59
T_2	3.94	4.08	4.16	4.23
T_3	8.33	8.45	8.56	8.63
T_4	8.68	8.75	8.84	8.93

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

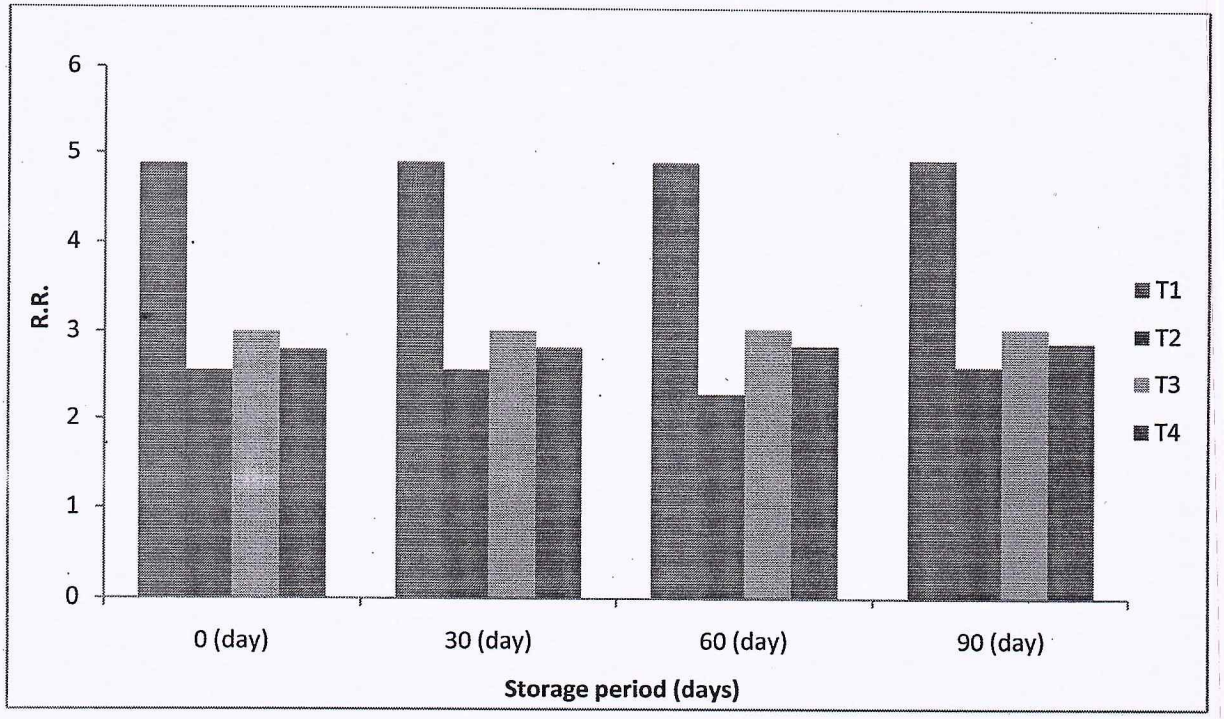


Fig. 4.4.1 Effect of Rehydration ratio on Tray dried papaya slices for 55°Brix during storage periods.

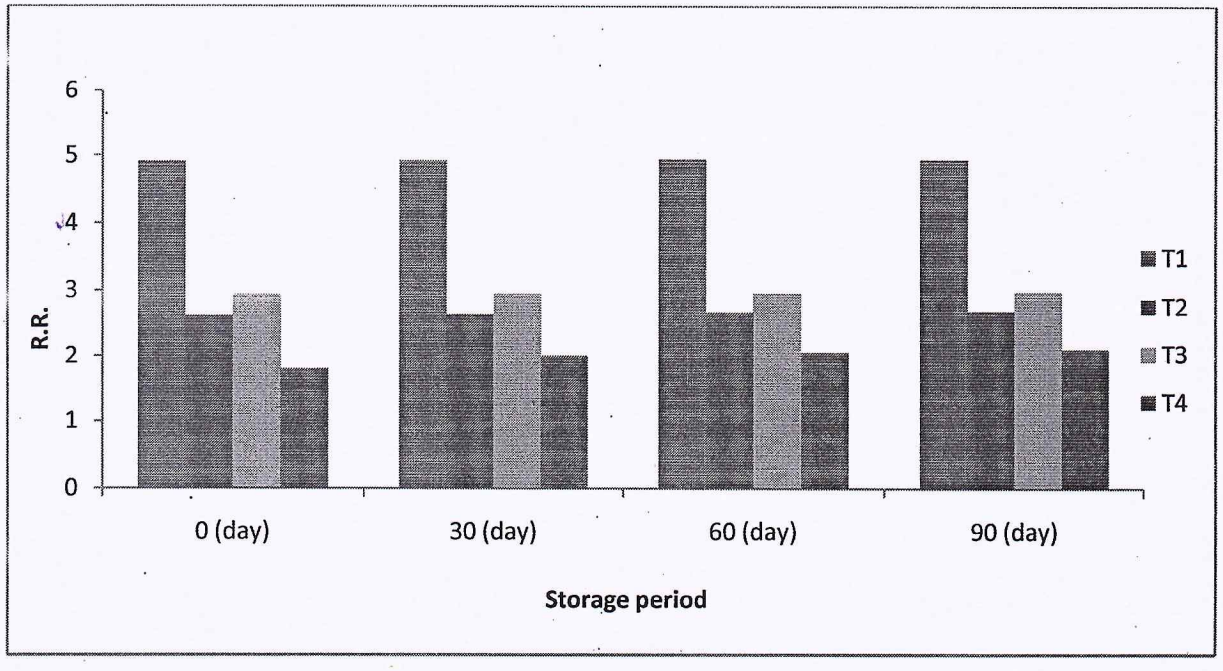


Fig. 4.4.2 Effect of Rehydration on Tray dried papaya slices for 65°Brix during storage periods.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

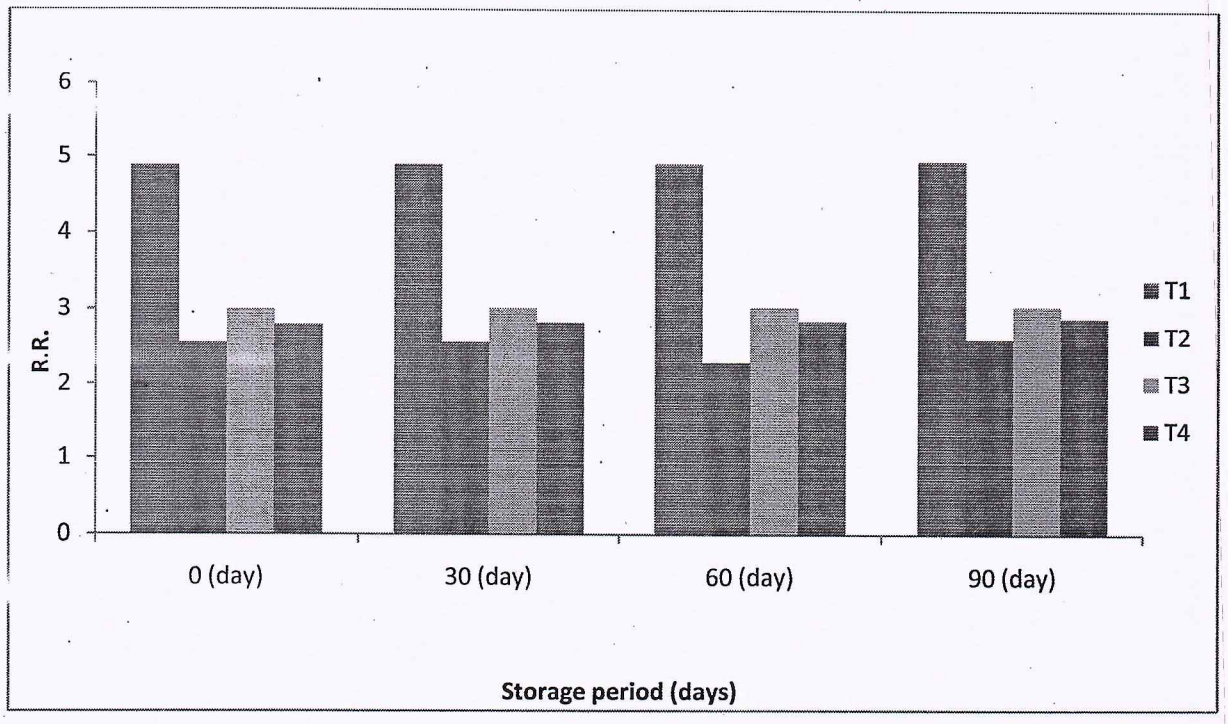


Fig. 4.4.3 Effect of Rehydration ratio on Hot air oven dried papaya slices for 55°Brix during storage periods.

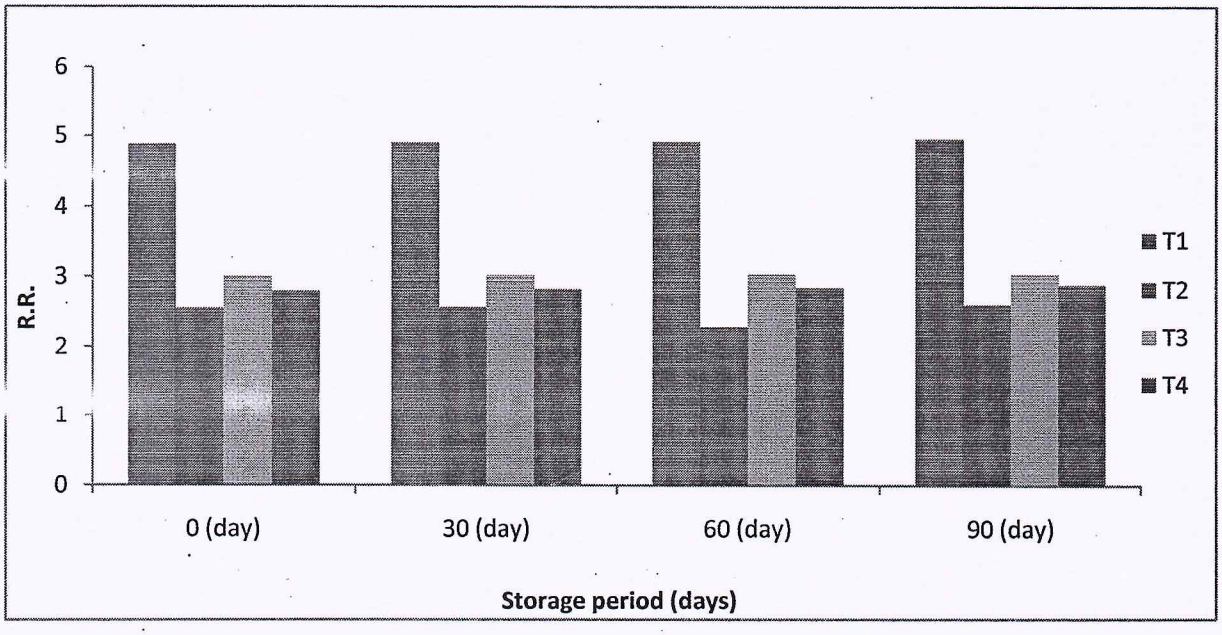


Fig. 4.4.4 Effect of Rehydration ratio on Hot air oven dried papaya slices for 65°Brix during storage periods.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

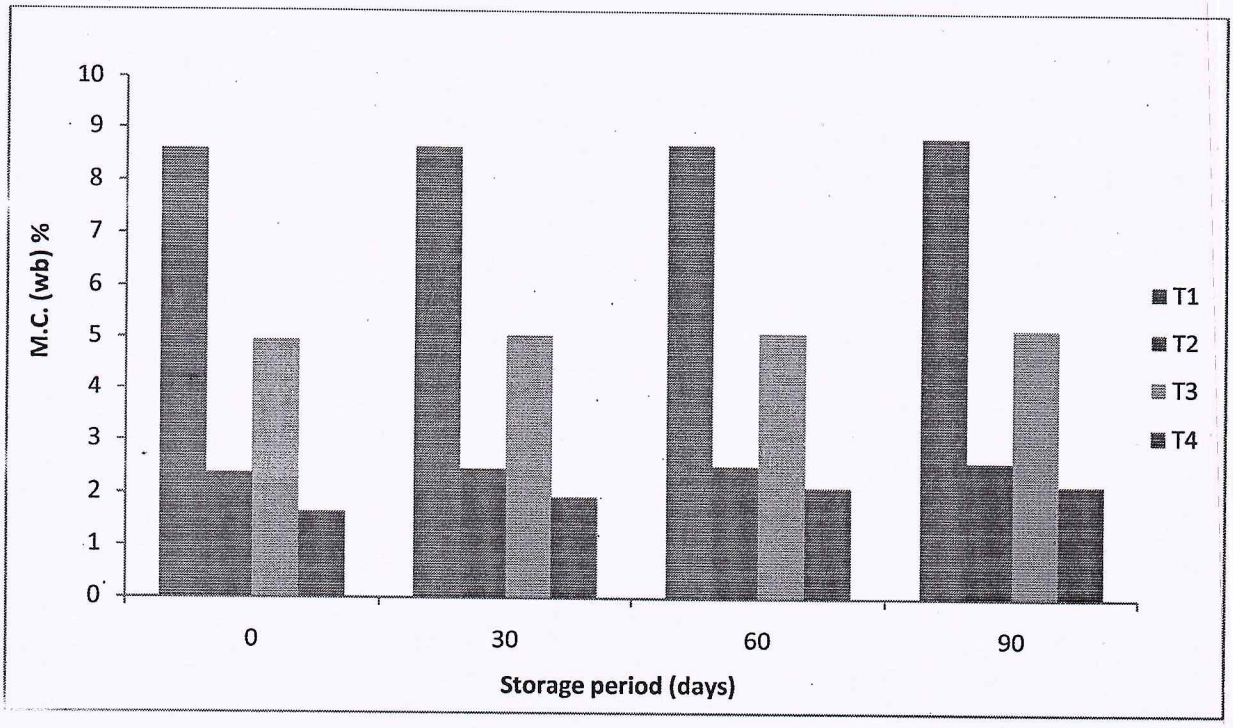


Fig. 4.5.1 Effect of Moisture content on Tray dried papaya slices for 55°Brix during storage periods.

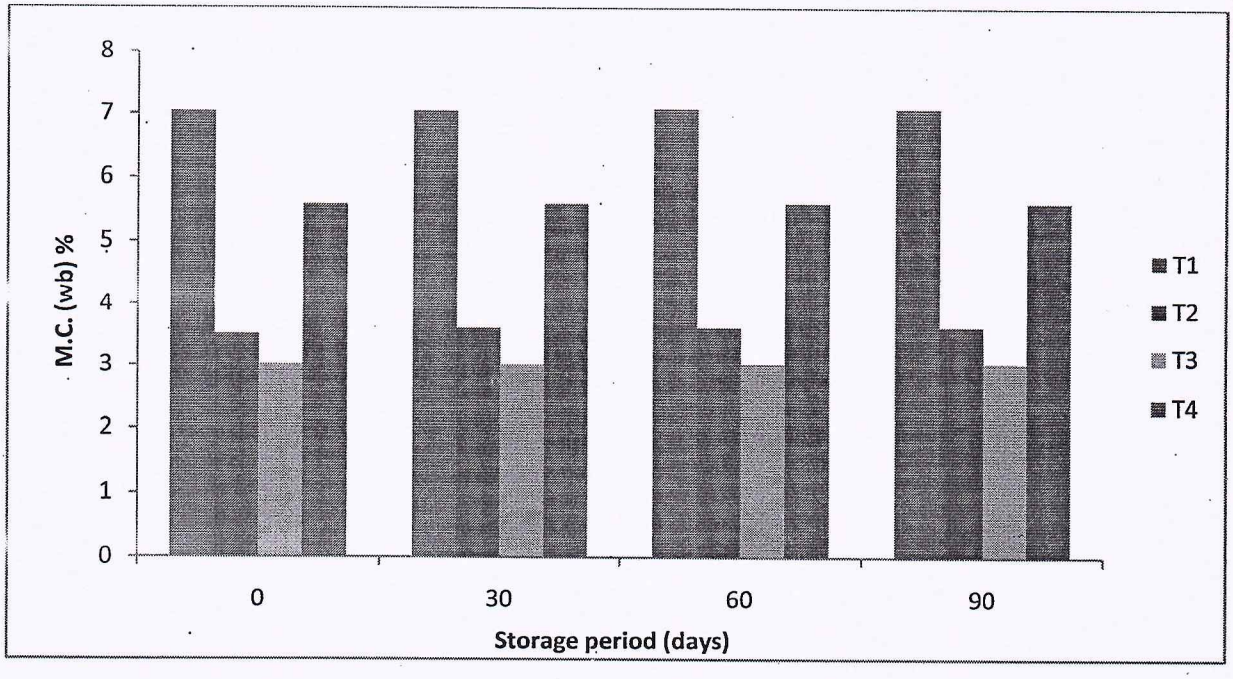


Fig.4.5.2 Effect of Moisture content on Tray dried papaya slices for 65°Brix during storage periods.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

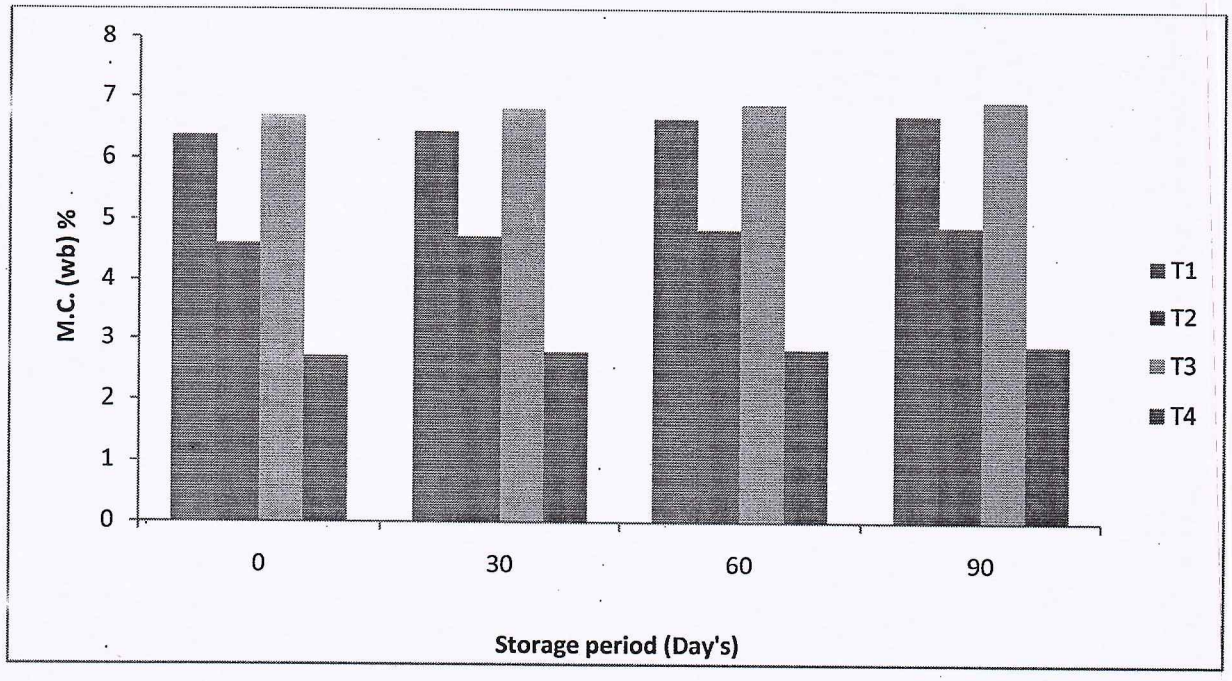


Fig. 4.5.3 Effect of Moisture content on Hot air oven dried papaya slices for 55°Brix during storage periods.

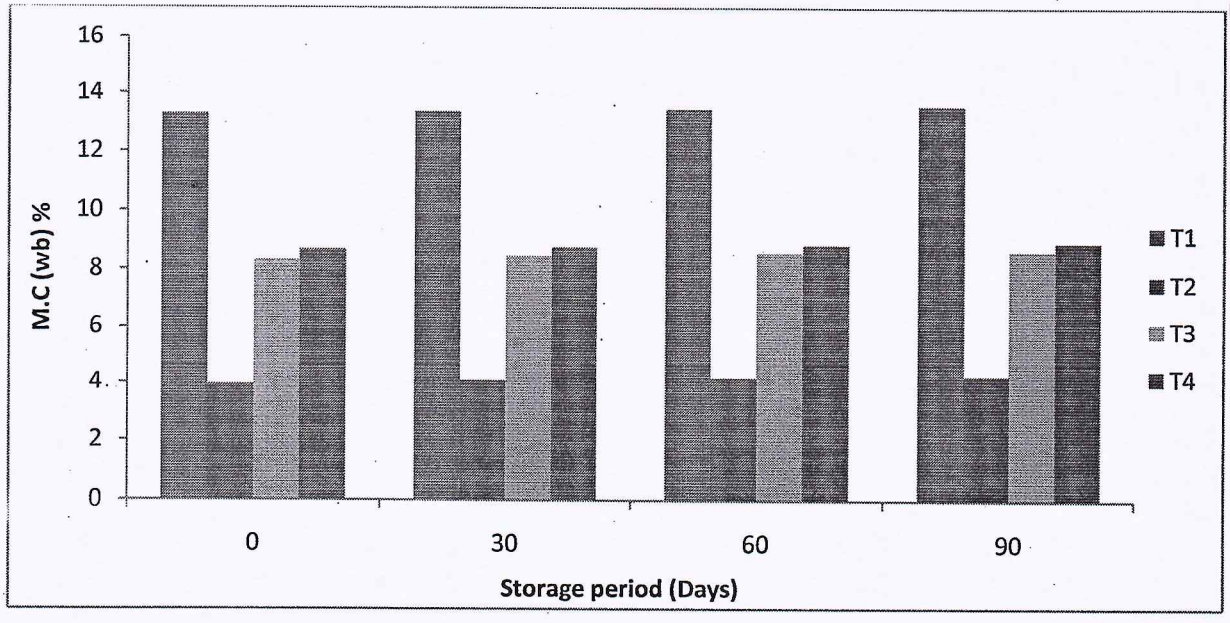


Fig. 4.5.4 Effect of Moisture content on Hot air oven dried papaya slices for 65°Brix during storage periods.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

4.6.0 Chemical Evaluation of papaya slices

The moisture content of papaya was found about as 95.99% (wb). The acidity content of papaya was found about 0.135% that average of 100 gm papaya fruits. Acidity levels also influence overall acceptability of imitation. Acidity in papaya fruits is an important factor to determine maturity. The vitamin A content of papaya was found about 285 µg that can be presented in average 100 gm. papaya. Papaya was an excellent source of vitamin C, The total ascorbic acid (Vitamin C) of papaya was found about 60.901 mg that is average in 100 gm papaya fruits.

Table 4.6.1 Chemical Evaluation data of papaya slices.

Nutrient Unit Value per 100 g

Nutrient	Unit	Value per 100 g
M.C. (wb)	%	95.99
Acidity	%	0.135
Vitamin A	µg	285
Vitamin C	Mg	60.901

4.7.0 Sensory Evaluation

Sensory quality is evaluated on parameters i.e. taste, color, flavor and overall acceptability. The score ranged from 1 to 9 which represented "Like extremely" to "dislike extremely", the dried samples were tasted by 8 judges. The Samples with osmotic pretreatment were more appreciable in comparison to samples without osmotic treatment. The mean sensory score of osmosed and untreated dried papaya slices has been shown in **Table 4.7.1 to 4.7.4** The finding has been in agreement with an earlier study **(Raoult-Wack *et al.*, 1991)** which reported that osmotic pretreatment was able to improve quality of dried product. The

Co-ordinater
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

analysis shows that, the osmotic pretreatment and drying air temperature have significant effect on sensory evaluation. The ANOVA was performed to estimate the effect of parameters on color, taste, flavor and overall acceptability score and result were found to be significant at 5 % level of significance is given in Appendix- D.

Table: 4.7.1 Mean sensory score for cabinet tray dried papaya slices at 60°C for 55°B

S. No.	Treatments	Color	Taste	Flavor	Overall Acceptability
1	T_1	5	5	5	6
2	T_2	7	6	6	7
3	T_3	7	7	7	8
4	T_4	8	8	8	9

Table 4.7.2 Mean sensory score for cabinet tray dried papaya slices at 60°C for 65°B

S. No.	Treatments	Color	Taste	Flavor	Overall Acceptability
1	T_1	5	5	5	5
2	T_2	6	7	7	7
3	T_3	7	8	8	8
4	T_4	8	9	9	9

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Table 4.7.3 Mean sensory score for Hot air oven dried papaya slices at 60°C for 55°B.

S. No.	Treatments	Color	Taste	Flavor	Overall Acceptability
1	T_1	5	6	5	5.5
2	T_2	7	7	7	7
3	T_3	8	8	8	8
4	T_4	9	9	9	9

Table 4.7.4 Mean sensory score Hot air oven dried papaya slices at 60°C for 65°B.

S. No.	Treatments	Color	Taste	Flavor	Overall Acceptability
1	T_1	5	5	5	5
2	T_2	6	7	6	7
3	T_3	7	8	8	8
4	T_4	8	9	9	9

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

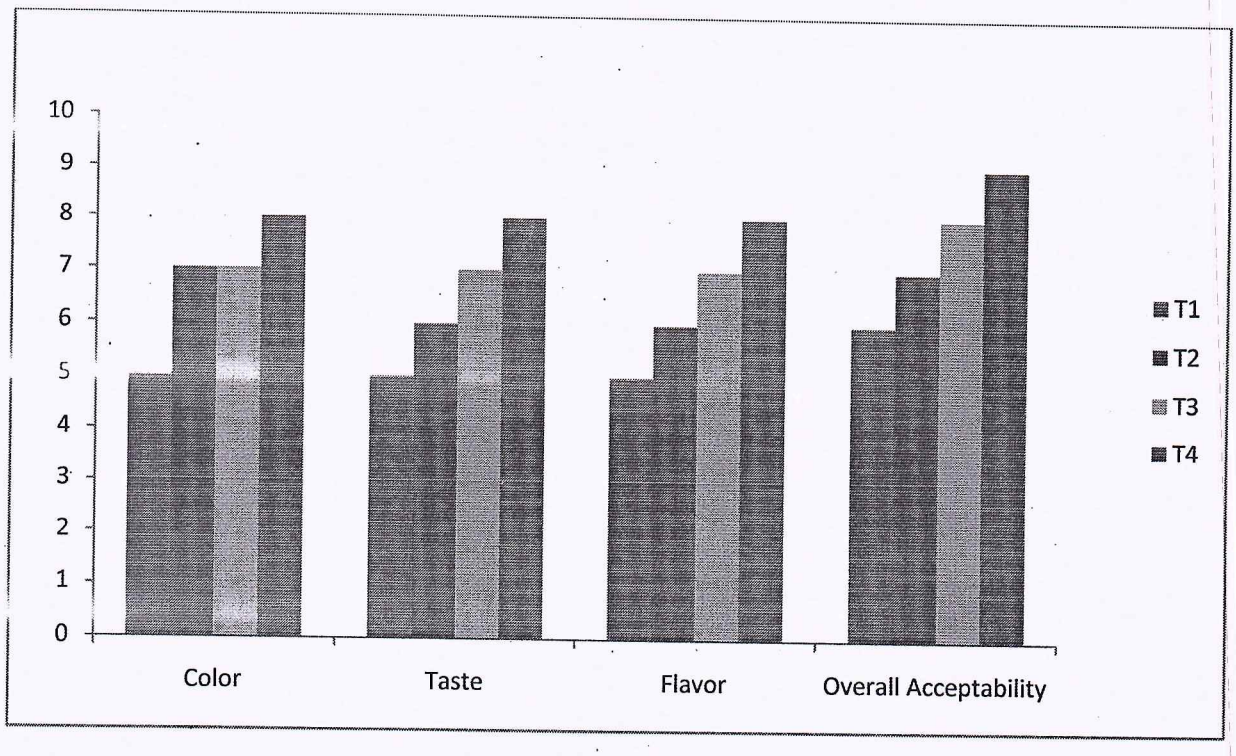


Fig. 4.7.1 Mean sensory score for cabinet tray dried papaya slices at 60°C for 55°Brix.

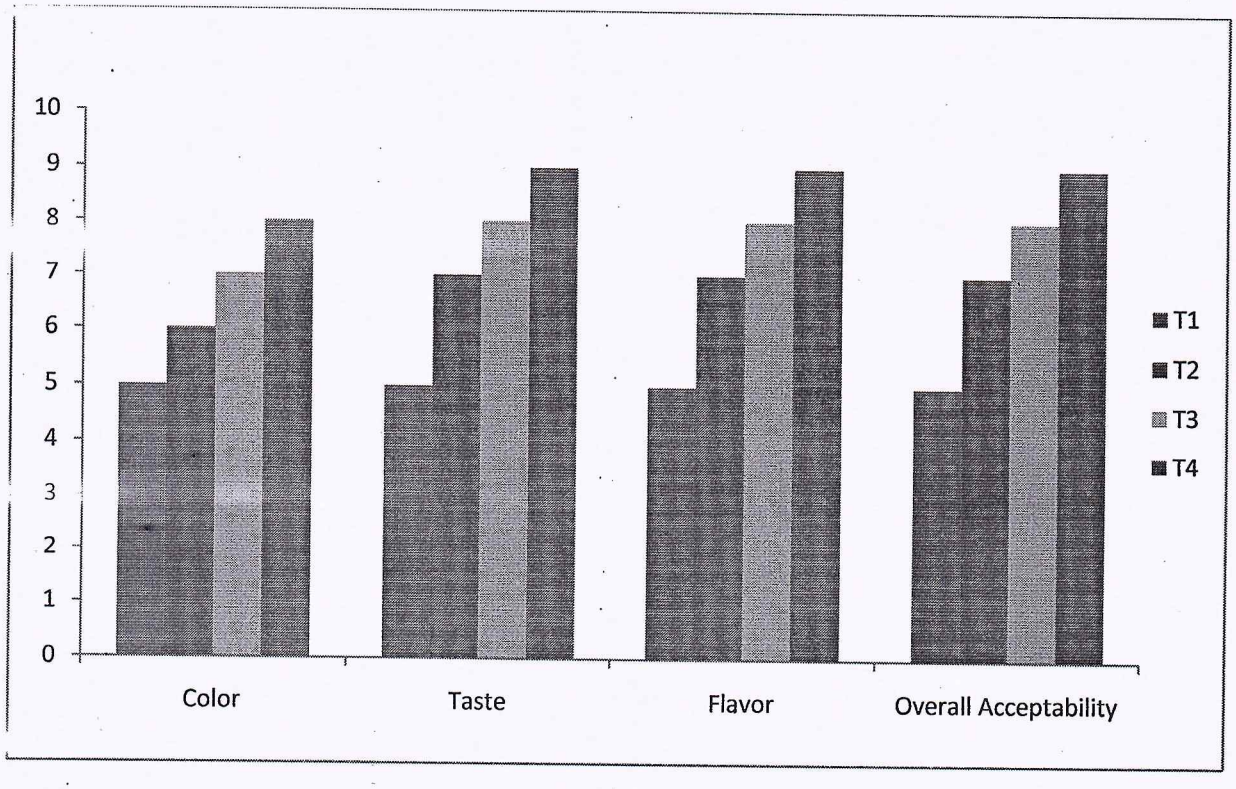


Fig. 4.7.2 Mean sensory score cabinet tray dried papaya slices at 60°C for 65°Brix.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

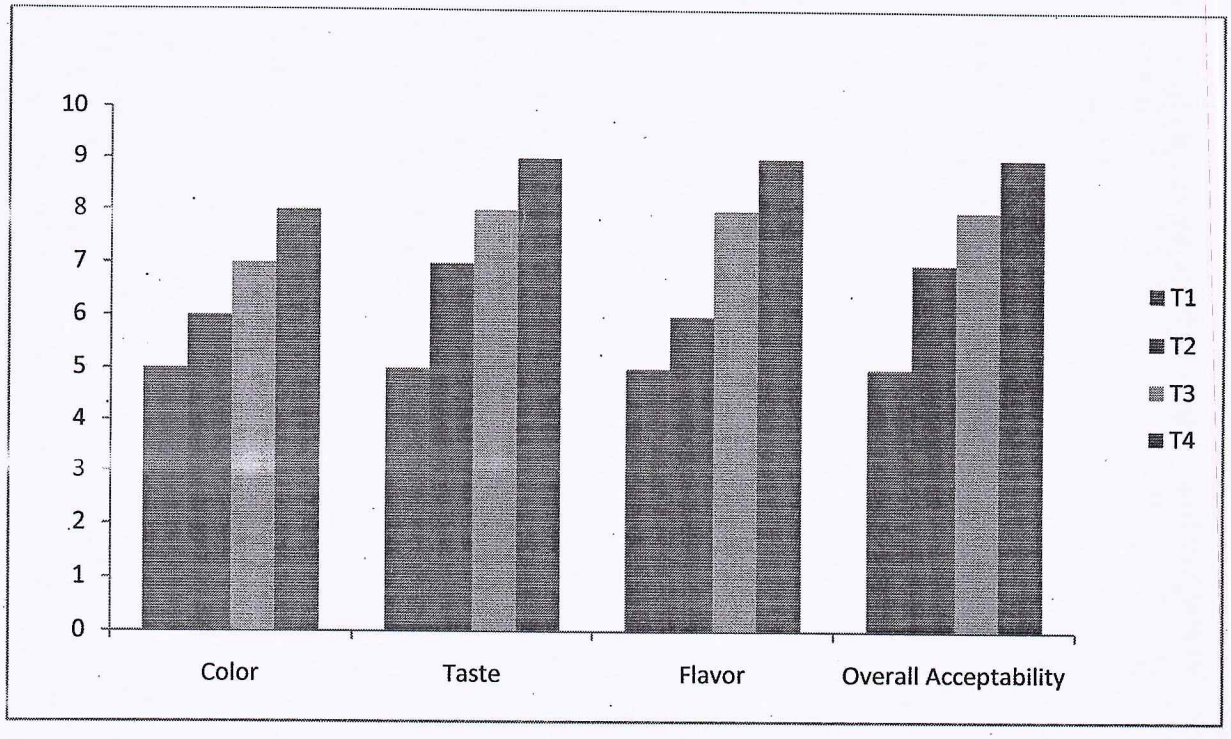


Fig. 4.7.3 Mean sensory score for Hot air oven dried papaya slices at 60°C for 55°Brix.

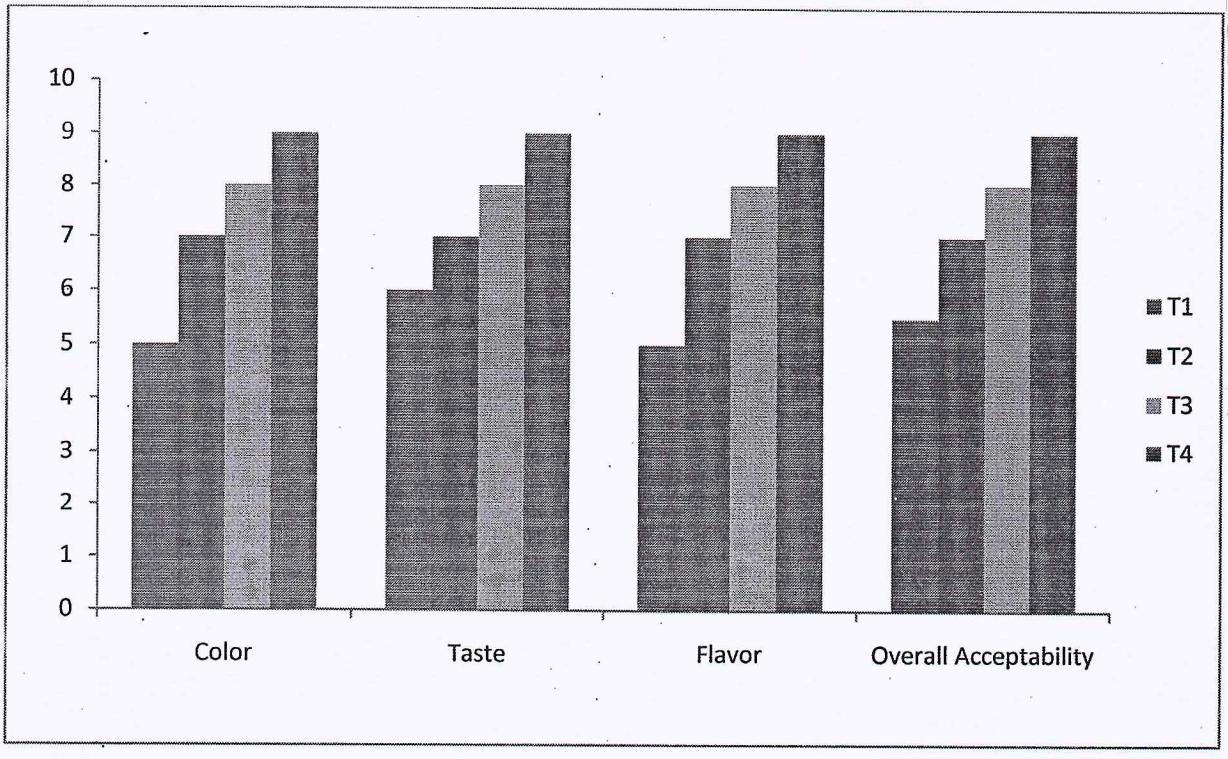


Fig. 4.7.4 Mean sensory score for Hot air oven dried papaya slices at 60°C for 65°Brix.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Chapter-5

SUMMARY AND CONCLUSION

Papaya (***Carica papaya*** **L.)** is an important fruit crop grown widely in tropical and subtropical low land regions. Papaya is a powerhouse of nutrients and is available throughout the year. The fruit is nutritive, rich in **vitamins A** and **C** and presents good organoleptic characteristics. Papaya is emerging as a popular fresh fruit which offers health benefiting properties. The use of fresh-cut papaya in food service institutions is very limited owing to the many technical problems involved in maintaining its quality and microbiological safety during storage.

Osmotic dehydration involves the immersion of foods (fish, vegetables, fruits and meat) in osmotic solution such as salts, alcohols, starch solutions and concentrated sugars, which some extent to dehydrates the food

Many investigators have studied different aspects of osmotic dehydration as an effective method for preservation of fruit and vegetables. It has potential advantage for the processing industry to maintain the food quality and preserve the wholesomeness of the food. The process of dehydration of papaya slices in two stages, removal of water using as an osmotic agent and subsequent dehydration in a dryer where moisture content is further reduced to make the product shelf stable.

The present study was conducted to study the influence of osmotic dehydration on papaya slices.

The work was carried out in the department of Agricultural Engineering, Sardar Vallabhbhai patel University of Agriculture and Technology, Modipuram, Meerut

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

1. Papaya fruit were washed well in distilled water to removing the dirt which present on the surface of fruit. Than the fruit were peeled off with the help of stainless steel knife. And then make the slices into the 2.5x2.5x2.5 cm cube shaped.
2. In this study the two concentration levels of sugar solution 55°Brix and 65°Brix were used and to compare the effect the sugar solution on osmotic dehydration.
3. Papaya slices were immersed in the osmotic temperature at 55°C in the water bath. The osmotic dehydration was done for a periods of 30, 60, 90, 120, 150 and 180 and replicated thrice.
4. The dependent variables were studied water loss mass reduction, solid gain and moisture content after dehydration.
5. The drying behavior was investigated for osmo-dehydrated and untreated papaya slices samples were dried in Tray dryer and Hot air oven at 60°C. The drying rate was calculated during the convective drying process. The quality of dehydrated sample was analyzed such as Rehydration Ratio, Ascorbic Acid and Vitamin A.
6. The fresh Papaya has been found the 95.99% moisture content in wet basis. For sample osmotic dehydrated at 55°C 30 minute osmotic solution at 55°Brix and 65°Brix the maximum and minimum water loss for T_2, T_3, T_4 were 14.505%, 27.291%, 27.578% and 21.63%, 26.79%, 30.32% for 180 min. And 5.05%, 6.37%, 10.21% and 5.70%, 7.17% and 8.93 % respectively.
7. The mass reduction various maximum from 12.17%, 20.83%, 20.67% for 55°Brix and 65°Brix the mass reduction were 17.67% , 20.67%, 22.33% for T_2, T_3, T_4 and minimum mass reduction were found 4.33%, 4.0%, 8.67%, and 5.33, 6.5%, 7.5% respectively.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

8. The minimum solid gains were found 0.72, 2.37, 1.71 and 0.393, 0.67, 1.43 and the maximum solid gains were found 2.34, 6.46, 6.91 and 3.96, 6.13, 7.99 for T_2, T_3 &T_4 at 55°Brix and 65°Brix respectively.
9. The drying curves were affected by the drying air temperature and osmotic dehydration as a pretreatment. Drying rate increase with increase in drying temperature from 60°C (Tray dryer and Hot air oven).
10. The values of rehydration ratio of tray dried samples were increased with storage periods from 0 to 90 days. The rehydration ratio of T_1, T_2, T_3, T_4 samples ranged from 4.814-4.821, 3.06-3.11, 2.42-2.47, 3.44-3.45 & 4.92–4.96, 2.62– 2.69, 2.94 –2.98, 1.8–2.1 for 55 and 65°Brix respectively.
11. The values of rehydration ratio of conventionally hot air oven dried sample were increase with storage periods from 0 to 90 days. The rehydration ratio of T_1, T_2, T_3, T_4 samples ranged from 5.04-5.08. 2.24-2.30, 3.02-3.07 and 2.48-2.56 & 4.88-4.95, 2.56-2.61, 3.0-3.05, 2.82-2.89 for 55°Brix and 65°Brix respectively.

Suggestions for further study:

12. Osmo-convectively dried papaya slices can be used for value added products for medicinal and other uses.
13. Storage studies of osmo-convectively dehydrated papaya slices should be conducted for assessing its keeping quality.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Chapter -6

BIBLIOGRAPHY

Akbarian, M., Ghasemkhani, N. and Moayedi, F. (2013). Osmotic dehydration of fruits in food industrial: A review, *International journal bioscience* Vol. **3**(12):1-16.

Akbarian, M., Ghasemkhani, N. and Moayedi, F. (2014). Osmotic dehydration of fruits in food industrial. *International Journal of Biosciences*, Vol. **4**(1):42-57.

Aktas, T., Fujii, S., Kawano, Y. and Yamamoto, S. (2007). Effects of pretreatments of sliced vegetables with trehalose on drying characteristics and quality of dried products, Food and Bio products processing, **85**(3):178-183.

Alakali, J.S., Ariahu, C.C. and Nkpa, N. N. (2006). Kinetics of osmotic dehydration of mango. *Journal of Food Processing and Preservation.*30:597-607.

Alamzeb, A., Khan, R., Saeed, M. And Manan, S.S. (1994). Influence of crystalline sucrose and chemical preservatives on water activity and shelf storability intermediate banana chips. *S .J Agri.*, 10: 721-726.

Alves, D.G., Barbosa, J.L., Antonio, G.C. and Murr, F.E.X. (2005). Osmotic dehydration of acerola fruit (Malpighia punicifolia L.). *Journal of Food Engineering* 68:99–103.

Aminzadeh, R., Abarzani, M. and Sargolzaei, J. (2010). Preserving melon by osmotic dehydration in a ternary system, *international journal of chemical, moleculae, nuclear, materials and metallurgical engineering,* Vol. **4**(8):487-493.

AOAC. (1990). Official methods of analysis. 14□□ Edition. Edited by Sidney williums. Published by. *The Association of official analysis chemists, Inc. Arlinton, Virginia, 22209, USA*

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

AOAC. (1990). Official methods of analysis. AOAC International suite 500481 North Fredrick Avenue Gaithersburg, Maryland 20877- 2417, USA.

Aravind, G., Debjit, B., Duraivel, S. and Harish, G. (2013). Traditional and medicinal uses of *Carica papaya* L. *Journal of Medicinal Plants Studies* vol. **1**(1):7-15.

Arganosa, A.C.S.J., Raposo, M.F.J., Paula C.M.T. and Morais, A.M.M.B.(2008). Effect of cut-type on quality of minimally processed papaya. 4200-072.

Azoubel, P.M. and Murr, F.E.X., (2003). Optimization of Osmotic Dehydration of Cashew Apple (Anacardium occidental L.) In Sugar Solutions. *International journal of food science and technology,* vol. **9**(6):427–434.

Azoubel, P.M. and Silva, F.O. da. (2008). Optimisation of osmotic dehydration of 'Tommy Atkins' mango fruit. *International Journal of Food Science and Technology*, 43, 1276–1280.

Azuara, E. and Beristain, C.I. (2002). Osmotic dehydration of apples by immersion in concentrated sucrose matlodextrin solution. Journal of Food Processing hesewation. 26: 295- 306.

Barnabas, M., Siores, E. and Lamb, A. (2010). Non-thermal microwave reduction of pathogenic cellular population. *International journal of Food Eng*ineering 6:1-18.

Behsnilian, D. and Spiess, W.E. (2006). Osmotic dehydration of fruits and vegetables. IUFOST.

Bellary, A.N., Sowbhagya, H.B. and Rastogi, N.K. (2011). Osmotic dehydration assisted impregnation of curcuminoids in coconut slices. *Journal Food Engineering* 105:453–459.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College
Muzaffarnagar

Beristain, C.I., Azuara, E., Cortes, R. and Garcia, H.S. (1990). Mass transfer during osmotic dehydration of pineapple rings. *International journal of food science and technology* **25**(5):576–582.

Birthal, P.S, Joshi, P.K., Roy, D. and Throat, A. (2007). Diversification in Indian agriculture towards high value crops. The role of small holders, IFPRI Discussion Paper.

Chandra, S. and Kumari, D. (2015). Resent development in osmotic dehydration of fruit and vegetables: A Review. Critical Reviews in Food Science and Nutrition, 55:552-561.

Chavan, U.D. and Amarowicz, R. (2012). Osmotic dehydration process for preservation of fruits and vegetables. *Journal of Food Research* Vol. **1**(2):202-209.

Deepika, K. and Gayathri, V. (2015). Optimization of Process Parameters on Osmotic Dehydration of Radish Slices using Response Surface Methodology., Vol. **3**(3):1-10.

Dixon, G.M. Jen, J.J. and Paynter, V.P. (1976). Tasty apple slices result from combined osmotic dehydration and vacuum drying process. *Food Prod Dev* vol. **10**(7): 60–66.

Doymaz, I. (2004). Effect of pre-treatment using potassium metabisulphite and alkaline ethyl oleate on the drying kinetics of apricots. *Biosystems engineering*, 89:281-287.

Egea, M.B., Borsato, D., Silva, R. S. D. S. F. D. and Yamashita, F. (2012). Osmo-Dehydrated Functional Product Containing Fructo-oligosaccharides: Physical, Chemical and Sensorial Characteristics. *Braz. Arch. Biol. Technol.* Vol. **55**(6):927-936.

El-Aouar, A. A., Azoubel, M. P., Barbosa, L. J. and Murr, X. E. F. (2006). Influence of osmotic agent on the osmotic dehydration of papaya (*Carica papaya* L.). *Journal of Food Engineering* 75: 267-274.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

El-Aouar, A.A., Azoubel, M.P., Jr. Barbosa, L.j. and Murr, X.E.F. (2003). Drying kinetics of fresh and osmotically pre- treated papaya (*Carica papaya* L.). *Journal of Food Engineering* 59: 85-91.

Erle, U. and Schubert, H. (2001). Combined osmotic and microwave-vacuum dehydration of apples and strawberries. *Journal of Food Engineering.* 49:193-199.

Eroglu, E. and Yildiz, H. (2010). Recent Developments in OsmoticDehydration. *Academic Food Journal* Akademik Gıda, **8**(6):24-28.

Falade, K.O. and Aworh, O.C. (2005). Sensory evaluation and consumer acceptance of osmosed and oven-dried African star apple and African mango. *Journal Fd. Agril. Environ.* **3**(1):91-96.

Farzaneh, P., Fatemian, H., Hosseini, E., Asadi, G. H. and Darvish, F. (2011). A Comparative Study on Drying and Coating of Osmotic Treated Apple Rings. *International Journal of Agricultural Science and Research*, Vol **2**(2):1-15.

Fasogbon, S.O., Gbadamosi, And Taiwo, K.A. (2013). Studies on the Osmotic Dehydration and Rehydration Characteristics of Pineapple Slices. *Journal Food Process Tech* vol. 4(4):1-9.

Garcia MR., Diaz R., Martinez Y and Casariego A., (2010). Effects of chitosan coating on mass transferduring osmotic dehydration of papaya, *Food Research International*, 43, 1656-1660.

Ispir, A. and Togrul, T.I. (2009). Osmotic dehydration of apricot: Kinetics and the effect of process parameters. *Chemical Engineering Research and Design* 87:166-180.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Jain, S.K., Verma, R.C., Murdia, L.K., Jain, H.K. and Sharma, G.P. (2011). Optimization of process parameters for osmotic dehydration of papaya cubes. *Journal of food science and technology* **48**(2):211–217.

Jose, E., Zapata, M., Johan, M., Arias, A. and Gelmy, L. C. G. (2011). Optimization of osmotic dehydration of pineapple using the response surface methodology optimization osmotic de pineapple (Ananas cosmoses.) aplicando superficies de respuesta Agron. Colomb. 29.

Josephine, S.N., Baskar, G. and Singh, A. (2014). Effect of various pretreatment methods on osmotic dehydration of fruits for qualitative and quantitative advantage. *International journal of chem. Tech research* **6**(12):4995-5001.

Kalyani, B.S.B., Reddy, S.B., Kalyani, U.P., Devi, H.V., Ravi, L., Shanti, M. and Singh,E. (2015). Study On Dehydration of Papaya Slices Using Osmotic Dehydration Mediated Hot Air Oven Drying. **9**(2):72-95.

Kaur, K. and Singh, A.K. (2013). mass transfer kinetics and optimization during osmotic dehydration of beetroot(beta vulgaris L.). *International Journal of Scientific and Research Publications*, Vol. **3**(8):2250-3153.

Kedarnath, V.R.C., Kumar, A. and Tyagi, L. (2013). Mass exchange during osmotic dehydration of sapota. *International Journal of Agriculture. Engineering.*, **6**(2):323-328.

Khan, R.M. (2012). Osmotic dehydration technique for fruit preservation. *Pakistan journal of food science,* **22**(2):71-85.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College
Muzaffarnagar

Khatir, A., Achebe, H., Malek, A. and Ferradji, A. (2013). Optimization of osmotic dehydration of orange pieces (valencia late) in sugar solution using response surface methodology. Revue des Energies Renouvelables, Vol. **16**(2):247–256.

Kowalska, H., Belka M. and Lenart A. (2007). Influence of microwave heating on mass transfer during osmotic dehydration of Apples, Pol. *Journal of food nutritional science*.Vol. **57**(4):317-323.

Krokida, M.K., Maroulis, Z.B. and Marinos, K.D. (1998) Kinetics on color changes during drying of some fruits and vegetables. Drying Technology, *16*, 667–685.

Kumari, D., Chandra, S. and Samsher (2013). Assessment of mass transfer properties during osmotic dehydration of ripe banana slice. *Beverage and Food World.* **40**(12):39-42.

Lazarides, H.N. (1994). Osmotic pre-concentration: developments and prospects. In minimal processing of foods and process optimization; an interface, Singh RP, Oliveira, F. AR (Eds.). CRC Press, London,

Lenart, A. (1996). Osmo-convective drying of fruits and vegetables: technology and application. Drying Technology, 14, 391–413.

Lewicki, P.P. and Porzecka, P.R. (2005). Effect of osmotic dewatering on the apple tissue structure. *Journal of Food Engineering* 66: 43-50.

Maneepan, P. and Yuenyongputtakal, W. (2011). Osmotic dehydration of coconut pieces influence of vacuum pressure pretreatment on mass transfer and physical characteristics. kasetsart J. (Nat. Sci.) 45: 891–899.

Marzec, A., Kowalska, H. and Pasik, S. (2009). Mechanical and Acoustic Properties of Dried Apples. Journal of Fruit and Ornamental Plant Research, Vol. **17**(2): 127- 137.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Mastrangelo, M.M., Rojas, A.M., Castro, M.A., Gerschenson, L.N. and Alzamora, S.M. (2000). Texture and structure of glucose-infused melon. Journal Science of Food and Agriculture 80: 769-776.

Mauro, M.A. and Menegalli, F.C. (2005). Evaluation of water and sucrose diffusion coefficients in potato tissue during osmotic concentration. *Journal of Food Engineering* 57:367-374.

Milivoj, R., Mirko, B., Ljiljana, B., Ivan, P., Masa, B., Sinisa, B. and Vangelce, M. (2015). Effects of osmotic pretreatment on quality and physical properties of dried quinces (*Cydonia oblonga*) *Journal of Food and Nutrition Research* Vol. **54**(2):142-154.

Morton, I.D. and Macleod, A.J. (1990). (Eds): Food Flavour: Part C, the Flavor of Fruits. London: Elsevier.

Mosayebi, B.D. (2010) Optimization of the prosecc of osmo–convective drying of edible buttom mushrooms using response surface methodology. *International journal of chemical and molecular engineering*, vol. **4**(1):106-110.

Moura, C.P., Masson, M.L. and Yamamoto, C.I. (2005). Effect of osmotic dehydration in the apple (pyrus malus) varieties gala, gold and fuji Engenharia Termica (Thermal Engineering), Vol. **4**(1):46-49.

Mundada, M., Hathan, S.B. and Maske, S. (2011). Mass transfer kinetics during osmotic dehydration of pomegranate arils. *Journal of Food Science* 76: 31-39.

Najafi, H.A., Yusof, Y.A., Rahman, R.A., Gajloo, A. and Ling, C.N. (2014). Effect of osmotic dehydration process using sucrose solution at mild temperature on mass

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College
Muzaffarnagar

transfer and quality attributes of red pitaya (Hylocereus polyrhizusis), IFRJ 21(*2*): 625-630.

Naknean, P. (2012). Factors affecting mass transfer during osmotic dehydration of fruit. *International Food Research Journal* 19: 7-18.

Narang, G. and Pandey, J.P. (2013). Optimization of osmotic dehydration process of grapes using response surface methodology, FMFI Vol. **2**(2):78-85

Nsonzi, F. and Ramaswamy, H.S. (1998). Osmotic dehydration kinetics of bluberries. Drying Technol., **16**(3-5):725-741.

Nunes, Y. and Moreira, R.G. (2009). Effect of osmotic dehydration and vacuum-frying parameters to produce high- quality mango chips, food engineering and physical properties 24, 355-362.

Nurul, A.M.Z., Idayu, I.M. and Liza, M.S. (2007) drying characteristics of papaya(*carica papaya* L.) during microwave-vacuum treatment. *International Journal of Engineering and Technology*, Vol. **4**(1):15-21.

Okos, M.R., Narsimham, G., Singh, R.K. and Witnauer, A.C. (1992). Food dehydration. In D. R. Heldman & D. B. Lund (Eds.), Handbook of food engineering. New York: Marcel Dekker.

Panagiotou, N.M., Karathanos, V.T. and Maroulis, Z.B. (1998). Mass transfer modeling of the osmotic dehydration of some fruits. Int. J. Food Sci. Tech., 33, 267-284.

Pereira, M.L., Carmello-Guerreiro, M.S., Bolini, M.A.H., Cunha, L.R. and Hubinger, D.M. (2007). Effect of calcium salts on the texture, structure and sensory acceptance of osmotically dehydrated guavas. *Journal Science of Food and Agriculture* 87: 1149-1156.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College
Muzaffarnagar

Petchi, M. and Manivasagan, R. (2009). Optimization of osmotic dehydration of radish in salt solution using response surface methodology. International journal *of Food Engineering* 5:1-11.

Petrotos, K.B. and Lazarides, H.N. (2001). Osmotic concentration of liquid foods. *Journal of Food Engineering.* 49:201-206.

Phisut, N. (2012). Factors affecting mass transfer during osmotic dehydration of fruits. *International Food Research Journal* **19**(1):7-18.

Phisut, N., Rattanawedee, M. and Aekkasak, K. (2013). Effect of osmotic dehydration process on the physical, chemical and sensory properties of osmo-dried cantaloupe. *International Food Research Journal* **20**(1):189-196.

Pisalkar, P.S., Jain, N.K., Pathre, P.B.,Murumkar, R.P. and Revaskar, V.A. (2014). Osmotic dehydration of aloe vera cubes and selection of suitable drying. *International food research journal*, **21**(1):373-378.

Pointing, J.D., Watterss, G.G., Forrey, R.R., Stangly, W.L. and Jackson, R. (1966). Osmotic dehydration of fruits. *J. Food Sci. Technol*, **20**(10):125-128.

Priyono, M.M., Rahayu, Puji S.M.S. And Susanto, S.I.M.M. (2014). Training use of papaya (*carisa papaya L.*) dried fruit papaya into sweets. *International Journal of Small Business and Entrepreneurship Research* vol. **2**(3):33-41.

Prothon, F., Ahrne, L.M., Funebo, T., Kidman, S., Langton, M. and SjoKholm, I. (2001). Effects of Combined Osmotic and Microwave Dehydration of Apple on Texture, Microstructure and Rehydration Characteristics, vol. **34**(2):95-101

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College
Muzaffarnagar

Radjcin, M., Mirko, B., Ljiljana,B., Ivon, P., Masa, B., Sinica, B. and Vangelce, M. (2015). Effects of osmotic pretreatment on quality and physical properties of dried quinces. *Journal of food and nutrition research* Vol. **54**(2):142-154.

Rahimi, J., Singh, A., Adewale, P.O., Adedeji, A.A., Ngadi, M.O. and Raghavan, V. (2013). Effect of carboxyl methyl cellulose coating and osmotic dehydration on freeze drying kinetics of apple slices. Vol. 2 pp. 170-182.

Rahman, M. S. and Lamb, J. (1991). Air-drying behaviour of fresh and osmotically dehydrated pineapples. *Journal of Food Process Engineering.* 14: 163-171.

Rahman, M.S. and Lamb, L. (1990). Osmotic dehydration of pineapple. *Journal Food Science Technology*, 27: 50-152.

Ramalloa, L.A. and Mascheronib, (2012). Quality evaluation of pineapple fruit during drying process Food and bio products processing 275–283.

Ramarjuna, M.N. and Jayaraman, K.S. (1980). Studies on the preparation and storage stability of intermediate banana. *Journal Food Science Technology* 17, 183.

Ramolla, L.A. and Mascheroni, R.H. (2005). Rate of water loss and sugar uptake during the osmotic dehydration of pineapple, *Braz Arch Biol Technol,* **48**(5):761–770.

Ranganna, S. (1986). Handbook of analysis and quality control for fruits and vegetable products.2nded, Tata McGraw Hill Publishing Company Limited, New Delhi, India.

Ranganna, S. (2010). Handbook of analysis and quality control for fruits and vegetable products. *Tata McGraw Hill Publishing Company Limited*, New Delhi, India.

Raoult- Wack, L., Guilbert, S., Maguer, M.L. And Rios, G. (1991). Simultaneous water and solute transport in shrinking media. 1-Application to de-watering and

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

impregnation soaking process analysis (osmotic dehydration). Drying technology, 9: 589-612.

Rapusas, RS. And Drisoll RH. (1995). Thermo physical properties of fresh and dried while onion slices. Journal of Food Engineering, 24: 955-963.

Rastogi, N.K. and Raghavarao, K. (1997). Water and solute diffusion coefficients of carrot as a function of temperature and concentration during osmotic dehydration. *Journal of Food Engineering. 34:429- 440.*

Renu, K., Shukla, R.N. and Joshi, T. (2012). Mass transfer during osmotic dehydration of banana slices for drying process. *International Journal of Scientific and Research Publications*, Vol. **2**(7): 2250-3153.

Rivera, L.J., Ortiz, V.F.A., Zavala, A.J.F., Mundo, S.R.R. and Aguilar, G.G.A. (2005). Cutting shape and temperature affect overall quality of fresh-cut papaya. *Journal of food science* 70:482-489.

Rocha, T.; Lebert, A. and Marty-Audoin, C. (1992). Effect of drying condition on color of mint and basil (oumun basilium). A.S. Muyumber (Ed), pp. 1360-66.

Ruskova, M. and Aleksandrov, S. (2015). Effect of osmotic dehydration variables on the weight reduction of blackcurrants agricultural academy food research development institute International Scientific-Practical Conference "Food, Technologies & Health", Proceedings Book.

Salunkhe, D.K. and Kadam, S.S. (1995). Handbook of fruit Science and technology. New York: Marcel Dekker 297-314.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Selva, J.N., Baskar, G. and Singh, A. (2014). Effect of various pretreatment methods on osmotic dehydration of fruits for qualitative and quantitative Advantage. *International journal of chemical and Technology research,* **6**(12):4995-5001.

Sharma, R.C, Joshi, V.K., Chauhan, S.K., Chopra, S.K. and Lal, B.B. (1991). Application of osmosis-osmo-canning of apple rings, Journal of Food Science Technology 28, 86-88.

Shi, X.Q. and Maupoey, P.F. (1993). Vacuum osmotic dehydration of fruits. Drying Technology **11**(6):1429–1442

Silva, W.P.D., Silva, M.D.P.S., Farias, A.K.L.C. and Almeida, D. (2014). Description of guava osmotic dehydration using a three-dimensional analytical diffusion model. *Hindawi Publishing Corporation Journal of Food Processing,* Volume 2014, Article ID 157427.

Silvana, A., Andres, E.L.R., Juliana, M.T., Gabriel, A.S. and Marta Helena, F.S. (2016). Effects of chemical treatments on fresh-cut papaya. *Food Chemistry* 1182-1189.

Singh, B., Panesar, P.S. and Nanda, V. (2008). Osmotic dehydration kinetics of carrot cubes in sodium chloride solution. *International Journal of Food Science and Technology. 43: 1361-1370.*

Singh, E., Kalyani, B., Reddy, B.S., Kalyani, P.U., Devi, V.H., Ravi, L. and Shanti. M. (2015). Study On dehydration of Papaya Slices Using Osmotic Dehydration Mediated Hot Air Oven Drying. *IOSR-JESTFT*, Vol. **9**(11):72-95.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Sormani, A., Maff, D., Bertolo, G. and Torreggiani, D. (1999). Texture and structural changes of dehydro freeze-thawed strawberry slices: effect of different dehydration pretreatments. *Food Science and Technology International* 5: 479- 485.

Stefan, J.K., Joanna, M.L. and Justyna, S. (2013) Quality aspects of fruit and vegetables dried convectively with osmotic pretreatment. *Chemical process engineering*, **34**(1): 51-62.

Surendar, J., Sonkar, C., Karande, D., Devi, E. W. and Mahajan, I. (2014). Studies on effect of sulphur compounds on osmotically dehydrated guava slices. *IJREAT* Vol. 2(**3**):20-35.

Swati, V.M. and Bhosale, M.G. (2015) Effect of process variable in osmo-convective dehydration of pomegranate arils. *International journal of innovations in engineering and technology*, vol. 5(**4**): 285 -293.

Taiwo, K.A., Eshtiaghi, M.N., Ade-Omowaye, B.I.O. and Knorr, D. (2003). Osmotic dehydration of strawberry halves: influence of osmotic agents and pretreatmentmethods on mass transfer and product characteristics. *International Journal of Food Science and Technology.* 38: 693-707

Tiwari, R.B. (2005). Application of osmo air dehydration for processing of tropical fruits in rural areas. *Indian Food Industry*, **24**(6):62-69.

Torreggiani, D. and Bertolo, G. (2001a). Highquality fruit and vegetable products using combined processes. In Osmotic Dehydration and Vacuum Impregnation, Fito. P., Chiralt. A., Bara.t J. M., Spiess. W. E., and Behsnilian. D. (Editors). Lancaster, PA: Technomic Publishing Company, Inc.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Torres, J.D., Talens, P. and Escriche, I.A. (2006). Chiralt Influence of process conditions on mechanical properties of osmotically dehydrated mango. *Journal of Food Engineering.*74: 240-246.

Tortoe, C., (2010). A review of osmodehydration for food industry. *African Journal of Food Science*, Vol. **4**(6):303 – 324.

Valle, J.M.D., Aranguiz, V. and Leoan, H. (1998). Effects of blanching and calcium infiltration on PPO activity, texture, microstructure and kinetics of osmotic dehydration of apple tissue. Food Res Int. **31**(8):557–569.

Wijaya, H. C. and Chen, F. (2013). Flavour of papaya (*Carica papaya* L.) fruit. Biotropia, 20(1):50-71.

Yadav, A.K. and Singh, S.V. (2012). Osmotic dehydration of fruits and vegetables: a review Journal Food Science Technology. **51**(9):1654–1673.

Yadav, A.K. and Singh, S.V. (2014). Osmotic dehydration of fruits and vegetables: a review. Journal Food Science and Technology **51**(9):1654–1673.

Yeomans, S.J. (2014). Establishing optimal dehydration process parameters for papaya By employingA firefly algorithm, goal programming approach. *Journal of Engineering Research and Applications* vol. **4**(9):145-149.

Yeomans, S.J. and Yang, S.X. (2014). Determining optimal osmotic drying parameters for papaya using the firefly algorithm. Lecture notes in management science, 6:32-39.

Yetenayet, B. and Hosahalli, R. (2010). Going beyond conventional osmotic dehydration for quality advantage and energy savings, *Ethiopian Journal of Applied Sciences and Technology*, Vol. **1**(1):1-15.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Yousefi, A., Niakousari, M. and Moradi, M. (2013). Microwave assisted hot air drying of papaya (*Carica papaya L.*) pretreated in osmotic solution. *Africon journal of agricultural research* Vol. **8**(25):3229-3235.

Yousefi, A.R. and Ghasemian, N. (2016). Prediction of papaya fruit moisture content using hybrid GMDH – neural network modeling during thin layer drying process. *Iranian food science and technology research journal*, vol. **11**(6): 747-757.

Zaki, N.A.M., Muhamad, I.I., Salleh, L.M. and Khairudin, N. (2007). Drying characteristics of papaya during microwave-vacuum treatment. *International Journal of Engineering and Technology*, Vol. **4**(1):15-21.

Co-ordinater
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Shri Ram College
Approved by UGC, NCTE and Affiliated to MS University, Saharanpur
Muzaffarnagar - 251001, NCR (U.P.)
A++ Grade Accredited by NAAC

PROJECT PROPOSAL LETTER

DATE-9/JUNE/2023

To
Director BINDAL DUPLEX
Pvt. Ltd. Muzaffarnagar

SUBJECT- Proposal letter of a project in district Muzaffarnagar with the partnership of your industry.

With reference to the proposed project scope that we have shared during a meeting held between us on May, 10 2023 & a careful studying and consideration by my team visited in your industry, I want to inform you about the innovative and affordable project we decided to deliver with the partnership of your industry named as **"Green Chemistry And Its Application On The Paper And Pulp Industry"** kindly accept the proposal according to the term outline within.

Work will be commencing upon the delivery of 100000/- and the settlement of advance payment as per the project term and condition looking forward. We assure you that the project will be in a clean manner and under the guidance principle investigator & surely will be completed in the time period of 6 months as per the terms and conditions discussed.

We are positively waiting for you response and willingly looking forward as a future partner.

Regards

Rajdeep 09/06/23

Mr. Rajdeep Saharawat
Basic Science Department
(Shri Ram College Muzaffarnagar)

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Contact @ 9927028908, 9927011422
Website : www.srgcmzn.com E-Mail : src_mzn@rediffmail.com

TIN No. : 09372800455
C.S.T. No. : MZ-05122531

BINDLAS DUPLUX LIMITED

Manufacturers of : KRAFT PAPER & DUPLEX BOARD

PROJECT ACCEPTANCE LETTER

DATE-8/JULY/2023

SUBJECT- Proposal acceptance letter of a project with the partnership of our industry.

To

Mr. Rajdeep Saharawat
Basic Science Department
(Shri Ram College Muzaffarnagar)

With reference to the proposed project scope that you have shared after a meeting held between us on June,15 2023 about a project you decided to deliver with the partnership of our industry named as **"Green Chemistry And Its Application On The Paper And Pulp Industry"** we positively accept the proposal according to the term outline within. Kindly commence the work upon the delivery of 65000/- as the settlement of advance payment as per the project terms and condition , project should be initiate from 12/July/2023 & completed up to 12/January/2024 within a time period of 6 months as per the terms and conditions discussed.

Thanks

Padam Bansal

Director BINDAL DUPLEX
Pvt. Ltd. Muzaffarnagar

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Regd. Office & Works :10.6 Km. Bhopa Road, Jat Munjhera, Muzaffarnagar - 251 001 (U. P.) INDIA
Phone : +91-131-2468589, 2468590, 2468593, Fax : +91-131-2468588, e-mail: dbindlas@yahoo.co.in
Corres. Add.: 47, South Bhopa Road, New Mandi, Muzaffarnagar-251 001 Phone : +91-131-2605889

REPORT ON EXPENSES FOR THE PROJECT

Title of the Project: Green Chemistry and Its Application on the Paper and Pulp Industry
Institution: Shri Ram College, Muzaffarnagar
Case Study: Bindals Duplex Paper Mill Private Limited
Total Budget Allocated: ₹65,000

---

1. **Expense Breakdown**

1.1 Research and Development (R&D):

- **Literature Review and Data Collection:**
  - Expenses incurred for books, journals, and online resources.
  - Cost: ₹10,000
- **Laboratory Testing:**
  - Chemicals, reagents, and consumables used for experimental validation.
  - Cost: ₹12,000

1.2 Field Study:

- **Site Visits to Bindals Duplex Paper Mill Private Limited:**
  - Travel expenses for research team members.
  - Accommodation and meals during visits.
  - Cost: ₹12,000
- **Data Collection Tools:**
  - Surveys, interviews, and questionnaires.
  - Cost: ₹3,000

1.3 Infrastructure and Equipment:

- **Specialized Equipment:**
  - Purchase or rental of specific tools for analysis related to green chemistry applications.
  - Cost: ₹15,000

1.4 Documentation and Reporting:

- **Report Writing:**
  - Expenses for formatting, editing, and preparing the final report.
  - Cost: ₹3,000
- **Printing and Binding:**
  - Printing of multiple copies of the final report.
  - Cost: ₹2,000

1.5 Miscellaneous Expenses:

- **Administrative Costs:**
  - Coordination, communication, and unforeseen expenses
  - Cost: ₹8,000

---

2. Summary of Expenses

Category	Amount (₹)
Research and Development	22,000
Field Study	15,000
Infrastructure and Equipment	15,000
Documentation and Reporting	5,000
Miscellaneous	8,000
Total	**65,000**

Verified Gajdeep 21/Jan/24

---

3. Conclusion

The project successfully utilized the allocated budget of ₹65,000 to explore and demonstrate the application of green chemistry principles in the paper and pulp industry, with specific insights from Bindals Duplex Paper Mill Private Limited. This study emphasizes sustainable practices and eco-friendly solutions that align with environmental conservation goals.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Utilization Certificate

S.N.	Detail of sanction of Fund with Project name and Duration	Amount
1.	6 months project on Green chemistry and Its application on paper And pulp industry: A Case study Date of Sanction of Fund- 08-07-2023 as per Sanction Letter	65000.00 /-
	TOTAL	65000.00/-

It is Certified that out of Rs. 65000.00/- (Sixty Five Thousands only) of grants sanctioned by **Bindal Duplex Limited, Muzaffarnagar** during the year 2023-2024 in favor of **Shri Ram College, Muzaffarnagar,** a sum of Rs. 65000.00 has been utilized for the purpose of the project for which it was sanctioned and that the balance of Rs. **Nil** remaining unutilized at the end of the year has been surrendered. The Extra amount (If any) is met out by Shri Ram College.

2. Certified that we have satisfied our self that the conditions on which the grant was sanctioned have been duly fulfilled/are being fulfilled and that we have exercised the following checks to see that the money was actually utilized for the purpose for which it was sanctioned.

Kinds of checks exercise-

1. Checking of cash book
2. Checking of payment vouchers.
3. Checking of salary register.
4. Checking of expense bill.

For Shri Ram College

Secretary
Date: 29-01-2024
Place: Muzaffarnagar

For Goel Rakesh & Co.
Chartered Accountants

Rakesh Kumar Goel
Proprietor

GOEL RAKESH & CO. CHARTERED ACCOUNTANTS Muzaffar-Nagar (U.P.)

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

A

PROJECT REPORT
On

"GREEN CHEMISTRY AND ITS APPLICATION
On
PAPER AND PULP INDUSTRY: A CASE STUDY"

(2023-24)

Submitted by:
Mr. Rajdeep Saharawat
Assistant Professor
Shri Ram College Muzaffarnagar

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Green Chemistry and Its Application in the Paper and Pulp Industry: A Case Study

2023-24

SHRI RAM COLLEGE

MUZAFFARNAGAR

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Table of Contents

Green Chemistry and Its Application on the Paper and Pulp Industry 4

Abstract 4

1. Introduction 5

2. Overview of Green Chemistry Principles 5

Prevention of Waste 5

Atom Economy 5

Safer Chemical Design 6

Use of Renewable Feedstocks 6

Energy Efficiency 6

Safer Solvents and Auxiliary Substances 6

Design for Degradation 6

Catalysis and Process Intensification 6

Real-Time Analysis and Pollution Prevention 6

Inherently Safer Chemistry for Accident Prevention 6

Application to the Paper and Pulp Industry 7

3. The Paper and Pulp Industry: An Environmental Perspective 7

Deforestation and Raw Material Sourcing 7

Water Usage and Pollution 7

Energy Consumption and Emissions 7

Bleaching and Chemical Usage 7

Waste Generation and Management 8

Case in Point: Bindal Duplex Paper Mill 8

4. Case Study: Bindal Duplex Paper Mill, Muzaffarnagar 8

Company Profile 8

Current Practices 8

Challenges and Opportunities 9

Strategic Recommendations 9

Implementation Roadmap 9

5. Green Chemistry Applications in Paper and Pulp Industry 9

Raw Material Sourcing 10

Energy Efficiency 10

Water Conservation 10

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Waste Management 10
Alternative Bleaching Technologies 10
Process Optimization 10
6. Challenges in Implementing Green Chemistry 10
7. Recommendations for Bindal Duplex Paper Mill 11
8. Conclusion 12
9. References 13

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Green Chemistry and Its Application on the Paper and Pulp Industry

Abstract

Green chemistry, a transformative approach emphasizing the reduction or elimination of hazardous substances in industrial processes, holds immense potential for revolutionizing the paper and pulp industry. This sector, a cornerstone of global commerce, contributes significantly to environmental degradation through deforestation, water and air pollution, high energy consumption, and the generation of hazardous waste. The application of green chemistry principles offers sustainable solutions to these challenges, fostering innovation and eco-friendly practices.

This report examines the integration of green chemistry into the operations of Bindal Duplex Paper Mill, a prominent manufacturer in Muzaffarnagar, India. The mill produces duplex boards essential for various packaging applications, yet its traditional production methods contribute to significant environmental concerns. Key issues include excessive water usage, reliance on non-renewable energy sources, chlorine-based bleaching processes, and inadequate waste management systems. By adopting green chemistry principles, the mill has the potential to transform its operations, enhancing both environmental sustainability and economic performance.

The study explores various strategies for implementing green chemistry in the paper and pulp industry. These include the use of sustainable raw materials, such as agricultural residues and certified forestry products, and the adoption of energy-efficient technologies like cogeneration and renewable energy systems. Advanced water conservation techniques, including closed-loop recycling and enhanced effluent treatment, can significantly reduce the mill's water footprint. Waste management innovations, such as byproduct recovery and increased recycling, further align with green chemistry goals. The report also highlights the shift from chlorine-based bleaching to environmentally benign alternatives, such as elemental chlorine-free (ECF) and totally chlorine-free (TCF) technologies.

Despite the promising benefits, the transition to green chemistry poses challenges. High initial investment costs, limited access to advanced technologies, regulatory complexities, and resistance to change within traditional industrial settings are notable obstacles. Addressing these barriers requires collaborative efforts among industry stakeholders, policymakers, and academic researchers.

The Bindal Duplex Paper Mill serves as a case study to illustrate the practical application of these principles. Recommendations for the mill include investing in renewable energy, implementing closed-loop water systems, adopting TCF bleaching methods, and enhancing waste recovery processes. By aligning its operations with green chemistry principles, the mill can achieve significant reductions in its environmental impact while improving operational efficiency and market competitiveness.

In conclusion, the integration of green chemistry into the paper and pulp industry represents a critical step toward sustainable industrial practices. For Bindal Duplex Paper Mill, this approach offers a pathway to environmental stewardship and economic resilience. As global demand for sustainable products continues to rise, the adoption of green chemistry principles is not just an ethical imperative but also a strategic necessity for long-term success.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

1. Introduction

The paper and pulp industry is indispensable to modern life, producing materials for communication, packaging, and hygiene products. However, the environmental footprint of this industry is substantial. Traditional manufacturing methods contribute to deforestation, significant water and air pollution, high energy consumption, and hazardous waste generation. The environmental impacts are particularly pronounced in countries like India, where industrial growth and environmental regulations often clash.

Green chemistry, also known as sustainable chemistry, provides a pathway to address these challenges by integrating environmentally friendly principles into industrial practices. Originating from the 12 principles outlined by Paul Anastas and John Warner, green chemistry emphasizes waste prevention, energy efficiency, renewable feedstocks, and the use of safer chemicals. The goal is to create industrial processes that are economically viable while minimizing their ecological impact.

Bindal Duplex Paper Mill, located in Muzaffarnagar, Uttar Pradesh, is a key player in the Indian paper and pulp sector. Specializing in duplex boards used for packaging, the mill operates in an environmentally sensitive region. Its traditional processes—such as chlorine-based bleaching, high water usage, and reliance on non-renewable energy—highlight the pressing need for sustainable transformation. These practices strain local ecosystems and increase operational costs and regulatory pressures.

Adopting green chemistry principles presents a dual opportunity for Bindal Duplex Paper Mill: to mitigate its environmental impact and to enhance its market competitiveness in an increasingly sustainability-focused global economy. This report aims to evaluate the mill's current practices, propose actionable strategies for implementing green chemistry, and assess this transition's potential benefits and challenges.

The following sections delve into the principles of green chemistry, the environmental challenges of the paper and pulp industry, and the specific case of Bindal Duplex Paper Mill. By providing practical recommendations and highlighting best practices, this report seeks to illustrate the transformative potential of green chemistry in achieving sustainable industrial development.

---

2. Overview of Green Chemistry Principles

Green chemistry, also known as sustainable chemistry, represents a paradigm shift in industrial and scientific practices. Developed from the 12 foundational principles introduced by Paul Anastas and John Warner, green chemistry aims to minimize the environmental and human health impacts of chemical processes. These principles are a blueprint for designing safer, more efficient, and sustainable industrial systems.

Prevention of Waste

One of the core tenets of green chemistry is waste prevention. Unlike conventional waste management, which focuses on treating or disposing of waste, green chemistry seeks to design processes that eliminate waste generation at the source.

Atom Economy

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Atom economy emphasizes maximizing the incorporation of all raw material atoms into the final product, reducing byproducts and improving material efficiency.

Safer Chemical Design

Green chemistry advocates for the design of chemicals and processes that are inherently less hazardous to human health and the environment. This includes avoiding substances that are toxic, carcinogenic, or environmentally persistent.

Use of Renewable Feedstocks

Replacing finite resources with renewable alternatives, such as biomass, aligns industrial processes with sustainable resource management goals. For the paper and pulp industry, this means exploring alternative raw materials like agricultural residues and non-wood fibers.

Energy Efficiency

Reducing energy requirements through innovative technologies and process optimization is another key principle. For instance, integrating cogeneration systems and renewable energy sources can drastically lower the energy footprint of industrial operations.

Safer Solvents and Auxiliary Substances

Traditional solvents often contribute significantly to environmental and health risks. Green chemistry encourages the use of water, supercritical fluids, or ionic liquids as safer alternatives.

Design for Degradation

Products designed under green chemistry principles should break down into harmless substances after their intended use, preventing long-term environmental accumulation.

Catalysis and Process Intensification

Using catalysts instead of stoichiometric reagents enhances efficiency, reduces waste, and minimizes energy requirements. Process intensification, on the other hand, focuses on combining or simplifying steps to achieve the same or better outcomes.

Real-Time Analysis and Pollution Prevention

Incorporating advanced monitoring tools into industrial processes allows for the immediate detection and correction of inefficiencies, ensuring compliance with green chemistry standards.

Inherently Safer Chemistry for Accident Prevention

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Lastly, green chemistry seeks to minimize the risks of chemical accidents by designing processes and materials that are inherently safer under operating conditions.

Application to the Paper and Pulp Industry

Incorporating these principles into the paper and pulp industry involves rethinking raw material sourcing, energy systems, water usage, and waste management. Specific strategies include transitioning to elemental chlorine-free and totally chlorine-free bleaching, using biomass-based feedstocks, and recycling process water.

The application of these principles in the paper and pulp industry can address key environmental challenges while improving process efficiency.

---

3. The Paper and Pulp Industry: An Environmental Perspective

The paper and pulp industry is a cornerstone of modern life but one fraught with environmental challenges. Traditional processes heavily rely on wood, contributing to deforestation and loss of biodiversity. Additionally, these methods consume vast amounts of water, leading to significant wastewater discharge containing hazardous chemicals such as chlorinated compounds and organic pollutants.

Deforestation and Raw Material Sourcing

The industry's dependence on forest-derived raw materials drives deforestation, with cascading effects on carbon sequestration and climate change. Unsustainable logging practices degrade ecosystems and threaten wildlife habitats. Green chemistry encourages the use of agricultural residues, recycled fibers, and certified sustainable forestry products to mitigate these issues.

Water Usage and Pollution

Water-intensive processes in paper production lead to high volumes of polluted effluents. These discharges harm aquatic ecosystems, contaminating water bodies with organic matter, heavy metals, and chlorine derivatives. Employing closed-loop water systems and advanced effluent treatment technologies can significantly reduce the industry's water footprint.

Energy Consumption and Emissions

The paper and pulp sector is energy-intensive, often relying on fossil fuels. This contributes to greenhouse gas emissions and air pollution. Transitioning to renewable energy sources like biomass, solar, and wind can reduce the carbon footprint of paper mills while improving energy efficiency.

Bleaching and Chemical Usage

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Traditional chlorine-based bleaching processes generate toxic byproducts, including dioxins and furans, which are harmful to both humans and the environment. Alternatives such as elemental chlorine-free (ECF) and totally chlorine-free (TCF) technologies align with green chemistry principles by minimizing toxicity and environmental harm.

Waste Generation and Management

Paper mills produce significant amounts of solid and liquid waste. Effective waste management strategies, such as byproduct recovery and enhanced recycling systems, can convert waste into valuable resources like biogas or compost. This not only reduces environmental impact but also improves economic viability.

Case in Point: Bindal Duplex Paper Mill

Bindal Duplex Paper Mill exemplifies the environmental challenges faced by the industry. Located in Muzaffarnagar, India, the mill's traditional methods involve high water usage, energy consumption, and reliance on chlorine-based bleaching. Implementing green chemistry principles can transform its operations, addressing environmental concerns while enhancing efficiency and compliance with regulations.

In summary, the paper and pulp industry must embrace green chemistry to reconcile its economic importance with environmental sustainability. By adopting innovative practices and technologies, this sector can significantly reduce its ecological footprint, paving the way for a greener future.

---

4. Case Study: Bindal Duplex Paper Mill, Muzaffarnagar

Company Profile

Bindal Duplex Paper Mill, located in Muzaffarnagar, Uttar Pradesh, is a leading manufacturer of duplex boards widely used in packaging. The mill has a robust production capacity and caters to diverse industries, but its traditional manufacturing methods present significant environmental challenges.

Current Practices

The mill's production processes rely heavily on conventional methods, including chlorine-based bleaching, non-renewable energy sources, and high water usage. Key environmental concerns include:

- **Water Usage:** Excessive reliance on freshwater, coupled with inadequate recycling.
- **Energy Consumption:** Dependence on fossil fuels, contributing to greenhouse gas emissions.
- **Bleaching Processes:** Use of chlorine compounds, resulting in toxic effluents.
- **Waste Management:** Limited recycling and recovery systems, leading to substantial waste generation.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Challenges and Opportunities

Challenges

1. **Technological Constraints:** Limited access to advanced green technologies.
2. **High Costs:** Initial investments required for transitioning to sustainable practices.
3. **Regulatory Compliance:** Adapting to evolving environmental regulations.
4. **Market Dynamics:** Balancing sustainability goals with cost competitiveness.

Opportunities

1. **Renewable Energy:** Transitioning to solar, biomass, or wind energy can reduce carbon emissions.
2. **Sustainable Raw Materials:** Using agricultural residues or certified wood sources.
3. **Closed-Loop Systems:** Recycling water and recovering chemicals to minimize waste.
4. **Innovative Bleaching Methods:** Adopting TCF and ECF processes to eliminate harmful effluents.

Strategic Recommendations

1. **Energy Transition:** Invest in renewable energy systems, such as biomass boilers or solar installations, to reduce reliance on fossil fuels.
2. **Water Conservation:** Implement advanced recycling systems and closed-loop technologies to optimize water usage.
3. **Eco-Friendly Bleaching:** Replace chlorine-based processes with TCF or ECF methods to reduce toxicity.
4. **Waste Recovery:** Develop systems to recycle and repurpose solid and liquid waste.
5. **Collaboration:** Partner with research institutions and green technology providers to drive innovation.

Implementation Roadmap

1. **Short-Term (1-2 years):** Conduct feasibility studies, pilot test sustainable technologies, and raise environmental awareness among stakeholders.
2. **Medium-Term (3-5 years):** Scale up the adoption of green practices, optimize processes, and monitor environmental impact metrics.
3. **Long-Term (5+ years):** Achieve full integration of green chemistry principles, aligning operations with global sustainability standards.

By embracing these strategies, Bindal Duplex Paper Mill can position itself as a leader in sustainable manufacturing, contributing to a healthier environment and a resilient business model.

---

5. Green Chemistry Applications in Paper and Pulp Industry

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Raw Material Sourcing

The adoption of sustainable raw materials is critical for reducing the paper industry's environmental impact. Using agricultural residues, such as bagasse, wheat straw, and bamboo, offers a renewable alternative to wood-based feedstocks. Additionally, certified sustainable forestry practices ensure responsible raw material sourcing, reducing deforestation and preserving biodiversity.

Energy Efficiency

Energy efficiency is a cornerstone of green chemistry in the paper and pulp industry. Implementing cogeneration systems, which simultaneously produce heat and power, can significantly reduce energy consumption. Transitioning to renewable energy sources like solar, wind, or biomass further minimizes the carbon footprint of production processes.

Water Conservation

Water conservation is essential for sustainable paper manufacturing. Closed-loop water systems recycle process water, reducing freshwater usage and effluent discharge. Advanced effluent treatment technologies, such as membrane filtration and biological treatments, ensure that discharged water meets environmental standards.

Waste Management

Effective waste management aligns with green chemistry by recovering valuable byproducts and enhancing recycling. Solid waste, such as pulp sludge, can be converted into biogas or used as raw material for producing fertilizers and building materials. Increasing the use of recycled fibers in production reduces dependency on virgin raw materials.

Alternative Bleaching Technologies

Traditional chlorine-based bleaching methods release harmful chlorinated compounds into the environment. Elemental chlorine-free (ECF) and totally chlorine-free (TCF) bleaching technologies offer safer alternatives. TCF processes use oxygen, hydrogen peroxide, or ozone, significantly reducing toxic effluent and improving product quality.

Process Optimization

Integrating process optimization tools, such as real-time monitoring and advanced analytics, ensures efficient resource utilization. Automation and control systems enhance operational efficiency, reducing waste generation and energy consumption.

---

6. Challenges in Implementing Green Chemistry

Implementing green chemistry faces several challenges, particularly in traditional industries like paper and pulp. Key obstacles include:

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

1. **High Initial Costs:** Transitioning to sustainable technologies and processes demands significant investments, deterring many businesses.
2. **Technological Barriers:** Limited access to advanced green technologies and a lack of technical expertise hinder widespread adoption.
3. **Regulatory Issues:** Inadequate or poorly enforced environmental regulations create inconsistencies, complicating industry compliance.
4. **Resistance to Change:** Traditional mindsets and reluctance to deviate from established practices impede innovation.
5. **Resource Constraints:** Developing countries often face shortages of renewable materials, reliable energy, and skilled labor.
6. **Market Dynamics:** Balancing sustainability with competitive pricing pressures requires careful strategic planning.
7. **Infrastructure Limitations:** Existing facilities may lack the capacity for retrofitting with green technologies.
8. **Supply Chain Complexities:** Ensuring sustainable raw material sourcing and waste management requires coordinated efforts.
9. **Knowledge Gaps:** Limited awareness about green chemistry's benefits and applications among stakeholders stifles progress.
10. **Economic Risks:** Uncertainty about long-term returns on investment in green initiatives poses risks for businesses.

Addressing these challenges requires collaboration among industry players, policymakers, and researchers. Government incentives, robust regulations, and awareness campaigns can drive change. For Bindal Duplex Paper Mill, targeted investments in renewable energy, closed-loop water systems, and chlorine-free bleaching are crucial steps toward overcoming barriers and achieving sustainability.

---

7. Recommendations for Bindal Duplex Paper Mill

1. **Adopt Renewable Energy Sources:** Transition to solar, wind, or biomass energy to reduce reliance on fossil fuels and lower greenhouse gas emissions.
2. **Implement Closed-Loop Water Systems:** Reuse and recycle water within the production process to minimize freshwater consumption and effluent discharge.
3. **Switch to Elemental Chlorine-Free (ECF) or Totally Chlorine-Free (TCF) Bleaching:** Use oxygen-based or peroxide-based alternatives to eliminate harmful chlorine compounds.
4. **Enhance Recycling Efforts:** Increase the use of recycled fibers in production to reduce dependence on virgin raw materials and minimize waste.
5. **Invest in Advanced Waste Recovery Systems:** Convert solid and liquid waste into valuable byproducts like biogas or fertilizers, reducing environmental impact and creating additional revenue streams.
6. **Use Sustainable Raw Materials:** Source raw materials from certified sustainable forestry or agricultural residues like bagasse and wheat straw to ensure eco-friendly operations.
7. **Optimize Energy Efficiency:** Upgrade machinery and adopt cogeneration systems to maximize energy use and reduce overall consumption.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

8. **Engage in Stakeholder Collaboration:** Partner with researchers, policymakers, and industry experts to drive innovation and create sustainable practices tailored to the mill's needs.
9. **Increase Awareness and Training:** Educate employees about green chemistry principles and sustainable practices to foster a culture of environmental responsibility.
10. **Monitor and Report Progress:** Establish metrics to evaluate the effectiveness of green chemistry initiatives, ensuring continuous improvement and compliance with environmental standards.

By implementing these recommendations, Bindal Duplex Paper Mill can significantly reduce its ecological footprint, enhance operational efficiency, and gain a competitive edge in the market.

---

8. Conclusion

The integration of green chemistry into the paper and pulp industry is not merely an option but a necessity for achieving sustainable development. Bindal Duplex Paper Mill exemplifies the challenges and opportunities in this transition. By adopting practices such as renewable energy, closed-loop water systems, and environmentally friendly bleaching methods, the mill can significantly reduce its environmental footprint while enhancing operational efficiency and competitiveness.

Green chemistry's principles, including waste reduction, energy efficiency, and the use of safer chemicals, align with global sustainability trends. These practices also contribute to the United Nations Sustainable Development Goals (SDGs), particularly those related to responsible production, climate action, and clean water. For Bindal Duplex Paper Mill, embracing these practices ensures compliance with regulatory standards, improves public perception, and positions the company as a leader in sustainable manufacturing.

Despite the evident benefits, implementing green chemistry is fraught with challenges. The high initial investment required for new technologies, coupled with resistance to change and regulatory hurdles, poses significant barriers. However, these obstacles can be overcome through strategic planning, stakeholder collaboration, and leveraging government incentives and policies designed to promote sustainability.

The benefits of green chemistry extend beyond environmental conservation. They include cost savings from resource efficiency, reduced waste disposal costs, and new market opportunities in the growing demand for sustainable products. Furthermore, green chemistry fosters innovation, encouraging the development of advanced materials and processes that further drive sustainability.

As global demand for eco-friendly products rises, the transition to green chemistry becomes not just an ethical imperative but a competitive advantage. For Bindal Duplex Paper Mill, investing in green chemistry is an investment in the future, ensuring long-term resilience and success in an evolving market landscape.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

In conclusion, the adoption of green chemistry in the paper and pulp industry represents a transformative shift toward sustainability. While challenges persist, the rewards—environmental, economic, and social—far outweigh the costs. Bindal Duplex Paper Mill has the potential to lead this transformation, setting a benchmark for the industry and contributing to a greener, more sustainable world.

---

9. References

1. Anastas, P. T., & Warner, J. C. (1998). *Green Chemistry: Theory and Practice.*
2. Sharma, Y. C., et al. (2020). "Sustainable Practices in the Paper Industry." *Journal of Environmental Chemistry.*
3. Bindal Duplex Paper Mill Official Reports (2024).
4. Government of India. (2023). "Environmental Guidelines for the Paper and Pulp Sector."
5. International Paper Association. (2022). "Global Sustainability Trends in Paper Manufacturing."
6. Bajpai, P. (2012). *Biotechnology for Pulp and Paper Processing.*
7. European Commission. (2021). "Best Available Techniques for Pulp and Paper Mills."
8. Howard, R. C. (2019). "Green Chemistry Innovations in Paper Production." *Journal of Cleaner Production.*
9. National Council for Air and Stream Improvement (NCASI). (2020). "Environmental Metrics in the Paper Industry."
10. UN Environment Programme. (2018). "Greening the Paper Supply Chain."
11. Ali, M., & Sreekrishnan, T. R. (2001). "Aquatic Toxicity from Pulp Mill Effluents." *Advances in Environmental Research.*
12. Kinnarinen, T., et al. (2016). "Energy-Efficient Technologies for Pulp Dewatering." *Energy Research Journal.*
13. Sustainable Forestry Initiative (SFI). (2020). "Certification Standards for Responsible Forestry."
14. Kumar, R., & Gupta, R. (2021). "Alternative Fibers in Paper Manufacturing." *Materials Today Proceedings.*
15. Ragauskas, A. J., et al. (2006). "Biomass for Sustainable Paper Production." *Industrial Biotechnology.*
16. World Wildlife Fund (WWF). (2019). "Reducing Deforestation in the Paper Industry."
17. EPA (Environmental Protection Agency). (2023). "Effluent Guidelines for Pulp and Paper Mills."
18. Zaman, A. (2015). "Recycling in the Paper Industry: Challenges and Solutions." *Waste Management.*
19. Indian Paper Manufacturers Association (IPMA). (2022). "Paper Industry Sustainability Trends in India."
20. Ozone Secretariat. (2020). "Ozone-Based Bleaching Techniques for Eco-Friendly Paper Production."
21. Patil, S., et al. (2017). "Catalysts in Green Chemistry Applications for Pulp Mills." *Catalysis Today.*

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

22. Water Footprint Network. (2018). "Minimizing Water Footprint in Paper Manufacturing."
23. FAO (Food and Agriculture Organization). (2021). "Forest Products and Sustainability in Paper Production."
24. Chakar, F. S., & Ragauskas, A. J. (2004). "Review of Bleaching Technology in the Paper Industry." *Progress in Polymer Science.*
25. Reeve, D. W. (2001). "Introduction to Green Chemistry in the Paper Industry." *Pulp & Paper Canada.*

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

अखिल भारतीय उद्योग व्यापार सुरक्षा मंच
जनपद मुजफ्फरनगर

मुख्य कार्यालय : 83, मॉडल बस्ती, ईस्ट पार्क रोड, करोल बाग, नई दिल्ली-110005
फोन : 011- 23633333, 23550630
पत्राचार कार्यालय : 60 सी, वकील रोड, नई मण्डी, मुजफ्फरनगर, फोन : 8790015829

नीरज गुप्ता
जिला अध्यक्ष
9837081244

निशांक जैन
जिला महामंत्री
8791015829

दिनांक: 04-01-2024

आदरणीय प्रधानाचार्या
श्री राम कॉलेज
मुजफ्फरनगर

महोदय,

अखिल भारतीय उद्योग व्यापार सुरक्षा मंच मुजफ्फरनगर का एक प्रसिद्ध एवं महत्वपूर्ण व्यापारिक संगठन है इस संगठन के तत्वधान में पूर्व में आहुत की गई अनेक बैठकों में पश्चिमी उत्तर प्रदेश में डिजिटल भुगतान का छोटे व्यवसायों पर पड़ने वाले प्रभाव के विषय में गहन विचार विमर्श किया जाता रहा है। डिजिटल भुगतान का पश्चिमी उत्तर प्रदेश के छोटे व्यवसायों पर पड़ने वाले प्रभाव का कोई डेटा उपलब्ध नहीं है जिस कारण पूर्व मे किसी प्रकार की योजना को क्रियान्वित नहीं किया जा सका है। इसी के संदर्भ में व्यापार संघ श्री राम कॉलेज के माध्यम से कोई ऐसा शोध कराना चाहता है जो डिजिटल भुगतान के प्रत्यक्ष प्रभाव को छोटे व्यवसायों पर दिखा सके। अखिल भारतीय उद्योग व्यापार सुरक्षा मंच श्री राम कॉलेज से निवेदन करता है इस कार्य में सहायता कर अपने सामाजिक दायित्वो के निर्वाह में एक कदम और बढ़ाए। इस शोध में आने वाले सभी खर्चों को वहन करने में व्यापार संघ सदैव तत्पर रहेगा।

उपरोक्त के संबंध में आपके उत्तर की प्रतीक्षा रहेगी।

भवदीय,

(निशांक जैन)
जिला महामंत्री, मुजफ्फरनगर

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College
Muzaffarnagar

Shri Ram College

Approved by UGC, NCTE and Affiliated to MS University, Saharanpur
Muzaffarnagar - 251001, NCR (U.P.)

A++ Grade Accredited by NAAC

Date: 12-01-2024

To

The General Secretary

Akhil Bhartiye Udyog Vyapar Suraksha Munch, Muzaffarnagar

Subject: Regarding Research Project

Respected Sir

With reference to your letter, it gives me immense pleasure to inform you that Shri Ram College will be grateful to participate in social contribution with Akhil Bhartiye Udyog Vyapar Suraksha Munch, Muzaffarnagar through the conduct of this research. I nominate **Dr M S Khan**, Assistant Professor in the Department of Commerce, as the Investigator for this research project.

Dr M S Khan is a distinguished academician with extensive experience in teaching and research. His expertise in "Accounting, Finance, and Human Resources aligns perfectly with the objectives of this project. Dr Khan has consistently demonstrated his ability to lead and deliver high-quality research outcomes.As the Principal Investigator; he will be responsible for overseeing the project, ensuring adherence to the proposed timeline and objectives, and contributing to the advancement of knowledge in the field. You are also requested to discuss regarding project expenses duration and total expected budget with him.

I am confident that Dr Khan is expertise and commitment will make this project a success and bring significant recognition to our institution.

We extend our best wishes to him for the successful execution of this research endeavour.

Regards.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

(Dr. Prerna Mittal)
Principal, SRC

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Contact @ 9927028908, 99270[illegible]427
Website : www.srgcmzn.com E-Mail : src_mzn@rediffmail.com

अखिल भारतीय उद्योग व्यापार सुरक्षा मंच
जनपद मुजफ्फरनगर

मुख्य कार्यालय : 83, मॉडल बस्ती, ईस्ट पार्क रोड, करोल बाग, नई दिल्ली-110005
फोन : 011- 23633333, 23550630
पत्राचार कार्यालय : 60 बी, वकील रोड, नई मण्डी, मुजफ्फरनगर, फोन : 8790015829

नीरज गुप्ता
जिला अध्यक्ष
9837081244

निशांक जैन
जिला महामंत्री
8791015829

आदरणीय

दिनांक: 16–01–2024

डॉ0 एम एस खान
शोध समन्वयक, वाणिज्य संकाय
श्री राम कॉलेज, मुजफ्फरनगर

श्री राम कॉलेज पत्रांक दिनांक 12–01–2024 के संबंध में आपको सूचित किया जाता है कि अखिल भारतीय उद्योग व्यापार सुरक्षा मंच जनपद मुजफ्फरनगर के द्वारा प्रस्तावित शोध के लिए 50000/– रु की धनराशि स्वीकृत की जाती है। इस शोध से अपेक्षा है कि पश्चिमी उत्तर प्रदेश में डिजिटल भुगतान का छोटे व्यवसायों पर पड़ने वाले प्रभाव का गहन एवं विस्तृत अध्ययन कर, छोटे एवं मझले व्यापारियों के लिए उत्पन्न चुनौतियों का सामना करने के उपायों की भी अनुशंसा करे ।

आपसे यह भी अपेक्षा की जाती है कि शोध की समाप्ति के पश्चात अनुमोदित धनराशि का लेखा जोखा, यथाशीघ्र आखिल भारतीय उद्योग व्यापार सुरक्षा मंच के कार्यालय में संबंधित आख्या के साथ जमा करना सुनिश्चित करेंगे।

आशा है कि यह शोध मुजफ्फरनगर के व्यापारियों के लिए एक मील का पत्थर साबित होगा ।

भवदीय;

Nishank Jain

(निशांक जैन)
जिला महामंत्री, मुजएफरनगर

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Shri Ram College
Approved by UGC, NCTE and Affiliated to MS University, Saharanpur
Muzaffarnagar - 251001, NCR (U.P.)
A++ Grade Accredited by NAAC

"To Whom it May Concern"

Date: 30-04-2024

It is certified that the a three months research project sponsored by non-government agency "**Akhil Bhartiye Udyog Vyapar Suraksha Munch, Muzaffarnagar**" entitled **"Impact of Digital Payments on Small Businesses in Western Uttar Pradesh"** is done by **Dr M S Khan** as Principal Investigator & **Dr Ashfaq Ali** as Co-investigator, during the academic year 2023-2024. This project has not previously formed on the basis for the award any degree, diploma, associateship or similar other titles and that is an independent work done investigators.

I wish him/ them every success in life.

(Dr Prerna Mittal)
Principal, Shri Ram College

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Contact @ 9927028908, 9[illegible]
Website : www.srgcmzn.com E-Mail : src_mzn@rediffmail.com

Project Fund Detail

Date: 29-04-2024

1. Title of Project: **"Impact of Digital Payments on Small Businesses in Western Uttar Pradesh"**
2. Principal Investigator and Co-Investigator: **Dr M S Khan & Dr Ashfaq Ali Department of Commerce, Shri Ram College, Muzaffarnagar.**
3. Implementing College and Sponsored Body: **Department of Commerce, Shri Ram College & Akhil Bhartiye Udyog Vyapar Suraksha Munch, Muzaffarnagar**
4. Sanctioned Project Amount by **Akhil Bhartiye Udyog Vyapar Suraksha Munch, Muzaffarnagar: Rs. 50,000/-**
5. Project Duration: **January, 2024 to April 2024**
6. Project Completion Date: **April 29th 2024**

Statement of Expenditure

Amount Received (In Rs.)		**Rs. 50,000/-**
Less Expenditure:		
1. Five Surveyor's Stipend	36,000/-	
2. Stationeries	1,250/-	
3. Local Travelling	4,150/-	
4. Refreshments	955/-	
5. Printing & Typing	4,725/-	
6. Miscellaneous expenses	2,860/-	**49,940/-**
Balance:		**60/-**

(Dr M S Khan)
Project Coordinator

(Dr Prerna Mittal)
Principal, Shri Ram College

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Utilization Certificate

S.N.	Detail of sanction of Fund with Project name and Duration	Amount
1.	3 months project on Impact of Digital Payments on small Businesses in Western Uttar Pradesh Date of Sanction of Fund- 16-01-2024 as per Sanction Letter	50000.00 /-
	TOTAL	50000.00/-

It is Certified that out of Rs. 50000.00/- (fifty Thousands only) of grants sanctioned by **Akhil Bhartiye Udyog Vyapar Surksha Munch, Muzaffarnagar** during the year 2023-2024 in favor of **Shri Ram College, Muzaffarnagar,** a sum of Rs. 50000.00 has been utilized for the purpose of the project for which it was sanctioned and that 'the balance of Rs. **Nil** remaining unutilized at the end of the year has been surrendered. The Extra amount (If any) is met out by Shri Ram College.

2. Certified that we have satisfied our self that the conditions on which the grant was sanctioned have been duly fulfilled/are being fulfilled and that we have exercised the following checks to see that the money was actually utilized for the purpose for which it was sanctioned.

Kinds of checks exercise-

1 Checking of cash book
2 Checking of payment vouchers.
3 Checking of salary register.
4 Checking of expense bill.

For Shri Ram College

Secretary
Date: 04-05-2024
Place: Muzaffarnagar

For Goel Rakesh & Co.
Chartered Accountants

Rakesh Kumar Goel
Proprietor

GOEL RAKESH & CO. CHARTERED ACCOUNTANTS Muzaffar-Nagar (U.P.)

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Impact of Digital Payments on Small Businesses in Western Uttar Pradesh

ABSTRACT

This research explores the transformative impact of digital payments on small businesses in Western Uttar Pradesh. It examines how digital payment systems influence business efficiency, customer satisfaction, and financial inclusion. The research draws on both primary data collected through surveys and interviews and secondary data from reports and academic literature. Analytical insights are provided using statistical tools.

INTRODUCTION

The advent of digital payments has revolutionized the way businesses operate globally. In India, the government's push for digital transformation through initiatives like Digital India and demonetization has significantly boosted the adoption of digital payments. Western Uttar Pradesh, a region with a mix of urban and rural areas, offers an interesting case study due to its diverse demographic and economic profile. This paper aims to assess the impact of digital payments on small businesses in this region, focusing on benefits, challenges, and future potential.

LITERATURE REVIEW

A thorough review of existing literature reveals the multifaceted impact of digital payments on small businesses, highlighting global, national, and regional perspectives:

Digital Payments and Business Transformation: Studies by the World Bank (2020) emphasize the role of digital payments in fostering economic development by reducing transaction costs and increasing operational efficiency.

Technological Adoption: Research from the IMF (2019) highlights how digital payments have enabled small businesses to compete in global markets by leveraging digital ecosystems.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Policy Interventions: According to Gupta and Agarwal (2018), the demonetization initiative and Digital India program significantly boosted the adoption of digital payment systems across India.

Impact on Small Businesses: Studies by KPMG (2020) reveal that small businesses using digital payments reported a 40% increase in transaction efficiency and a 25% rise in customer satisfaction.

Challenges in Adoption: Research by Singh et al. (2021) discusses barriers such as digital illiteracy, infrastructure gaps, and cybersecurity concerns.

Adoption Trends: A study by the Indian Institute of Technology (IIT) Kanpur (2020) shows that urban areas in Western Uttar Pradesh exhibit higher adoption rates due to better infrastructure and awareness compared to rural areas.

Socioeconomic Impact: Research by Sharma and Verma (2019) highlights the role of digital payments in increasing financial inclusion, particularly for women entrepreneurs and marginalized groups.

Case Studies: Localized studies by non-governmental organizations (NGOs) reveal success stories of small businesses transitioning from cash to digital modes, leading to increased revenues and expanded customer bases.

The literature underscores the transformative potential of digital payments while emphasizing the need to address existing challenges for equitable growth.

OBJECTIVES

1. To analyze the extent of adoption of digital payments among small businesses in Western Uttar Pradesh.
2. To evaluate the benefits of digital payments for business operations and customer relationships.
3. To identify challenges faced by small businesses in adopting digital payments.
4. To provide recommendations for enhancing digital payment adoption.

METHODOLOGY

The study employs a mixed-method approach, combining qualitative and quantitative research methods. Data were collected from:

- **Primary Sources**: Surveys of 200 small business owners and interviews with 30 stakeholders, including customers and digital payment service providers.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

- **Secondary Sources**: Review of existing literature, government reports, and industry publications.

Statistical tools such as frequency analysis, regression analysis, correlation metrics, and predictive modeling (e.g., logistic regression) were used to derive insights from the quantitative data. Comparative frameworks and time-series analysis were employed to track adoption trends and identify key influencing factors.

FINDINGS

Adoption of Digital Payments

Metric	Value
Adoption Rate (Urban Areas)	90%
Adoption Rate (Rural Areas)	60%
Overall Adoption Rate	75%
Popular Platforms (UPI, Mobile Wallets, POS)	65%, 50%, 40%
Annual Growth in UPI Adoption	25%

1. **Extent of Adoption**: Approximately 75% of surveyed small businesses have adopted digital payment systems. Adoption rates are higher in urban areas (90%) compared to rural regions (60%).

Chi-square Test: Significant association ($p < 0.05$) between geographic location and adoption rates.

2. **Types of Digital Payment Platforms**: Popular platforms include UPI (Unified Payments Interface) at 65%, mobile wallets like Paytm and Google Pay at 50%, and point-of-sale (POS) systems at 40%.

Trend Analysis: UPI adoption has shown a year-on-year growth rate of 25%.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

BENEFITS OF DIGITAL PAYMENTS

Benefit	Quantitative Insight
Reduction in Transaction Time	30%
Correlation with Customer Satisfaction	r = 0.82
Access to Financial Services (Variance Explained)	45%

1. **Improved Business Efficiency**: Digital payments reduce transaction time and eliminate the need for cash handling, leading to operational efficiency.

Time-Savings Analysis: Businesses reported a 30% reduction in average transaction time.

2. **Enhanced Customer Satisfaction**: Customers appreciate the convenience and security of digital transactions.

Correlation Coefficient: A strong positive correlation (r = 0.82) between digital payment adoption and customer satisfaction scores.

3. **Financial Inclusion**: Digital payments have facilitated access to formal financial services, enabling small businesses to avail of credit and other financial products.

Regression Analysis: Digital payment adoption explains 45% of the variance in access to financial services.

CHALLENGES

Challenge	Quantitative Insight
Limited Digital Literacy	50% of rural respondents
Perceived High Transaction Fees	2-3% of monthly revenue
Concerns about Fraud	40% of non-adopters
Internet Connectivity Issues	70% of rural businesses

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

1. **Technological Barriers**: Limited digital literacy and inadequate infrastructure in rural areas hinder adoption.

Survey Results: 50% of rural respondents cited lack of digital knowledge as a primary barrier.

2. **Transaction Costs**: Some business owners perceive transaction fees as a burden.

Cost Analysis: Average transaction fees account for 2-3% of monthly revenue for small businesses.

3. **Trust Issues**: Concerns about cybersecurity and fraud deter some businesses from embracing digital payments.

Thematic Analysis: Interviews revealed that 40% of non-adopters have fears related to fraud.

4. **Intermittent Internet Connectivity**: Poor internet services in certain areas affect the reliability of digital transactions.

Network Reliability Survey: 70% of rural businesses reported frequent connectivity issues.

DISCUSSION

The findings indicate a positive trend in digital payment adoption among small businesses, driven by government policies and the proliferation of smartphones. However, the digital divide between urban and rural areas remains a significant challenge. Enhancing digital literacy and improving infrastructure are crucial for bridging this gap.

Comparative analysis with neighboring states shows that Western Uttar Pradesh lags in infrastructure support despite similar policy incentives. Time-series analysis

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

reveals a steady increase in adoption rates post-2016, attributed to demonetization and UPI integration.

The study also highlights the role of digital payments in fostering financial inclusion. By integrating into the digital economy, small businesses can unlock new growth opportunities and build stronger customer relationships.

RECOMMENDATIONS

Recommendation	Proposed Action
Infrastructure Development	Improve connectivity, expand POS
Incentivizing Adoption	Subsidies, lower transaction fees
Awareness Campaigns	Address trust issues
Policy Enhancements	Region-specific approaches

1. **Capacity Building**: Conduct training programs to improve digital literacy among small business owners.
2. **Infrastructure Development**: Strengthen internet connectivity and expand POS terminal networks in rural areas.
3. **Incentivizing Adoption**: Introduce subsidies or lower transaction fees to encourage digital payment adoption.
4. **Awareness Campaigns**: Run targeted campaigns to address trust issues and promote the benefits of digital payments.
5. **Enhanced Cyber security Measures**: Provide guidelines and tools to small businesses to safeguard against fraud.
6. **Policy Enhancements**: Develop region-specific policies that address the unique needs of urban and rural small businesses.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

CONCLUSION

Digital payments have the potential to transform small businesses in Western Uttar Pradesh by enhancing operational efficiency, fostering financial inclusion, and improving customer experiences. While significant progress has been made, addressing technological and infrastructural challenges is essential for ensuring equitable growth. Comparative data suggest that Western Uttar Pradesh has significant room for improvement in rural digital infrastructure. With the right policy measures and collaborative efforts, digital payments can become a catalyst for economic development in the region.

REFERENCES

1. Reserve Bank of India (2021) *Annual Report on Digital Transactions.*
2. Ministry of Electronics and Information Technology(2020)*Digital India Programme*
3. Academic Journals on Digital Payments and Financial Inclusion.
4. Local Industry Reports and White Papers.
5. Survey and Interview Data from Field Research in Western Uttar Pradesh
6. World Bank Group (2020) *Digital Economy for Development.*

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

INDIAN INDUSTRIES ASSOCIATION

AN APEX BODY OF MICRO, SMALL & MEDIUM ENTERPRISES

(IN THE SERVICE OF MSME SINCE 1985)

Muzaffarnagar Chapter : 159/A-8, 15, Prakash Market, Lala Lajpat Rai Chowk, Muzaffarnagar-251001 (U.P.)

Tel. : 0131-2623762 • E-mail : iia.mznchapter@gmail.com

Date: 25-10-2023

The Principal,
Shri Ram College, Muzaffarnagar

Respected Madam

Greetings

Indian Industries Association (IIA) is an apex representative body of Micro, Small and Medium Enterprises (MSME) with a strong membership base of about 13500 Micro, Small and Medium Enterprises (MSMEs). IIA Muzaffarnagar chapter is a renowned and important MSMEs organization of Muzaffarnagar In several meetings held in the past under the aegis of this organization, impact of microfinancing on developing or developing micro, small, medium enterprises in Muzaffarnagar have been discussed in details. There is no data available on the impact of microfinancing on developing or developing micro, small, medium enterprises in Muzaffarnagar, due to which no plan could be implemented in the past to mitigate these effects. In this context, the IIA Muzaffarnagar wants to conduct research through Shri Ram College which can show the direct impact of microfinance on MSMEs Muzaffarnagar. IIA Muzaffarnagar requests to Shri Ram College to take a step forward in fulfilling its social responsibilities by helping in this work. The IIA will always be ready to bear all the expenses incurred in this research.

Awaiting your reply on the above.

(Sunil Jain)
Secretary,
IIA, Muzaffarnagar Chapter

Corporate Office : IIA Bhawan, Vibhuti Khand, Phase-II, Gomti Nagar, Lucknow - 226010
Tel. : +91-522-2720090, 24004350, 9335804257 • Fax : +91-522-2720097 • E-mail : iia@iiaonline.in
Website : www.iiaonline.in

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Shri Ram College
Approved by UGC, NCTE and Affiliated to MS University, Saharanpur
Muzaffarnagar - 251001, NCR (U.P.)
A++ Grade Accredited by NAAC

Date: 27-10-2023

To
The Secretary IIA
Muzaffarnagar Chapter

Respected Sir

With reference to your letter, it gives me immense pleasure to informed you that Shri Ram College will be grateful to participate in social contribution with IIA through the conduct of this research. We nominate **Dr Ashfaq Ali & Dr M S Khan**, Associate Professor in the Department of Commerce, as the Principal Researcher & Co-Researcher for the research.

Dr. Ashfaq Ali is a distinguished academician with extensive experience in teaching and research. His expertise in "Accounting, Finance, and Human Resources aligns perfectly with the objectives of this project. Dr Ali has consistently demonstrated his ability to lead and deliver high-quality research outcomes. As the Principal Investigator, he will be responsible for overseeing the project, ensuring adherence to the proposed timeline and objectives, and contributing to the advancement of knowledge in the field. You are also requested to discuss regarding project expenses duration and total expected budget with him.

I am confident that Dr Ali' & Dr Khan is expertise and commitment will make this project a success and bring significant recognition to our institution.

We extend our best wishes to him for the successful execution of this research endeavour.

Regards,

(Dr Prerna Mittal)
Principal, SRC

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Contact @ 9927028908, 9927011422
Website : www.srgcmzn.com E-Mail : src_mzn@rediffmail.com

INDIAN INDUSTRIES ASSOCIATION
AN APEX BODY OF MICRO, SMALL & MEDIUM ENTERPRISES
(IN THE SERVICE OF MSME SINCE 1985)
Muzaffarnagar Chapter : 159/A-8, 15, Prakash Market, Lala Lajpat Rai Chowk, Muzaffarnagar-251001 (U.P.)
Tel. : 0131-2623762 • E-mail : iia.mznchapter@gmail.com

Date: 01-11-2023

To
The Principal
Shri Ram College, Muzaffarnagar

Subject: Sponsorship for Research Project and Requirement for Fund Utilization Report

Honourable Madam

The **Indian Industries Association (IIA), Muzaffarnagar Chapter**, is pleased to sponsor funds amounting to **1,50,000/-** for the research project titled **"Microfinance Institutions and the Evolution of Small-Scale Enterprises in Muzaffarnagar"** undertaken by your esteemed college. This initiative aligns with our vision of fostering innovation and contributing to the advancement of knowledge in areas critical to industrial and societal development.

We request that these funds be utilized strictly for the purpose outlined in the approved project proposal, including but not limited to (mention broad categories such as research materials, data collection, analysis, and reporting).
To ensure transparency and proper accountability, we kindly ask you to provide a detailed utilization report upon the project's completion. This report should include:

1. A summary of activities and outcomes achieved.
2. A financial statement detailing the allocation and expenditure of funds.
3. Copies of invoices, receipts, and any supporting documentation.

We value this collaboration and trust that the institution will make the most effective use of this sponsorship to achieve the desired outcomes. Should you require any additional assistance or clarification, please do not hesitate to reach out to us.
We look forward to receiving the utilization report and wish your institution great success in this research endeavour.
Yours sincerely,

(Amit Jain)
Secretary,
IIA Muzaffarnagar Chapter

Coordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Utilization Certificate

S.N.	Detail of sanction of Fund with Project name and Duration	Amount
1.	4 months project on Microfinance Institutions and the Evolution of small Scale enterprises in Muzaffarnagar Date of Sanction of Fund- 01-11-2023 as per Sanction Letter	150000.00 /-
	TOTAL	150000.00/-

It is Certified that out of Rs. 150000.00/- (One Lacs fifty Thousands only) of grants sanctioned by **IIA, Muzaffarnagar** during the year 2023-2024 in favor of **Shri Ram College, Muzaffarnagar,** a sum of Rs. 150000.00 has been utilized for the purpose of the project for which it was sanctioned and that the balance of Rs. **Nil** remaining unutilized at the end of the year has been surrendered. The Extra amount (If any) is met out by Shri Ram College.

2. Certified that we have satisfied our self that the conditions on which the grant was sanctioned have been duly fulfilled/are being fulfilled and that we have exercised the following checks to see that the money was actually utilized for the purpose for which it was sanctioned.

Kinds of checks exercise-

1. Checking of cash book
2. Checking of payment vouchers.
3. Checking of salary register.
4. Checking of expense bill.

For Shri Ram College

Secretary
Date: 06-03-2024
Place: Muzaffarnagar

For Goel Rakesh & Co.
Chartered Accountants

Rakesh Kumar Goel
Proprietor

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Microfinance Institutions and the Evolution of Small-Scale Enterprises in Muzaffarnagar

ABSTRACT

The objective of the study was to investigate the role of MFI in developing MSE in Muzaffarnagar. Primary and secondary data were collected from MSMEs owner and operators and MFI loan officers in through a questionnaire using a list of leading questions. A multilinear regression technique of analysis was employed to analyze the data with help of SPSS v 20. The growth and development of MSMEs attributed to the contributions of MFIs such as financial and non-financial products and services (F=4.608; P-value = 0.0001) the finding of the study further indicate that there was a positive relationship of MSMEs growth and development with the services and products and MFIs in Muzaffarnagar (R=0.348 with MFI loan and training and consultancy).

Index Terms - MFI, MSE, Financial and Non-financial services, Growth and Development

I. INTRODUCTION

This research study aimed to examine the Role of MFIs in developing MSMEs in Muzaffarnagar. The study was done by collecting all the necessary data and analyzed to achieve its intended objectives. The main aspect of this study presents the finding of the financial and non-financial product and service contributions of MFIs to the growth and development of MSMEs. To investigate how the MSMEs growth and development is influenced by the financial and non-financial products and services contributions of MFIs in Muzaffarnagar both primary and secondary data were collected during the data collection and reached findings.

Statement of the problem

Over the past three decades, the provision of adequate microfinance service has been believed as a pro-poor promising financing strategy in Muzaffarnagar. The RBI has taken a timely step and practical to provide policies and legal framework services that promote financial intermediation in the country, where the majority of the people face acute shortage of access to financial capital, being engaged in subsistence activities, which is little supported by modern technologies thus, yield very low rate of return on investment. During this period, there were thirty-five MFIs that were initiated but due to the lack of equitable service allocation system, these were unevenly distributed among the states of the country. In Muzaffarnagar where this study was selected as its setting, there has been an effective microfinance service for the fifteen years only regardless of the large unmet demand of the Muzaffarnagar. Most of the economies over the globe, particularly in the developing countries like India, MSMEs are very important and a key factor for sustainable growth and development. According to Okpara and Wynn (2007), the elaboration of the MSMEs is generally regarded as the key factor of the economic growth and development, decrease the unemployment rate through job creation and poverty reduction in developing countries.

The MSMEs sector is the bridge to achieve the objectives of the country (MoFED, 2011). The major problem with the growth and development despite many contributions of the Muzaffarnagar & Western Uttar Pradesh in MSMEs are lack of or shortage of debt and financing equity. Significance constraints for the growth of country's MSMEs are the lack of adequate financial resources; hence, forthis and many more reasons, MFIs should play their role in order to provide the needed resources for the growth and developmentof MSMEs. This study was designed to investigate the role of MFIs on the developing MSMEs in Muzaffarnagar and forward more effective approach for the growth and development of MSMEs to MFIs and government in order to adopt growth and development-oriented approach of MSMEs in Muzaffarnagar. Therefore, this study is the first study that was conducted concerning Role of MFIs in Developing MSMEs in Muzaffarnagar.

Objectives of the study

The objectives of this study include;

To examine the contributions of MFIs on MSMEs growth in Muzaffarnagar

To ascertain the effects of non-financial services of MFIs on developing MSMEs in Muzaffarnagar

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Significance of the Study

The need of the study from the fact is that there were no studies that had done before in Muzaffarnagar which focused on the Role of MFIs in developing MSMEs, the benefit of MFIs' loans to MSMEs and to know how the loan provided by MFIs helped the MSMEs and their owners and operators as well for growth and development. Therefore, to the researcher's knowledge, it's the first to provide a comprehensive approach to the understanding of the role of MFIs on MSMEs growth and intended to fill the gap in this arena of Muzaffarnagar. Generally, this study contributes knowledge in many important areas of financial institutions and MSMEs studies. It helps to come out with substantive possible alternative policy interventions which help to address problems and challenges that Muzaffarnagar MSMEs face and paves a forward way of development for the government, policymakers, and financial institutions and to the general public at large to understand the different roles of financial institutions on the enterprise's development process.

Review of Literature

Microfinance Institution

MFI is one of the poverty alleviation mechanisms that are widely used and became a diverse and growing industry; according to USAID (2005) thousands of microfinance institutions that provide financial service to millions of MSMEs exist, ranging from grassroots self-help groups to commercial banks to millions of microenterprises and low-income households and further noted that the support and services received by MFIs are not only from a donor like agencies, but also from investors that need to invest their excess money, lenders, rating firms, consulting firms, and other specialized business enterprises. MFIs provide financial and none financial products and services in a wide range of MSMEs, clients that have a low income, self-employed low earnings working in the informal sectors of business. A sustainable social-economic for a long time, MFIs has been a powerful weapon for the development of economic (Alfred Nuwagaba, 2015). None financial services or social services mainly focus on advancing the reduction of poverty for micro-entrepreneurs that run MSE.

Microfinance is the supply of loans, savings, and other financial services to the poor. The term micro is in reference to small amounts typically involved in practice. These services are small, micro because a person who does not have a lot of money most likely will not need a loan of several thousand of rupees (Mrs. Soma S. and Dr. Anant D., 2013), they further noted that a loan of a few hundred rupees may make a huge difference in their lives, giving them the ability to purchase livestock for a small farm, a sewing machine to help in making accessories and clothes, or supplies for a small store. Lack of access to financial services is one of the major constraints hindering the development of MSMEs, and therefore the supply of entrepreneurial activities not just in India, but also in the other developing countries. Commercial banks have traditionally concentrated lending large formal enterprises which possess collateral and therefore, contended to be less risky (R., Makorere, 2014).

There are a number of financial services that are provided to MSE by MFI and these services include one or any combination of savings, credit, insurance, pension/retirement payment services. Apart from providing financial service to poor and low-income people, microfinance also provides for MSE with the provision of social and business growth and development services, such as providing non-financial services to business enterprises like; business consultancy and training. According to CGAP, microfinance clients have low income and are often self-employed in the informal economy, conditions that together typically deny them access to banks and other formal financial institutions. They commonly run small stores on street stalls, create and sell items they make in their homes and rural areas, microfinance clients may be small-scale farmers and those who process or trade crops and goods. The main characteristics of MFI that differentiate from the other part of financial institutions, like it's being a substitute for formal financial institutions which generally does not require collateral and have simple procedures compared to it and less documentation, easy and flexible repayment schemes, financial assistance of members of group in case of emergency, most deprived segments of population are efficiently targeted, and last but not least, group interaction. According to SEEP (2005) MFI became a different growing industry and many MFIs exist starting from self-help groups to formal banks that provide financial service to many MSMEs and low-income households. The service and support received by MFIs are not only from donors,but also from lenders, investors, rating firms, host of other specialized businesses, and network organizations.

According to Ledgerwood (1999), the techniques that MFI use to advance for the welfare of the poor include none financial services provided mainly for development of the poor are; providing education for the poor entrepreneurs to run their day-to-day business activities like literacy training and skill training, marketing, bookkeeping, providing health and nutrition facilities. MFIs have become a strategy for reduction of poverty, financial services such saving facilities and small loans are provided to the poor and poorest people that were not given the opportunities to have the services of the formal commercial banks. Providing financial access to the poor (men and women) with aim of giving opportunities to get and have a great role in their economics in building income, social empowerment, and bargaining power through entrepreneurship. There have been different models implemented for microfinance credit services. It has been found some of the models for this study out of that lending model of MFIs are Village banking, Grameen model, and Individual model.

There are a number of products and services provided by MFIs in which their main objectives are to serve the community who have not been served by the formal banks because of their inability to provide collateral that is demanded to access the financial services of the formal banks. The MFIs services provided to clients who are below or above the line of poverty can be classified into four different categories in which most of them are financial services without collateral like; Financial Intermediation, Social Intermediation, Enterprises Development Services and Social Services (Ledgerwood, 2009). Most of the poor clients that need to be served by the financial institutions ask for small amount of loan and the financial institutions find it too risky because clients

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

are either cannot explain themselves why they are needed the loan or illiterates or due to a far distance from the available financial institutions to get access to finance. In developing countries many financial services including commercial banks, MFIs, cooperatives and many more others provide financial services to MSMEs and these financial service providers target specific sub-segments of the MSMEs landscape having the motives and the capacities as well, while the other larger financial institutions including commercial banks that provide financial services to MSMEs tend to focus on the firms which are large and formal business enterprises but. MFI are known to their financial services (Glisovic, Jasmina, and Meritxell Martinez, 2012).

Impact assessment of Microfinance on MSMEs Development

Financial markets will be a better work for the poor, and make a better work, firstly it is important to understand what are the things that are taking place in the financial market systems, what are the impacts of the services that are provided, how they are provided, who provided and to whom they are provided, the type of the financial services lacked including the segment of the population, how they lacked the access of the financial services that are demanded and which financial services they would like to use (J., Ledgerwood, 2013). And also described in the book of the New Microfinance Handbook about the services of MFIs, "the impact of the service quality and convenience of the MFIs, dignity, safety and the outcomes of financial services after long period usage can only be understood through assessment" in which the value of increased financial inclusion provide better understanding and the importance of investing again and again. It is the lack of access to financial services for the poor that holds them to be in poverty (Muhamed Y., 2003). It has been argued similarly the main reason that formal banking financial services cannot be given to the poor is lack of collateral as the formal banks need some things that can be converted in to cash at the time the borrower cannot able to pay back the loan that was taken from the formal banks from every person that is expected to have the access of financial services from their financial institutions that commercial financial institutions.

The services of MFIs are in a demand whenever there are unhealthy conditions by the MFIs such as; when there are low levels of production/productivity that require financial assistance, MFIs are one of the most likely available and accessible means of financing to those MSMEs even if they are in a situation of less retained earnings and revenue generation still the bigger portion of MSMEs' capital belongs to MFIs (Xitian Wang, 2013). According to D. Makina and L. M. Malobola (2004) identified in their study that was aimed to assess microfinance program impact on enterprise finance which found that microfinance program has led business enterprises and economic welfare of household to improve their enterprise development through financial and non-financial programs provided to MSMEs because it targets those people who had been historically not served by the commercial banks and disadvantaged. MFIs have been involved in terms of providing financial services to MFIs which focused to eliminate poverty and make the poor to survive economically using many different strategies. Research done in Tanzania that examined the credit roll on the success of small enterprise by J. A. Kuzilwa (2005) show that the enterprises after the access to financial services of MFIs has increased the output of the business enterprises in Tanzania using qualitative case study on a sample of business enterprises that were relatively small and micro that had and gained the financial access of MFI.

Overview of Microfinance Institutions in Muzaffarnagar

An overview of microfinance institutions (MFIs) in Muzaffarnagar would include an examination of the key players, services offered, outreach, and the challenges faced by both institutions and borrowers in the region. Here's a structured overview:

Microfinance Institutions in Muzaffarnagar

The microfinance landscape in Muzaffarnagar consists of a mix of formal financial institutions, non-governmental organizations (NGOs), and specialized microfinance companies. Major types include:

- Banks with Microfinance Divisions: Banks such as the State Bank of India, Punjab National Bank, and regional rural banks have dedicated microfinance programs that provide small loans, savings schemes, and credit support tailored to micro-entrepreneurs.
- Non-Banking Financial Companies-Microfinance Institutions (NBFC-MFIs): These include notable players like *Bharat Financial Inclusion*, *Ujjivan Small Finance Bank*, and *Jana Small Finance Bank*, which are specifically focused on microfinance lending.
- Non-Governmental Organizations and Self-Help Groups (SHGs): Local NGOs and SHG federations in Muzaffarnagar often collaborate with larger financial institutions to extend microloans, promote financial literacy, and encourage community-based savings and lending models.

Authorized Microfinance Institutions (MFIs) in Muzaffarnagar

1. **State Bank of India (SBI)** – SBI offers various microfinance products, including loans for small businesses under schemes like the *Pradhan Mantri Mudra Yojana (PMMY)*, which provides collateral-free loans through Micro Units Development and Refinance Agency (MUDRA) to micro and small enterprises.
2. **Bank of Baroda** – Known for its microfinance services, Bank of Baroda offers loans targeted at self-help groups (SHGs) and microenterprises, focusing on promoting small-scale businesses and rural entrepreneurship.
3. **Punjab National Bank (PNB)** – PNB has dedicated microfinance products such as *PNB Mudra Yojana*, designed to assist small businesses and entrepreneurs in securing loans for business expansion, equipment purchase, and other operational needs.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

4. **HDFC Bank** – HDFC's microfinance services provide loans to microenterprises, often collaborating with NGOs and microfinance institutions (MFIs) to reach underserved areas. HDFC's products are especially beneficial for small businesses seeking short-term credit.
5. **ICICI Bank** – ICICI offers microfinance under schemes like the *Self-Employed Women's Association (SEWA)* and *Micro-Entrepreneur Loans*, focusing on women entrepreneurs and small business owners to promote financial inclusion and business growth.
6. **Uttar Pradesh State Cooperative Bank Ltd.** – The primary cooperative bank in the state, it extends microcredit through district cooperative banks across Uttar Pradesh, including Muzaffarnagar. It supports rural businesses, agriculture, and SHGs by offering low-interest loans and encouraging local economic development.
7. **District Cooperative Bank (DCB), Muzaffarnagar** – This district-specific cooperative bank provides credit facilities tailored to the needs of local small-scale entrepreneurs and farmers. They offer loans for agricultural purposes, small business ventures, and other microfinance needs to promote rural financial inclusion.
8. **Jana Small Finance Bank**- Jana Small Finance Bank's Group Loan is designed to extend loan facilities to women, with the objective of helping them meet their financial needs.

Microfinance Services Offered

- Microloans for MSMEs: These institutions provide small loans, typically ranging from ₹10,000 to ₹200,000, which are used for working capital, equipment purchases, and business expansion.
- Savings Products: Some MFIs offer savings schemes tailored to low-income groups, encouraging savings as a habit and offering emergency fund access.
- Insurance Services: Basic insurance products like life, health, and crop insurance are offered by certain MFIs, aimed at providing a safety net for micro-entrepreneurs.
- Financial Literacy and Training Programs: Many MFIs provide training to improve borrowers' financial literacy, teaching basic budgeting, debt management, and business planning.

Outreach and Impact

The reach of MFIs in Muzaffarnagar has grown over the last decade, with most institutions focusing on rural and semi-urban areas where traditional banks have limited penetration. The following summarizes the outreach impact:

- Targeted Beneficiaries: MSE owners, agricultural workers, and women are primary beneficiaries of microfinance services in Muzaffarnagar.
- Women's Empowerment: Many MFIs target female borrowers to encourage economic empowerment, leading to significant growth in women-led businesses in the area.
- Employment Generation: Microfinance has fostered employment by supporting MSMEs in various sectors, including retail, manufacturing, and agriculture, contributing to local economic activity.

Challenges Faced by MFIs and Borrowers

- High-Interest Rates: Many MFIs operate at high-interest rates due to operational costs, impacting the affordability of loans for low-income MSE owners.
- Repayment Issues: Borrowers in Muzaffarnagar, especially in agricultural sectors, face challenges with cash flow variability, which can make timely loan repayment difficult.
- Financial Literacy Gaps: Limited financial literacy among borrowers often leads to misuse of funds and debt management difficulties, underscoring the need for more training and support.
- Operational Costs for MFIs: Serving rural areas involves significant outreach costs for MFIs, including transportation and infrastructure, making it challenging to maintain sustainable operations.

Government and Regulatory Support

The Reserve Bank of India (RBI) and the Government of India have enacted policies to promote microfinance, such as the *Pradhan Mantri Mudra Yojana (PMMY)*, which provides refinancing to MFIs to support micro-entrepreneurs. Regional initiatives and collaborations with local MFIs in Muzaffarnagar also aim to extend financial services more broadly.

Future Directions and Opportunities

- Digitization: Digital platforms can help MFIs reduce operational costs, enhance loan processing efficiency, and improve repayment rates through mobile payment systems.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

- Customized Financial Products: MFIs can introduce products tailored to local needs, such as agricultural loans with flexible repayment terms or specific micro-insurance products.
- Expansion of Financial Literacy Programs: Expanding financial education programs will empower borrowers to use loans effectively and reduce default rates, helping both MFIs and clients achieve long-term financial sustainability.

Microfinance institutions play a crucial role in Muzaffarnagar's economic development by providing essential financial services to MSMEs and low-income communities. With focused efforts on improving accessibility, affordability, and financial literacy, MFIs can continue to drive inclusive growth in the region.

2.1. Micro and Small Business Enterprises

Micro and Small Business Enterprises (MSMEs) in Muzaffarnagar play a vital role in the region's economic landscape, particularly as drivers of employment and sources of local goods and services. Muzaffarnagar, with its agrarian background and semi-urban profile, has a dynamic MSE sector that caters to both rural and urban markets. Here is an overview of MSMEs in Muzaffarnagar, covering key sectors, challenges, and growth potential:

1. Sectors in Muzaffarnagar's MSE Landscape
   - Agriculture and Agri-Based Enterprises: Muzaffarnagar is known for its sugarcane production, with numerous small-scale sugar mills and jaggery (gur) production units. Other agri-based MSMEs include those involved in dairy, floriculture, and processing of grains and pulses.
   - Manufacturing: The city has a strong base in small manufacturing enterprises that produce agricultural tools, metal products, and machinery parts. Handicrafts and small-scale fabrication units are also prevalent, catering to local and regional markets.
   - Textile and Apparel: Textile businesses, including small-scale garment production and fabric shops, contribute significantly to the local economy. Many entrepreneurs operate tailoring and clothing shops, serving the needs of nearby rural and urban areas.
   - Retail and Wholesale: Retail and small wholesale businesses are widespread, ranging from grocery stores and hardware shops to local wholesale suppliers of food grains, spices, and other agricultural products.
   - Service Sector: Small service-oriented enterprises, such as repair shops, beauty salons, catering services, transportation, and logistics, support the needs of the local population and agricultural sectors.
2. Economic Contribution of MSMEs
   - Employment Generation: MSMEs are major employment providers in Muzaffarnagar, especially in semi-skilled and unskilled labor. They offer income opportunities for both urban and rural populations, often employing family members and providing flexible job options.
   - Local Economy Development: MSMEs help circulate money within the local economy by sourcing materials locally and serving the community's needs. This not only increases the standard of living but also strengthens local supply chains.
   - Support for Agriculture: Agri-based MSMEs play an essential role in value addition to agricultural products, enhancing the income of farmers and reducing post-harvest losses.
3. Challenges Faced by MSMEs in Muzaffarnagar
   - Limited Access to Credit: Many MSMEs struggle with access to affordable financing. Microfinance institutions (MFIs) have expanded in the area, but high-interest rates and repayment terms can be barriers for small business owners.
   - Lack of Infrastructure: Inadequate infrastructure, such as electricity, roads, and storage facilities, limits the operational efficiency of these enterprises, especially those in rural settings.
   - Market Access and Competition: MSMEs in Muzaffarnagar often have limited market access beyond their immediate region, and competition from larger enterprises can stifle growth. Expanding to digital platforms remains a challenge for most.

- Skill Gaps and Limited Technology Use: Many small businesses lack skilled labor and face difficulties adopting modern technology, impacting productivity and quality. Training programs are not always accessible, which can hinder business growth.
- Regulatory and Compliance Issues: Navigating regulations, tax requirements, and compliance can be challenging for small business owners who lack formal education or administrative support.

4. Growth Potential and Opportunities
- Microfinance and Financial Support: With increased access to microfinance and government-backed schemes, MSMEs have a pathway to expand operations, invest in better technology, and reach new markets. Initiatives like the *Pradhan Mantri Mudra Yojana* (PMMY) and other credit-linked schemes have potential for expanding MSMEs' credit accessibility.
- Skill Development Programs: The establishment of vocational training centers could benefit MSMEs by enhancing workforce skills, particularly in areas like manufacturing and textiles. Government and NGO-driven skill development programs can be critical in this regard.
- Digitalization and E-Commerce: Adoption of digital tools and e-commerce can open new market opportunities for MSMEs, allowing them to reach customers beyond Muzaffarnagar. Platforms such as Udyam and GeM (Government e-Marketplace) offer avenues for small enterprises to sell directly to government buyers.
- Value Addition and Diversification: MSMEs in agriculture and food processing can explore value-added products, such as organic jaggery, processed dairy products, or packaged foods, which fetch higher market prices. Diversifying product offerings can enhance profitability and reduce dependency on single-product markets.

5. Government and Institutional Support
- Skill India and Start-Up India Initiatives: These initiatives are designed to support small businesses by providing training, mentorship, and networking opportunities, equipping MSMEs with the skills needed for growth.
- Financial Inclusion Programs: Programs like *Jan Dhan Yojana* have enabled more people to access banking services, thereby facilitating easier microloan access for MSE owners.
- Local Industry Clusters: Encouraging industry clusters or business hubs for MSMEs in manufacturing, textiles, and food processing can improve economies of scale, reduce operational costs, and foster knowledge sharing.

6. Future Directions

To bolster the development of MSMEs in Muzaffarnagar, a comprehensive approach that combines financial support, infrastructure improvements, skill development, and digital access is essential. Such measures can empower MSMEs to expand sustainably, drive local economic growth, and elevate the livelihoods of those involved.

Muzaffarnagar's MSMEs have strong potential for growth, especially if challenges related to credit, infrastructure, and market access are effectively addressed. With targeted policy support and greater financial inclusion, these enterprises can become significant contributors to the region's economic resilience and development.

Micro and small business enterprises (MSMEs) in Muzaffarnagar, like those in many regions of India, face various challenges that can hinder their growth and sustainability. Here are some key challenges:

1. **Access to Finance**:
   - **Limited Funding**: Many MSMEs struggle to secure loans from banks due to stringent collateral requirements and a lack of credit history.
   - **High-Interest Rates**: When financing is available, it often comes with high-interest rates, making it difficult for small businesses to repay loans.
2. **Market Competition**:
   - **Local and National Competition**: MSMEs often compete with larger firms that can offer lower prices and better quality due to economies of scale.
   - **Lack of Branding and Marketing**: Many small businesses do not invest in marketing or branding, limiting their market reach.
3. **Regulatory Challenges**:

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

- **Complex Compliance Requirements:** Navigating the regulatory landscape can be challenging for small business owners, who may lack the resources or knowledge to comply with various laws.
- **Taxation Issues**: Understanding and adhering to tax regulations can be daunting for MSMEs.

4. **Infrastructure Deficiencies**:
   - **Poor Transportation and Logistics**: Inadequate transportation infrastructure can lead to increased costs and delays in delivering products.

     Lack of Reliable Utilities: Frequent power outages and unreliable water supply can disrupt business operations.
5. **Skill Gaps**:
   - **Lack of Skilled Labor**: MSMEs often face difficulties in finding skilled workers, which can limit their productivity and growth.
   - **Training and Development**: Limited access to training programs can hinder the development of employee skills.
6. **Technological Barriers**:
   - **Low Adoption of Technology**: Many small businesses may not adopt new technologies due to cost concerns or a lack of technical knowledge.
   - **Digital Divide**: Limited internet access can restrict MSMEs from leveraging online marketing and e-commerce opportunities.
7. **Supply Chain Issues**:

   Dependence on Local Suppliers: MSMEs may face challenges related to the reliability and quality of local suppliers.
   - **Inventory Management**: Inefficient inventory management can lead to stockouts or excess inventory.
8. **Economic Factors**:
   - **Market Fluctuations**: Economic downturns or fluctuations in demand can significantly impact MSMEs, making them vulnerable to market changes.
   - **Inflation**: Rising costs of raw materials can squeeze profit margins for small businesses.
9. **Lack of Government Support**:
   - **Insufficient Policies and Programs**: While there are various government initiatives aimed at supporting MSMEs, many business owners may not be aware of them or find them difficult to access.
10. **Social Factors**:
    - **Cultural Barriers**: In some cases, societal norms and practices may discourage entrepreneurship, particularly among certain demographics.

Addressing these challenges requires a multifaceted approach, including improved access to finance, government support, infrastructure development, and skill training programs tailored to the needs of MSMEs in Muzaffarnagar.

MSMEs Growth and Development in Muzaffarnagar

The growth and development of Micro and Small Enterprises (MSMEs) in Muzaffarnagar can be influenced by various factors, including government policies, market dynamics, and local economic conditions. Here are some key aspects:

1. Government Support and Policies:

- **Financial Assistance:** Government schemes such as the Credit Guarantee Fund Scheme for Micro and Small Enterprises (CGTMSE) and the Prime Minister's Employment Generation Programme (PMEGP) provide financial support and encourage entrepreneurship.
- **Skill Development Programs:** Initiatives aimed at enhancing skills among the workforce help in improving productivity and efficiency in MSMEs.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

- **Ease of Doing Business:** Simplifying regulatory frameworks and reducing bureaucratic hurdles facilitate the establishment and operation of MSMEs.

2. **Local Economic Conditions:**
   - **Market Demand:** Growing local and regional demand for products and services drives the expansion of MSMEs. Muzaffarnagar's agricultural and industrial base provides opportunities for agro-based and manufacturing MSMEs.
   - **Entrepreneurial Culture:** A vibrant entrepreneurial ecosystem encourages innovation and risk-taking among local populations, fostering the establishment of new enterprises.

3. **Infrastructure Development:**
   - **Transport and Connectivity:** Improved transportation networks enhance access to markets and suppliers, crucial for MSE operations.
   - **Industrial Clusters:** Establishing industrial parks or clusters can facilitate collaboration among businesses, sharing resources, and attracting investment.

4. **Technological Advancement:**
   - **Digital Adoption:** Encouraging MSMEs to embrace technology and e-commerce can open new markets and improve operational efficiency.
   - **Innovation Support:** Providing resources for research and development can lead to product innovations and better quality, giving MSMEs a competitive edge.

5. **Networking and Collaboration:**
   - **Business Associations:** Forming associations can provide MSMEs with a platform for advocacy, knowledge sharing, and collaboration on common issues.
   - **Public-Private Partnerships:** Collaborations between government, NGOs, and private sectors can enhance resource availability and support for MSMEs.

6. **Challenges to Address:**
   - **Access to Finance:** Continuous efforts are needed to improve access to affordable finance for MSMEs, which remains a significant barrier to growth.
   - **Skill Gap:** Addressing the mismatch between the skills available in the workforce and the needs of MSMEs is essential for sustainable development.

Working model generation for MFIs contribution on growth and development of MSMEs

There are a number of empirical and theoretical literatures that extensively investigated how the financial and non-financial services of MFI products and services influence the growth and development of MSMEs. Paul M., Mairuri (2014) has been identified how the non-financial products and services of MFI such as; training, BDS, and advisory and consultancy services affect the growth and of MSE. In addition to this, Ledgerwood (1999) identified MFIs uses a number of techniques to advance the welfare of the poor entrepreneur to run their business enterprises like providing literacy training, skill training, marketing, and bookkeeping. Generally, the literature survey of this study leads the researcher to formulate the below-depicted model to study MFI contributions on the growth and development of MFI by which it was partially developed from the literature for this study.

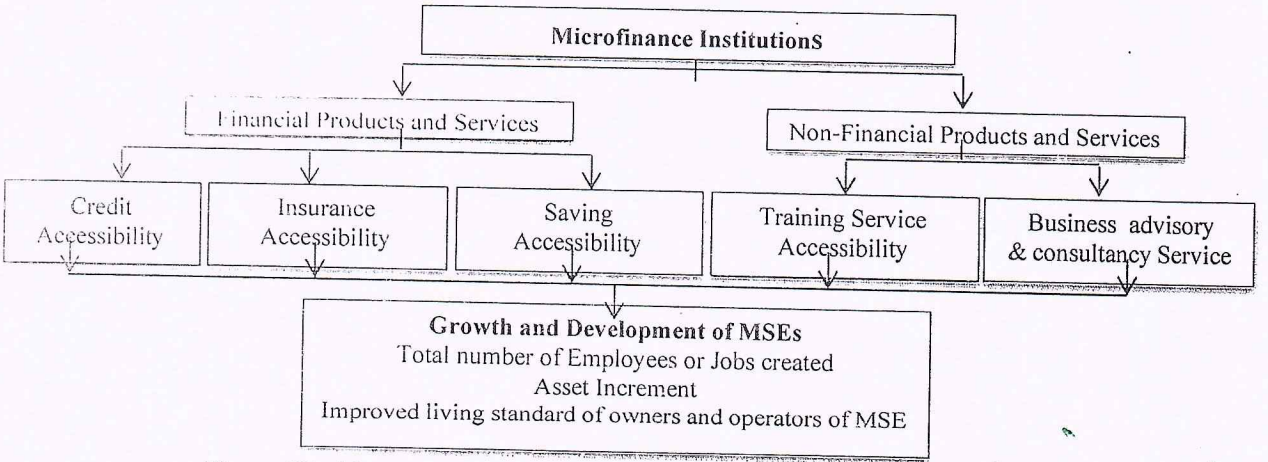


Figure: Working model to study MFI contributions on MSE growth and development

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

METHODOLOGY

Introduction

Research methodology is a course of action which defines the tools to be used when conducting a research study. Various methods, techniques, and procedures of data collection and method of data analysis were employed to collect and analyze the data for this study to reach the final conclusion on how microfinance helps the growth and development of MSE. It also discussed the population, sample frame, sample size and sampling techniques that were used during the research study.

Profile of the Study Area

Muzaffarnagar, located in the western part of Uttar Pradesh, India, is known for its agricultural economy, cultural diversity, and rich history. Here's an overview of key aspects of Muzaffarnagar:

1. **Geography and Location**
   - **Location**: Muzaffarnagar is situated between the Ganges and Yamuna rivers and is part of the Delhi NCR (National Capital Region). It is approximately 125 kilometres north of Delhi.
   - **Climate**: The city experiences a subtropical climate with hot summers, a monsoon season, and cool winters, making it conducive for various agricultural activities.
2. **Economy and Agriculture**
   - **Agricultural Hub**: Muzaffarnagar is often referred to as the "sugar bowl of India" due to its extensive sugarcane production. The economy relies heavily on agriculture, with crops like wheat, rice, and pulses also cultivated.
   - **Industrial Presence**: Apart from agriculture, Muzaffarnagar has a growing industrial base, including sugar mills, paper mills, and agro-based industries. Small and micro-enterprises also play a crucial role in the local economy.
3. **Historical and Cultural Significance**
   - **Historical Roots**: Muzaffarnagar was founded in the 17th century by Sayyid Muzaffar Khan, a noble under Mughal emperor Akbar. It has a deep-rooted history intertwined with Mughal and British influences.
   - **Cultural Diversity**: The city has a blend of Hindu and Muslim communities, and festivals such as Diwali, Eid, and Holi are celebrated with enthusiasm. Its culture reflects the traditions of Uttar Pradesh and the northern Indian plains.
4. **Education and Institutions**
   - **Educational Hub**: Muzaffarnagar hosts several schools, colleges, and institutions, including Chaudhary Charan Singh University-affiliated colleges. The city provides educational facilities from primary to higher levels, contributing to regional literacy and workforce development.
   - **Healthcare Facilities**: The district has hospitals and clinics, although healthcare infrastructure is continuously improving to meet the needs of a growing population.
5. **Challenges and Developmental Aspects**
   - **Economic Development**: While agriculture remains dominant, the city is working to diversify its economy with more industries and small businesses. Microfinance and cooperative banking are important for supporting local small enterprises.
   - **Infrastructure**: Roads and connectivity are expanding, but the city faces challenges such as traffic congestion, pollution, and the need for modern amenities. Development initiatives aim to enhance infrastructure to support growth.

Muzaffarnagar is thus a city that balances agricultural traditions with gradual industrial development, holding historical importance in India's cultural tapestry.

Population of the study

The population of the study covered in this research study was the entire MSMEs owners and operators including MFIs in Muzaffarnagar. To analyze the data at enterprise level, a focus had given to the owners and operators of MSMEs which have the access of MFI services to check whether their business enterprises, their living standard had got changed after the financial and none financial products and services of MFIs. This population had been given a priority due to the needy of the population living in Muzaffarnagar.

Research methods and design

A mixed-method strategy was used for this research study in which both qualitative and quantitative method was used. More than one method of approach can be used when a mixed method strategy is used in a data collection and analyses in a given research study. Multiple-method research design was used for this research study. This approach increases the reliability of the research study. A combination of primary survey-based data with secondary data from both MFIs and MSMEs were designed for the study.

Sampling Frame

A sampling frame was constructed based on the study area. The list of business enterprises in rural and urban areas that have the access to the services of MFIs in the study area was generated from the MFIs and al Micro, Small & Medium Enterprises that are found in the study area. Having in mind those parameters of MFIs and MSMEs the final sample size for the study was selected.

Sampling Techniques and Sample Size

The study required a data from a different area because it identifies aggregate study group and forms different clusters for this reason the researchers identified for the study required multi-stage random sampling technique and adopted for the study. It was impossible to collect data from the whole target population due to financial and time constraints but efforts were made to collect data from the entire population by selecting reasonable sample from the whole Muzaffarnagar by selecting towns & villages in

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Which a total of 350 questionnaires were distributed to both MFIs and owners and operators that operate in Muzaffarnagar. About 100 questionnaires were handed to MFIs operators while in this area approx. 50,000 MSMEs and more than 75,000 small business that were registered and out of this number of registered, only approx. 45000 got the services of through Microfinance Institutions (MFIs), Cooperative Banks and Commercial Banks and the researchers randomly selected 250.

Source of data, method of data collection and techniques of data analysis

Primary and secondary data were collected using a checklist of leading questions from Microfinance Institutions (MFIs), Cooperative Banks and Commercial Banks operating in Muzaffarnagar including various research papers, articles and journals, government and local NGOs. The data of this research has been collected using many methods of data collection such as; observation, structured questionnaire and interview, and documentation. After the required data for the study has been completed, it was described in the form of graphs, pie charts, and tables using descriptive statistics to analysis and summarized the aspects of MFI and MSMEs. In addition to this, inferential analytical techniques were used for the analysis of the collected data. Basically, the inferential analytical techniques that were employed are Multiple Linear Regression, and correlation analysis. Analyzes of the data was done with the help of SPSS v. 20 to find descriptive and inferential statistics, including frequencies and percentages because it has inbuilt formulas which can also be used to generate charts, correlation, tabulated reports and many more techniques of analysis. The analytical model of regression was used for the study and it represents the independent variables and the dependent variables measured by using various questions asked was shown as follows;

$$Y = \alpha + \beta_1 X + \beta_2 X + \beta_3 X + \beta_4 X + \beta_5 X + \beta_6 X + \beta_7 X + \varepsilon \qquad (1)$$

Where: Y = Growth and development level of

X1 = Sex of owners and operators of

X2 = Age of business enterprise
X3 = Education level of owner/operators
X4 = Marital status of owners/operators
X5 = Industry Sector of business enterprise
X6 = Training service of MFI
X7 = Microcredit of MFI
β = Coefficient of independent variables
α = Intercept that is the value of Y when all other variables take the value of zero
ε = Error term. Also known as residuals

Variables of the study

The study has three independent variables that were further divided into different categories consisting of owners' and operators' characteristic variables, firm characteristics variables and microfinance financial and non-financial product and service variables measured by its accessibility and adaptability of these products and services. The owners' characteristic variables were variables such as the age, level of education, marital status, and gender. The firm characteristic variables were the duration of the business enterprise, industry sector, and a number of business enterprise employees while MFIs characteristic variables were the financial and non-financial services of MFIs.

4. PRESENTATION AND ANALYSIS OF DATA

4.1. Profile of the Respondents

Table 1: Profile of the respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Sex of the Respondents					
Valid	Male	100	41.3	41.3	41.3
	Female	142	58.7	58.7	100.0
	Total	242	100.0	100.0	
Age of the Respondents					
Valid	18-25	43	17.8	17.8	17.8
	26-35	143	59.1	59.1	76.9
	36-49	53	21.9	21.9	98.8
	50-70	3	1.2	1.2	100.0
	Total	242	100.0	100.0	
Education Level of the Respondents					
Valid	Grade 1-8	63	26.0	26.0	26.0
	Grade 9-12	57	23.6	23.6	49.6
	Diploma	82	33.9	33.9	83.5
	First Degree	37	15.3	15.3	98.8
	Second Degree	3	1.2	1.2	100.0
	Total	242	100.0	100.0	
Marriage Status of the Respondents					
Valid	Married	152	62.8	62.8	62.8
	Unmarried	76	31.4	31.4	94.2

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

	Divorced	14	5.8	5.8	100.0
	Total	242	100.0	100.0	

As it can be revealed from the table 1 it provides information regarding the socio-economic profile of the respondents; about 58.7% of the total respondents were female, while about 41.3% of the total respondents were male. Therefore, the study found that majority of the respondents for this study was female. It further tells that majority of the clients of the MFIs in Muzaffarnagar that benefited from the MFIs were female. The analysis of the study also goes for the age of the respondents to have brief information about their age and found that 17.8%, 59.1%, 21.9%, and 1.2% of the total respondents were in between; 18-25, 26-35, 36-49, and 50-70 respectively. Therefore, the study revealed that the age of the majority of the respondents was in between 26-35 that is about 59.1% followed by 21.9% of the age in between 36-49. This age shows that the respondents are in the age of working as defined by OECD (2018) that working age of the population is the age in between 15-64.

In addition to the sex and age of the respondents, the study found out when the education level of the respondents was looked because it has a great effect on the source of capital specially in the first start-up of business and found 33.9%, 26%, 23.6%, 15.3%, and 1.2% of the total respondents have education level of diploma, grade 1-8, grade 1-12, first degree, and second degree respectively. Therefore, the education levels of the majority of the respondents had diploma level of education followed by grade 1-8. The study looked the marital status of the respondents and found that 62.8%, 3.4% and 5.8% of the total respondents were married, single and separated respectively. Therefore, the observed marital status of the majority of the respondents was married followed by a single.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Table 2: Characteristics of Business Respondents

		Freq	Percent	Valid Percent	Cumulative Percent
Duration and occupational distribution of enterprise					
Age of the Business Enterprises	1-5 years	133	55.0	55.0	55.0
	1-10 years	93	38.4	38.4	93.4
	Above 10 years	16	6.6	6.6	100.0
	Total	**242**	**100**	**100**	
Business Enterprise sector	Agriculture	44	18.2	18.2	18.2
	Service	50	20.7	20.7	38.8
	Trade	77	31.8	31.8	70.7
	Construction	31	12.8	12.8	83.5
	Manufacturing	40	16.5	16.5	100.0
	Total	**242**	**100**	**100**	
Start-up capital and its source					
Start-up capital of business enterprises	1,000-50,000	105	43.4	43.4	43.4
	50,001-100,000	79	32.6	32.6	76.0
	100,001-500,000	58	24.0	24.0	100.0
	Total	**242**	**100**	**100**	
Source of business enterprise start-up capital	Own Saving	177	73.1	73.1	73.1
	MFI	61	25.2	25.2	98.3
	Borrowed Capital	4	1.7	1.7	100
	Total	**242**	**100**	**100**	
Size of employees and development level of the business enterprises					
The current development of your business	Newly started	33	13.6	13.6	13.6
	Young, but with established production and customers	77	31.8	31.8	45.5
	Growing	87	36.0	36.0	81.4
	Well established, with steady production and customers	23	9.5	9.5	90.9
	Mature, but in need of renewal	22	9.1	9.1	100.0
	Total	**242**	**100**	**100**	

Above table shows that 55%, 38.4%, and 6.6% of the total business respondents have been doing their business for about 1-5 years, 1-10 years, and above 10 years. Therefore, the majority of the business respondents were doing their business 1-5 years since their business inception followed 1-10 years of business service. Based on this concept the majority of the business respondents have the near about same age with the exception of the others. It was observed that MFIs existence in Muzaffarnagar is the main causes for the establishment of many of these as the first MFIs. In additionto this, the study also investigated the type of sector of the business enterprises and found 18.2%, 20.7%, 31.8%, 12.8%, and 16.5% of the total enterprises were; agriculture, service, trade, construction, and manufacturing type of business respectively. Hence the business sector of the majority of the enterprises was a trade kind of business enterprise followed by services type of business enterprise. As it can be seen from table 2 regarding the start-up capital of the business respondents, the start-up capital of the majority of the business respondents were in between ETB 1,000-50,000 followed by ETB 50,001-100,000. Hence, based on the initial start-up capital of these business enterprises, the study found about 76% of the enterprises fall under the microenterprise while about 24% fall under the small enterprise. However, based on the Muzaffarnagar context analyses that the researcher has conducted about the determination of the business enterprises in terms of their capital, the majority of the business respondent fall under micro enterprises.

In line with the above discussion, the study analyzed the development level of the business enterprises and found that about 13.6%, 31.8%, 36%, 9.5% and 9.1% of the total business respondents of the study were newly started, Young, but with established production and customers, Growing, well established, with steady production and customers, and Mature, but in need of renewal business enterprises. Hence, as it can be seen from the discussion regarding with the current development of the business enterprises, the majority of the businesses' current level of development were business enterprises that were in the process or the stage of growth followed by business enterprises that were young, but with established production and customers.

Financial Service Contributions of MFI on the Growth of MSE in Muzaffarnagar

The study was investigated based on a survey conducted to achieve the objectives of the study. To handle this 250 respondents were randomly selected as a sample for the study from the population that have the access to the financial and non-financial services and products of MFIs in Muzaffarnagar for at least a period of eight years from 2016 in of Muzaffarnagar but the

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

copies of questionnaires returned to the researcher was 242 only. In developing countries, unevenly distribution of wealth is a common problem by which the follow of capital to micro or small from medium or large enterprises is not available at all levels, to ensure that there are a number of institutions to assist resources to reach the hands of the poor and poorest and created programs related to microcredit. The aim of this program was to help the poor or to get the access to finance and employment opportunities that consequently lead to income generation of the poor and the poorest.

Table 3: Distribution of loan to and its usage pattern among respondents

Have you ever applied for a loan (borrowed capital) to finance your business?		Loan usage pattern among respondents		Total
		To start a business	To expand existing business	
Valid	Yes	91	147	238
	No	2	0	2
	Total	93	147	240
		If it is borrowed. Where?		Total
		MFI	Banks	
Valid		143	93	236
	Total	143	93	236

Table 3 above shows us loan and its purpose in which out of the total respondents about 238 business respondents from a total of 240 got a loan from the MFIs in Muzaffarnagar. But, their objective of getting a loan was different from one another. 91business respondents got a loan from the MFIs to start a new business in which they need to use as initial start-up capital for their business enterprises while about 147 got a loan from MFIs for expansion of their existing business enterprises. Therefore, it was deducted from the discussion the majority of the business respondents which is about 238 business got a loan from the MFIs in Muzaffarnagar. In addition to the loan borrowed and its purpose, the business respondents have been askedwhere they borrowed the loan for their business enterprise establishment and expansion as well to be clear with the MFIs services contribute in terms of finance to the growth and development in Muzaffarnagar. A total number of 236 business respondents from the total sample of 242 business respondents in which about 143 got a loan from the MFIs in Muzaffarnagar and 93 business enterprises respondents got a loan from Banks. Hence, as it can be seen from the above discussion MFIs in Muzaffarnagar have a great contribution in terms of financial access to the with the objective of poverty elimination through employment creation and income generating for the poor and poorest through business enterprises.

Non-Financial Service Contributions of MFI on Growth and Development of MSMEs in Muzaffarnagar

To achieve the objectives of the study, the study sought to analyze the number of business enterprises received non-financial services of MFIs operating in Muzaffarnagar .

Table 4: Availability and objectives of MFIs' products designed for MSE

Does MFI have special products and services designed for MSE?					
		Freq	%	Valid %	Cumulative %
Valid	Yes	75	100	100	100
Objectives of these products and services					
Valid	To enable to mobilize funds	1	1.3	1.3	1.3
	Business expansion, encourage saving culture, Enable Mobilize funds & Use as collateral for accessing future loan	74	98.7	98.7	100
	Total	75	100	100	

Table 4.5 shows us MFIs have a special product designed for the growth and development of such as loan scheme, training,and education. About 75 questionnaires filled and returned back to the researcher out of 100 that were distributed to MFIs in of Muzaffarnagar so as to know whether there were products designed for growth and development regardless of their nature of the products such financial or non-financial products by the MFIs in the region. 100% of the respondents replied that there are products that were designed for growth and development. In addition to the above being said, the study further investigated the intended objective of these products by the MFIs and about 98.7% of the respondents replied that the objective of these products designed for was; business expansion, encourage saving culture, enable to mobiles fundsand uses as collateral for future loan from the financial institutions while only 1.3% of the respondents said that MFIs products are only intended for enabling to mobilize funds. Therefore, as it can be seen there are products designed for the growth and development of Muzaffarnagar.

Regression and correlation analysis

According to statistics solution (2018), MLR is the most common form of linear regression analysis. So, the determinants of MSMEs growth and development relationship with financial and non-financial service contributions of MFI, a multilinear regression model was employed so as to know and establish relative effects of financial and non-financial contribution of MFI on the MSE growth and development in Muzaffarnagar with particular to because it made easier the adjustment of independent variables as MLR allows controlling explicitly many other factors that can simultaneously affect it. The proposed dependent variable for this study was the growth and development level of business enterprises and financial products and service

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

particularly microcredit while non-financial products and service such as training and consultancy service of MFI were the independents.

The study sought to investigate the relationship and strength of the variables (independent and dependent variables) using correlation. In addition to this, analysis of variance (ANOVA) and determination coefficient have been produced by the model used for the study to know that the significance mean difference between the variables that are independent and dependent variables and ANOVA was conducted at 95% of confidence level.

Table 5. Regression Model Summary

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.348[a]	.121	.095	1.055
a. Predictors: (Constant), MFI Microcredit, Marriage Status of the Respondents, Industry sector of enterprise, Sex of the Respondents, Training service of MFIs, Age of the Respondents, Education Level of the Respondents				

As it can be revealed from the above summary of the regression model table 5 summary of multiple linear regression model and its overall fit statistics which has been used to analyses and establish a relationship between the variables used for the study including age of the owners and operators and business, sex and education level of the respondents, and business sector. The study using the above-mentioned model got a correlation value of 0.348. This value shows us the relationship that existed between the growth and development of Muzaffarnagar with the factors that affect which is mean the independent variables in Muzaffarnagar is a positive relationship which means, there is a linear dependence of growth and development to the financial and non-financial products and services of MFIs though it's not highly correlated because of the correlationvalue obtained which is not close to 1. With an adjusted R-square value of 0.121 which is to mean that the financial, and non- financial products and services of MFI as the model explains, there is about 12.1% of variation of the growth and development business enterprises but are highly influenced by another factor that has not been explained in the model.

On the other side, this can be explained, the growth and development operate in Muzaffarnagar were not highly dependent on the financial and non-financial product and service contributions of Muzaffarnagar n MFIs particularly Somali MFI for their business establishment and expansion as well. Hence, as it can be seen from the above correlation value, it can be concluded that the financial and non-financial products and services of the Muzaffarnagar MFI, have a small contribution on the growth and development of MSE in Muzaffarnagar though it was not that much contribution as expected.

Table 6: Summary of Model and ANOVA Test

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	35.876	7	5.125	4.608	.0001[b]
	Residual	260.256	234	1.112		
	Total	296.132	241			
a. Dependent Variable: Growth and Development level of business enterprise						
b. Predictors: (Constant), MFI Microcredit, Marriage Status of the Respondents, Industry sector of enterprise, Sex of the Respondents, Training service of MFIs, Age of the Respondents, Education Level of the Respondents						

As it can be revealed from the ANOVA statistics in the above table 6, after the data collected was processed, it was obtained that a P value of 0.0001 and this value is less than the significance level which is 0.05 this indicates the result of the study is statistically significant. The model had F ratio of 4.608 which is significant at 0.05 level of significant. Overall, the result of the model shows us the model is statistically significant and useful to predict at a significant level of 0.05. Hence, this result indicates the variable of financial and non-financial products and services of MFIs (microcredit and training and consultancy of MFI) are statistically significant for growth and development of business enterprises prediction.

4.2. Hypotheses Test

The study used a regression model to draw inferences about the sample population, a t-test was also used because t-test is one of the inferential types of statistics that are used to discover the significance difference of a group of two means (Del Siegle, 2002). It has been assumed dependent variable perfectly fits the normal distribution and used to prove the hypothesis using the sample results obtained. Besides this, the key idea of t-test was to specify the probability level of willing to accept the null hypothesis or not. Therefore, this study calculated for about two type of relationship that needs to be tested using ANOVA. For the test hypothesis of this study, the decision rule made was based on the observed P value in which if it's less than alpha with the confidence level of 0.05, null hypothesis of the study will be accepted which will lead to reject the alternative hypothesis vice versa. A hypothesis test was done at a significance level of 0.05. The result of a regression model that was presented for growth and development level of MSE shows the effects of MFI products and services contributions on the growth and development of MSE as follows:

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Growth and development level of business enterprise = $\alpha+\beta_{1X}$(Sex of owners/operators) + β_{2X}(Duration of enterprises) + β_{3X}(Education level) + β_{4X}(Marital Status) + β_{5X} (Business sector) + β_{6X} (Training and consultancy of MFI) + β_{7X} (Microcredit of MFI) + ε

Where: β = the coefficient of independent variables.

α = Intercept value of Y when all other variables take the value of zero

ε = Error term. Also known as residuals

Table 7: Regression output using growth and development level of business enterprise

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.410	.255		13.384	.0001
	Microcredit products of MFI	-.241	.109	-.143	-2.213	.028
	Training and consultancy services of MFI	-.130	.055	-.152	-2.354	.019
a. Dependent Variable: The current development of your business R Square 0.188 Adjusted R Square 0.027						

To achieve the objectives of the study hypothesis were formulated and tested as discussed as follows;

H_o1. Financial services of MFIs have significant effects on the growth of H_i1.

Financial services of MFIs have no significant effects on the growth of

As it can be revealed from the above coefficient table 7, there is a significant relationship of financial services of MFIs with the growth and development level of business enterprise with a P-value of 0.028 at a 95% of confidence level. Therefore, these results lead the study to accept the null hypothesis while it rejects the alternative hypothesis which is MFIs financial services have no significant effects on the growth and development in Muzaffarnagar.

H_o2. Non-financial services of MFIs enhance the performance of business enterprise for growth and development

H_i2. Non-financial services of MFIs do not enhance the performance of business enterprise for growth and development

Besides the first hypothesis, the above coefficient table 7 also indicates that there is a significant relationship of non-financial services of MFIs with the growth and development level of MSMEs having a P-value of 0.019 at a 95% of confidence level. Hence, these results lead the study to accept the null hypothesis formulated for the study which makes the study to reject the alternative hypothesis which is non-financial services provided by MFIs does not enhance the performance of business enterprise for growth and development in Muzaffarnagar. In Muzaffarnagar due to the transaction and other related cost conventional banks are only visible to business enterprises that are relatively medium and large but could not able to reach a large number of business enterprise.

In Muzaffarnagar, there are many that were successful and managed to grow to small and medium business enterprise from micro enterprises. But, in addition to above factors that help the growth and development of MSMEs in Muzaffarnagar, there are other institution that provide support to the such as government and non- governmental organizations.

Table 8: MFI service contribution evaluation

How do you evaluate the MFIs' service contribution in your business?					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very High	81	33.5	33.5	33.5
	High	125	51.7	51.7	85.1
	Fair	30	12.4	12.4	97.5
	Low	5	2.1	2.1	99.6
	Poor	1	.4	.4	100.0
	Total	242	100.0	100.0	

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

As it can be seen from table 8, the study investigated how the service contribution of MFI that is found in the study area was evaluated by the business enterprises respondents. 81 of business enterprises evaluated the MFIs service contribution to their business as "very high". 125 of business respondents evaluated as "High", 30 business respondents, 5 business respondents, and 1 respondent of the total business respondents as "Fair, Low, and Poor." respectively. Hence, MFI in were evaluated based of the financial and non-financial product and service contributions to their clients and was evaluated as "High" by the majority of the business enterprises respondents of the study.

CONCLUSION

The discussed the effects of financial and non-financial product and service contributions of MFIs on the growth and development of business enterprise in Muzaffarnagar. A comprehensive exploration was offered on the factors that have an effect or influence the growth and development of MSMEs. The study firstly identified these factors as two different factor namely financial services such as microcredit and non-financial services such as training and business consultancy. On the side in which the study was sought to investigate their growth and development effects by the MFIs product and service for growth and development, a detail information regarding such as firm characteristics, age, nature of business, sex of the owners and operators were collected from the owners and operators in Muzaffarnagar. For the growth and development of MSMEs, a massive program was implemented in which it has been designed by the government in Muzaffarnagar in which out of these program accesses to financial service for poor and poorest of was among the program in which it was highlighted in Muzaffarnagar MSMEs Development strategy. The study sought to investigate the role of MFI in developing MSMEs in Muzaffarnagar. It has also been proved that financial and non-financial products and services of MFI positively related to the growth and development of MSMEs in the country.

REFERENCES

[1] Alfred Nuwagaba (2015). Micro Financing of Small and Medium Enterprises (SMEs) in Zambia International Journal of Business and Management Invention

[2] Bereket Tadesse (2010). The role of Micro and Small Enterprises in employment creation and income generation. A survey study of India

[3] Berihu Assefa. Abebaw Zerfu, and Biruk Tekle (2014). Identifying Key Success Factors and Constraints of India's MSME Development: An Exploratory Research.

[4] Brhane Radesse (2014). Access to finance for Micro and Small Business in Uttar Pradesh. GJCR vol, 5, No 2 2019 PP 36-46

[5] D. Makina and L. M. Malobola (2004). Impact assessment of Microfinance Programmes, including lessons from Khula Enterprise Finance. ISSN 0376-835X print=ISSN 1470-3637 online=04=050799-16 #2004 Development Bank of Southern Africa DOI: 10.1080=0376835042000325714

[6] Del Siegle (2002). An introduction to t-test

[7] Ebisa Deribie, Getachew Nigussie and Fikadu Mitiku (2013). Filling the breach: microfinance. J.Bus. Econ. Manage, 1(1): 10-17

[8] Fantahun Melles (2004). Micro and Small Enterprise Development: Potential and Constraints

[9] FeMSEDA (2016). Micro and Small Enterprise Development Sector, Annual Statistical Bulletin (2010/11-2014/15 Fiscal Year)

[10] Glisovic, Jasmina, and Meritxell Martinez (2012). "Financing Small Enterprises: What Role for Microfinance Institutions?" Focus Note 81. Washington, D.C.: CGAP, July

[11] Goldmark, L. (1996). Business development service: A framework for analysis. Working paper Washington DC.: Inter-American Development Bank.

[12] Gupta, Priya, and Guha, Samapti & Subramanian Krishnaswami, Shiva. (2013). Firm growth and its determinants. Journal of Innovation and Entrepreneurship. 2.. 10.1186/2192-5372-2-15

[13] ICDF (2002). The Importance of Microcredit Programs in Sustainable Development. Special Reports

[14] J. A. Kuzilwa (2005). The Role of Credit for Small Business Success: A Study of the National Entrepreneurship Development Fund in Tanzania

[15] Joana Ledgerwood (2013). The New Microfinance Handbook, a Financial Market System Perspective

[16] Ledgerwood J. (1999). Microfinance handbook: An institutional and financial perspective, World Bank, Washington, D.C. pp 2, 5-7

[17] Lisa Danials (2009). The role of small enterprises in Africa: Lessons from four national surveys

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

[18] Makorere, R. (2014). The role of microfinance in promoting small and medium enterprises (SMEs) in Tanzania: empirical evidence from SMEs holder who has received microcredit from financial institutions in Morogoro, Tanzania. Global Business and Economics Research Journal, 3(4): 1-19
[19] Malhotra, M.Etal (2006). Expanding Access to Finance Good Practice and Policies for SME. USA, World Bank, Washington DC.
[20] Masakure, O., Cranfield, J., and Henson, S. (2008). The Financial Performance of Non-farm Measuring Performance of Microfinance Institutions (2005): A Framework for Reporting, Analysis, and Monitoring
[21] Mohammad Y. (2003): "Expanding Micro credit Outreach to Reach the Millennium Development Goal – some issues for Attention", paper presented at the International Seminar on "Attacking Poverty with microcredit organized by PKSF in Dhaka on January 8-9
[22] Mohammed A., (2014). Constraints and Growth Potentials of Micro and Small Enterprises: Case from Mekelle City. ISSN 2222-1700 (Paper) ISSN 2222-2855 (Online) Vol.5, No.24, 2014
[23] Mosley, P. (2001). Microfinance and Poverty in Bolivia, Journal of Development Studies, Vol. 37 (4), 101-132
[24] Mrs. Soma S. and Dr. Anant D. (2013). Microfinance facilities and analyzing the awareness level of about microfinance in Negur City
[25] OECD (2018), Working age population (indicator). (Accessed on 14 February 2018)
[26] sOkpara and Wynn (2007). Determinants of small business growth constraints in a sub-Saharan African economy. SAMAdvanced Management Journal (07497075); Spring2007, Vol. 72 Issue 2, p24
[27] Paul M., Muiruri (2014). The Role of Micro-Finance Institutions to the Growth of Micro and Small Enterprises (MSE) in Thika, Kenya (Empirical Review of Non-Financial Factors), IJARAFMS, Vol. 4 (4), pp. 249–262
[28] Robinson, M. (2001). The Microfinance Revolution: Sustainable Finance for the Poor. The World Bank, Washington, D.C. Open Society Institute, New York.
[29] Romano, C. (1989). Research strategies for small business: A case study Approach, International small business journal, 7 (4), 35-43
[30] Schiffer and Weder (2001). Firm Size and the Business Environment: worldwide Survey Results (IFC)
[31] Seep network (2005). Measuring Performance of Microfinance Institutions A Framework for Reporting, Analysis, and Monitoring
[32] Tegegne Gebre-Egziabher (2016). An assessment of the government support program for youth-owned micro and small enterprises () in Muzaffarnagar
[33] UNDP, (2015). Business Development Services, How to Guide
[34] USAID (2005). Understanding Micro and Small Enterprise Growth.
[35] Woday Amha and Tasse Woldehanna (2017). Access to finance: a tool to improve the performance of youth-owned micro and small enterprises () in Muzaffarnagar
AEMFI. Addis Ababa, Muzaffarnagar
[36] Xitian Wang (2013). The Impact of Microfinance on the Development of Small and Medium Enterprises: The Case of Taizhou, China. The Johns Hopkins University, Baltimore, MD, USA

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Shri Ram College
Approved by UGC, NCTE and Affiliated to MS University, Saharanpur
Muzaffarnagar - 251001, NCR (U.P.)
A++ Grade Accredited by NAAC

"To Whom it May Concern"

Date: 15-03-2024

It is certified that the research project sponsored by non-government agency **'Indian Industries Association Muzaffarnagar Chapter'**, entitled **"Microfinance Institutions and the Evolution of Small-Scale Enterprises in Muzaffarnagar"** is done by **Dr Ashfaq Ali**, Principal Investigator & **Dr M S Khan**, Co-investigator, during the academic year 2023-2024. This project has not previously formed on the basis for the award any degree, diploma, associateship or similar other titles and that is an independent work done investigators.

I wish him/ them every success in life.

(Dr Prerna Mittal)
Principal, SRC

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Contact @ 9927028908, 9927011422
Website : www.srgcmzn.com E-Mail : src_mzn@rediffmail.com

Shri Ram College

Approved by UGC, NCTE and Affiliated to MS University, Saharanpur
Muzaffarnagar - 251001, NCR (U.P.)

A++ Grade Accredited by NAAC

Project Fund Detail

Date: 15-03-2024

1. Title of Project: **Microfinance Institutions and the Evolution of Small-Scale Enterprises in Muzaffarnagar**
2. Principal Investigator and Co-Investigator: **Dr Ashfaq Ali & Dr M S Khan, Department of Commerce, Shri Ram College, Muzaffarnagar.**
3. Implementing College and Sponsored Body: **Department of Commerce, Shri Ram College & Indian Industries Association Muzaffarnagar Chapter**
4. Sanctioned Project Amount by **Indian Industries Association Muzaffarnagar Chapter: Rs. 150,000/-**
5. Project Duration: **November 2023 to February 2024 (Four Months)**
6. Project Completion Date: **February 29th 2024**

Statement of Expenditure

Amount Received		**Rs.150,000/-**
Less Expenditure		
1. 32Surveyors stipends for one-month Rs.3000*32	96,000/-	
2. Stationaries	8,950/-	
3. Local Travelling	17,150/-	
4. Refreshments	14,955/-	
5. Printing & Typing	7,725/-	
6. Miscellaneous expenses	7,635/-	152,415/-
Balance:		**- 2415/-**

(Dr Ashfaq Ali)
Research Project Coordinator

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

(Dr Prerna Mittal)
Principal Shri Ram College

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Shri Ram College

Approved by UGC, NCTE and Affiliated to MS University, Saharanpur
Muzaffarnagar - 251001, NCR (U.P.)

A++ Grade Accredited by NAAC

Date: 15 -09- 2023

To,
The Director
Sunrex Studio
Muzaffarnagar

Subject: Proposal for Collaboration on a 6-Month Student Project on Wedding and Event Photography

Dear Sir/Madam,

We, the Fine Art Department of Shri Ram College, are delighted to propose a collaboration with Sunrex Studio for a **6-month project** focused on **Wedding and Event Photography**. This initiative aims to provide our students with practical exposure and professional guidance in this vibrant and creative field.

Objective- The primary goal of this project is to bridge the gap between classroom learning and industry requirements. By collaborating with Sunrex Studio, we wish to offer our students an opportunity to learn real-world skills and build confidence in their craft.

Proposed Project Details

1. **Workshops and Training Sessions:**
   - Conducted by the experienced team at Sunrex Studio to cover advanced photography techniques, editing, and event management.
2. **On-Field Experience:**
   - Students will actively participate in live wedding and event photography projects under your supervision.
3. **Skill Development and Portfolio Building:**
   - Students will gain expertise in handling professional equipment, understanding client needs, and editing final outputs.
   - At the end of the project, they will have a professional portfolio showcasing their work.

Benefits of the Collaboration

- Students will gain invaluable practical knowledge and skills.
- Your studio will have the opportunity to engage with and mentor budding photographers.
- A joint certificate can be awarded to students, strengthening their career prospects.

We believe that this collaboration will be mutually beneficial and provide a platform for nurturing the next generation of creative talent. We request your kind consideration and approval to proceed with this partnership.

We look forward to your positive response and are happy to discuss the details further at your convenience.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Warm Regards,

Dr. Manoj Dhiman
Director - Fine Arts Department
Shri Ram College, Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Date: 29-09-2023

To
Dr. Manoj Dhiman
Director of Fine Arts Department
Shri Ram College
Muzaffarnagar

Subject: Acceptance of Proposal for Collaboration on a 6-Month Student Project on and Event Photography

Dear Dr. Dhiman,

We are pleased to accept your proposal for a collaboration on the 6-month project focused on Wedding and Event Photography. Sunrex Studio is excited to partner with the Fine Art Department of Shri Ram College for this initiative, which we believe will be highly beneficial for your students and the industry at large.

We acknowledge and agree to the outlined objectives and proposed project details, including:

1. **Workshops and Training Sessions** led by our experienced team to cover advanced photography techniques, editing, and event management.
2. **On-Field Experience** for students, providing hands-on participation in live wedding and event photography projects under our supervision.
3. **Skill Development and Portfolio Building** to help students gain expertise, develops practical skills, and creates a professional portfolio.

We are also pleased to confirm the financial commitment of ₹1, 35000/- for the project

We are confident that this collaboration will create a valuable learning platform for students and foster a strong relationship between Sunrex Studio and Shri Ram College.

Please let us know a suitable time for a formal discussion to finalize the schedule and other logistics for the project. We are committed to making this partnership a success and look forward to working with you and your students.

Warm regards,
29.09.2023
Rasheed Ahmad
(Director)
Sunrex Studio,
Muzaffarnagar

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Shri Ram College, Muzaffarnagar

Affiliated to MS University, Saharanpur
Muzaffarnagar - 251001, NCR (U.P.)
A++ Grade Accredited by NAAC

The cost of ₹1,35,000 for a six-month wedding and event photography project (from 3rd October 2023 to 30th March 2024) is summarized as follows:-

Expenditure Breakdown for Wedding and Event Photography Project

Duration: 3rd October 2023 – 30th March 2024
Total Expenditure: ₹1, 35,000/-

1. Equipment & Supplies

- Camera and lens rentals/purchase: ₹15,000/-(Rental)
- Lighting equipment: ₹ 25000/-
- Memory cards and storage devices: ₹5000/-

2. Travel and Logistics

- Travel expenses (fuel/transportation): ₹10,000/-
- Accommodation for outstation shoots: ₹6000/-

4. Post-production Costs

- Editing software subscription: ₹3000/-
- Outsourcing photo/video editing: ₹6000/-

5. Team Payments

- Stipends for student participants: ₹50,000/-
- Payments for hired assistants or professionals: ₹15000/-

Dr Manoj Dhiman
Principal Investigator (Wedding and Event Photography Project)
SRC, Mzn

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

1/2

Report Summary on 6-Month project of Wedding and Event Photography

This report presents an overview of the 6-month collaborative project between the Fine Arts Department of Shri Ram College and Sunrex Studio. The project aimed to bridge the gap between academic learning and industry practices in Wedding and Event Photography. Through Projects, on-field experience, and skill development initiatives, students gained hands-on expertise, improving their professional readiness. The collaboration was marked by knowledge sharing, mentorship, and practical learning, culminating in the development of professional portfolios by the participating students. A total of 15 students participated in this project.

Introduction:

Photography plays a crucial role in capturing moments and emotions, particularly in wedding and event settings. Recognizing the need for students to acquire real-world photography skills, the Fine Arts Department of Shri Ram College proposed a partnership with Sunrex Studio. This initiative provided students with professional training, exposure to industry workflows, and a structured pathway to enhance their creative and technical capabilities. Sunrex Studio, known for its expertise in event photography, welcomed this partnership, seeing it as an opportunity to mentor budding photographers and contribute to the industry's growth.

About Sunrex Studio:

Sunrex Studio, based in Muzaffarnagar, is a renowned photography studio specializing in high-quality wedding, event, portrait, and commercial photography. Equipped with the latest cameras, lighting setups, and advanced editing tools, the studio ensures that every captured moment is transformed into a stunning visual memory.

Owned by **Rasheed Ahmad**, Sunrex Studio has built a strong reputation for professionalism, creativity, and technical expertise over the years. The studio is operated by a dedicated team of **Seven skilled professionals**, each contributing their expertise in photography, editing, and client management.

The studio provides a wide range of services, including wedding photography, engagement shoots, birthday and anniversary coverage, corporate events, and customized photo sessions. Their team of experienced photographers and editors work meticulously to enhance images using modern photographic software and digital effects, ensuring high-quality results.

In addition to photography services, Sunrex Studio also offers high-quality printing, delivering beautifully designed albums with vibrant outdoor photography and elegant layouts. Whether its candid photography, traditional shoots, or cinematic video-graphy, the studio excels in capturing timeless memories.

Furthermore, Sunrex Studio serves as a learning hub for aspiring photographers by conducting workshops and training sessions to help develop their professional skills. With a commitment to innovation and excellence, Sunrex Studio continues to set high standards in photography and visual storytelling.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Tools and Equipment Used for Wedding and Event Photography

1. **Cameras**
2. **Lenses**
3. **Lighting Equipment**
4. **Stabilization Tools**
5. **Memory and Storage**
6. **Editing and Post-Processing Tools**
7. **Audio Equipment (for Videography)**
8. **Drones**

Methodology of the Project: The project was structured into three primary components:

Workshops and Training Sessions:

- Conducted by experts from Sunrex Studio covering topics such as advanced photography techniques, lighting, composition, editing, and event management.
- Hands-on training with professional cameras and editing software.

On-Field Experience:

- Students actively participated in live wedding and event photography assignments under the guidance of Sunrex Studio professional team members.
- Exposure to real-time client interactions, event coverage challenges, and workflow management.

Skill Development and Portfolio Building:

- Students refined their photography and editing skills through practical assignments.
- Each student compiled a professional portfolio showcasing their best work, helping them in future career opportunities.

Objective of the Project:

- To provide students with hands-on experience in wedding and event photography.
- To bridge the gap between theoretical knowledge and practical industry demands.
- To enhance students' technical skills, creativity, and confidence in professional settings.
- To facilitate mentorship opportunities and industry networking.
- To support students in building a professional portfolio for career advancement.

The Students did the Project work on following area:

As part of the **Wedding and Event Photography** project, students are exposed to various aspects of professional photography. They gain hands-on experience in different types of photography, learning the technical skills, creative composition, and industry techniques required to excel in this field. Below are some key photography angles and categories covered during the training:

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

1. **Learning Various Photography Angles**

2. **Wedding Photography**

3. **Fashion Show Event Photography**

4. **Event Photography**

Analysis and Findings:

- Students showed significant improvement in their technical and creative photography skills.
- Practical exposure increased their confidence in handling professional assignments.
- The mentorship from Sunrex Studio provided industry insights that are rarely covered in academic courses.
- Challenges such as real-time adjustments, handling client expectations, and managing lighting conditions were effectively addressed through hands-on experience.
- The collaborative approach fostered a learning culture that benefitted both students and mentors.

Outcomes of the Project:

- Successful completion of project and field training.
- Development of professional portfolios by participating students.
- Increased employability and confidence among students entering the photography industry.
- Strengthened relationship between academia and the industry through mentorship and collaboration.
- Financial commitment of ₹1, 35,000/- from Sunrex Studio was effectively utilized to support training sessions and on-field experiences.

Conclusion:

The 6-month collaborative project between Faculty of Fine Arts, Shri Ram College and **Rasheed Ahmad (Director) Sunrex Studio, Muzaffarnagar** proved to be highly effective in providing students with essential industry knowledge and hands-on training in Wedding and Event Photography. The structured approach, including workshops, field experience, and skill development, significantly enhanced students' professional capabilities. This initiative not only benefited the students but also helped Sunrex Studio engage with emerging talent. Future collaborations of this nature are recommended to continue bridging the gap between academic learning and industry demands, ensuring students are well-prepared for successful careers in photography. By participating in this training, students develop expertise in handling professional equipment, composing stunning shots, and understanding industry workflows. This hands-on experience boosts their confidence and prepares them for a successful career in photography, whether in weddings, fashion, or event photography.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College
Muzaffarnagar

Utilization Certificate

S.N.	Detail of sanction of Fund with Project name and Duration	Amount
1.	6 months project on Wedding and event photography Date of Sanction of Fund- 03-10-2023 as per Sanction Letter	135000.00 /-
	TOTAL	135000.00/-

It is Certified that out of Rs. 135000.00/- (One Lacs Thirty Five Thousands only) of grants sanctioned by **Sunrex Studio, Muzaffarnagar** during the year 2023-2024 in favor of **Shri Ram College, Muzaffarnagar,** a sum of Rs. 135000.00 has been utilized for the purpose of the project for which it was sanctioned and that the balance of Rs. **Nil** remaining unutilized at the end of the year has been surrendered. The Extra amount (If any) is met out by Shri Ram College.

2. Certified that we have satisfied our self that the conditions on which the grant was sanctioned have been duly fulfilled/are being fulfilled and that we have exercised the following checks to see that the money was actually utilized for the purpose for which it was sanctioned.

Kinds of checks exercise-

1. Checking of cash book
2. Checking of payment vouchers.
3. Checking of salary register.
4. Checking of expense bill.

For Shri Ram College

Secretary
Date: 07-04-2024
Place: Muzaffarnagar

For Goel Rakesh & Co.
Chartered Accountants

Rakesh Kumar Goel
Proprietor

GOEL RAKESH & CO. CHARTERED ACCOUNTANTS Muzaffar-Nagar (U.P.)

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Shri Ram College
Approved by UGC, NCTE and Affiliated to MS University, Saharanpur
Muzaffarnagar - 251001, NCR (U.P.)
A++ Grade Accredited by NAAC

CERTIFICATE OF COMPLETION

This is to certify that the **Faculty of Fine Arts, Shri Ram College, Muzaffarnagar** in collaboration with **Sunrex Studio, Muzaffarnagar** has successfully completed the **Wedding and Event Photography Project**, held from **3rd Oct23 to 30th March 2024.**

The project served as a unique platform for students and professionals to collaborate, showcasing creative excellence and technical expertise in photography, editing, and event documentation.

We extend our gratitude to all participants, coordinators, and mentors for their invaluable contributions, ensuring the success of this initiative.

Issued on: 1st April 2024

Authorized Signatories:

Dr Mahej Dhiman
Principal Investigator
Faculty of Fine Arts

Rahees Ahmad
Sunrex Studio, Muzaffarnagar

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Contact @ 9927028908, 9927011422
Website : www.srgcmzn.com E-Mail : src_mzn@rediffmail.com

Shri Ram College, Muzaffarnagar

Department of Fine Arts

Wedding and event Photography - 3 October 2023-24

S.N	REG.NO	STUDENTS NAME	FATHER'S NAME	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1	FA20011	MUKUL SAINI	KRISHANPAL SAINI	P	P	P	P	P	|	P	P	P	P	P	P	|	P	P	P	P	P	P	|	|	|	P	P	P	P	|	P	P
2	FA20012	YASH SHARMA	SANJEEV SHARMA	P	P	P	P	P	|	P	P	P	P	P	P	|	P	P	P	P	P	P	|	R	D	P	P	P	P	|	P	P
3	FA20015	PRIYANSHI SHARMA	NARESH KUMAR SHARMA	P	A	P	P	P	|	P	P	P	P	P	P	|	P	P	P	P	P	P	|	A	U	P	P	P	P	|	P	P
4	FA20016	RAMAN BALIYAN	RAVINDRA KUMAR	P	P	P	P	P	S	P	P	P	P	P	P	S	P	P	P	P	P	P	S	M	S	P	P	P	P	S	P	P
5	FA20017	SUMIT TYAGI	BRIJESH TYAGI	P	P	P	P	P	U	P	P	P	P	P	P	U	P	A	P	P	P	P	U		S	P	P	P	P	U	P	P
6	FA20023	ANSHIKA TAYAL	ASHISH TAYAL	P	P	P	P	P	N	P	P	P	P	P	P	N	P	P	P	P	P	P	N	N	H	P	P	P	P	N	P	P
7	FA20025	SAIJEL GOEL	AJAY KUMAR GOEL	P	P	P	P	P	D	P	P	P	P	P	P	D	P	P	P	P	P	P	D	A	E	P	P	P	P	D	P	P
8	FA20028	AYESHA	ARIF	P	P	P	P	P	A	P	P	P	P	P	P	A	P	P	P	P	P	P	A	V	R	P	P	P	P	A	P	P
9	FA20029	SHOKEEN ALI	YUSUF ALI	P	P	P	P	P	Y	P	P	P	P	A	P	Y	P	P	P	P	P	P	Y	M	A	P	P	P	P	Y	P	P
10	FA20030	ANURADHA	ASHOK KUMAR	P	P	P	P	P	|	P	P	P	P	P	P	|	P	P	P	P	P	P	|	I	|	P	P	P	P	|	P	P
11	FA20037	SIMRAN TYAGI	NIRANKAR TYAGI	P	P	P	P	P	|	P	P	P	P	P	P	|	P	P	P	P	P	P	|	|	|	P	P	P	P	|	P	P
12	FA20039	HIMADRI TYAGI	ASHOK TYAGI	P	P	P	P	P	|	P	P	P	P	P	P	|	P	P	P	P	P	P	|	|	|	P	P	P	P	|	P	P
13	FA20040	HIMANSHI TYAGI	MANOJ KUMAR	P	P	P	P	P	|	P	P	P	P	P	P	|	P	P	P	P	P	P	|	|	|	P	P	P	P	|	P	P
14	FA20048	MOHD. SHAHID	MOHD. SHAZID	P	P	P	P	P	|	P	P	P	P	P	P	|	P	P	P	P	P	P	|	|	|	P	P	P	P	|	P	P
15	FA20050	KM. SOOCHI	PINDKU TYAGI	P	P	P	P	P	|	P	P	P	P	P	P	|	P	P	P	P	P	P	|	|	|	P	P	P	P	|	P	P

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Shri Ram College, Muzaffarnagar

Department of Fine Arts

Wedding and event Photography - 1st Nov 2023-24

S.N	REG.NO	STUDENTS NAME	FATHER'S NAME	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1	FA20011	MUKUL SAINI	KRISHANPAL SAINI	P	A	P	P	P	P	P	P	P			H				P	P	A	|	P	P	P	P	P	A	|	P	P	A	P	
2	FA20012	YASH SHARMA	SANJEEV SHARMA	P	P	A	P	|	P	P	P	P			A				P	P	P	|	P	P	P	P	P	P	|	P	P	P	P	
3	FA20015	PRIYANSHI SHARMA	NARESH KUMAR SHARMA	P	P	P	P	S	P	P	P	A			P				P	P	P	S	P	P	P	P	P	P	S	P	P	P	P	
4	FA20016	RAMAN BALIYAN	RAVINDRA KUMAR	P	P	P	P	U	P	P	P	P			P				A	P	P	U	P	A	P	P	P	P	U	P	P	P	P	
5	FA20017	SUMIT TYAGI	BRIJESH TYAGI	P	P	P	P	N	A	P	P	P			Y				P	P	P	N	P	P	P	P	P	A	N	P	P	P	P	
6	FA20023	ANSHIKA TAYAL	ASHISH TAYAL	P	P	P	P	D	P	P	P	P							P	P	P	D	P	P	P	P	P	P	D	P	P	P	P	
7	FA20025	SAIJEL GOEL	AJAY KUMAR GOEL	P	A	P	P	A	P	P	P	P			D				P	P	A	A	P	P	P	P	P	P	A	A	P	P	A	
8	FA20028	AYESHA	ARIF	A	P	P	P	Y	P	P	P	P			I				P	P	P	Y	P	P	P	P	P	P	Y	P	P	P	P	
9	FA20029	SHOKEEN ALI	YUSUF ALI	P	P	P	P	|	P	P	P	P			W				A	P	P	|	P	P	P	A	P	P	|	P	P	P	P	
10	FA20030	ANURADHA	ASHOK KUMAR	P	P	P	P	|	P	A	P	P			A				P	P	P	|	P	P	P	P	A	P	|	P	P	P	P	
11	FA20037	SIMRAN TYAGI	NIRANKAR TYAGI	P	P	P	A	|	P	P	P	P			L				P	P	P	|	P	P	P	P	P	P	|	A	P	P	P	
12	FA20039	HIMADRI TYAGI	ASHOK TYAGI	P	P	P	P	|	P	A	P	P			I				P	P	P	|	P	A	P	P	P	A	|	P	P	A	P	
13	FA20040	HIMANSHI TYAGI	MANOJ KUMAR	P	P	P	P	|	P	P	P	P			|				P	P	P	|	P	P	P	P	P	P	|	P	P	P	S	
14	FA20048	MOHD. SHAHID	MOHD. SHAZID	P	P	P	P	|	P	P		P			|				P	P	P	|	P	P	P	P	P	P	|	P	P	P	P	
15	FA20050	KM. SOOCHI	PINDKU TYAGI	P	P	P	P	|	P	P	P	A			|				P	P	P	|	P	A	P	P	P	P	|	P	A	P	A	

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Shri Ram College, Muzaffarnagar

Department of Fine Arts

Wedding and event Photography - 1st December 2023-24

S.N	REG.NO	STUDENTS NAME	FATHER'S NAME	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1	FA20011	MUKUL SAINI	KRISHANPAL SAINI																									C						
2	FA20012	YASH SHARMA	SANJEEV SHARMA				A																					H	A				N	
3	FA20015	PRIYANSHI SHARMA	NARESH KUMAR SHARMA		A	S					A		S							S						S	R					E	
4	FA20016	RAMAN BALIYAN	RAVINDRA KUMAR			U							U			A				U				A		U	I					W	
5	FA20017	SUMIT TYAGI	BRIJESH TYAGI			N							N		A					N						N	S		A			Y	
6	FA20023	ANSHIKA TAYAL	ASHISH TAYAL			D							D						A	D						D	T					G	
7	FA20025	SAIJEL GOEL	AJAY KUMAR GOEL	A		A							A							A					A	A	M					A	
8	FA20028	AYESHA	ARIF			Y	A				A		Y							Y						Y	A	A				R	
9	FA20029	SHOKEEN ALI	YUSUF ALI												A													S						
10	FA20030	ANURADHA	ASHOK KUMAR								A																						C	
11	FA20037	SIMRAN TYAGI	NIRANKAR TYAGI																				A					D					O	
12	FA20039	HIMADRI TYAGI	ASHOK TYAGI																									A	A				U	
13	FA20040	HIMANSHI TYAGI	MANOJ KUMAR		A						A																	Y					D	
14	FA20048	MOHD. SHAHID	MOHD. SHAZID				A																										Y	
15	FA20050	KM. SOOCHI	PINDKU TYAGI													A										A			A				S	

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Shri Ram College, Muzaffarnagar

Department of Fine Arts

Wedding and event Photography - 1st January 2023-24

S.N	REG.NO	STUDENTS NAME	FATHER'S NAME	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1	FA20011	MUKUL SAINI	KRISHANPAL SAINI								P	P	P	P	P	P	|	P	P	P	P	P	P	|	P	P	A	P	R	P	|	P	P	P
2	FA20012	YASH SHARMA	SANJEEV SHARMA								P	P	A	P	P	P	|	P	P	P	P	P	P	|	P	P	P	P	E	P	|	P	P	P
3	FA20015	PRIYANSHI SHARMA	NARESH KUMAR SHARMA								P	P	P	P	P	P	S	P	P	P		P	P	S	P	P	P	P	P	P	S	P	P	P
4	FA20016	RAMAN BALIYAN	RAVINDRA KUMAR								P	P	P	P	P	P	U	P	P	P	A	P	P	U	P	P	P	P	U	P	U	P	P	P
5	FA20017	SUMIT TYAGI	BRIJESH TYAGI								P	P	P	P	P	P	N	P	P	P	P	P	P	N	P	P	P	P	B	P	N	P	P	P
6	FA20023	ANSHIKA TAYAL	ASHISH TAYAL								A	P	P	P	P	P	D	P	P	P	P	P	P	D	P	P	P	P	L	P	D	P	P	P
7	FA20025	SAIJEL GOEL	AJAY KUMAR GOEL								P	P	P	P	P	P	A	P	P	P	P	P	P	A	P	P	P	P	I	P	A	P	P	P
8	FA20028	AYESHA	ARIF								P	P	P	A	P	P	Y	P	P	P	P	P	P	Y	P	P	A	P	C	P	Y	P	P	P
9	FA20029	SHOKEEN ALI	YUSUF ALI								P	P	P	P	P	P	|	P	P	P	P	P	P	|	P	P	P	P		P	|	P	P	P
10	FA20030	ANURADHA	ASHOK KUMAR								P	P	P	P	P	P	|	A	P	P	P	P	P	|	P	P	P	P	D	P	|	P	P	P
11	FA20037	SIMRAN TYAGI	NIRANKAR TYAGI								P	P	P	P	P	P	|	P	P	P	P	P	P	|	P	P	P	P	A	P	|	P	A	P
12	FA20039	HIMADRI TYAGI	ASHOK TYAGI								P	P	P	P	P	P	|	P	P	P	P	P	P	|	P	P	P	P	Y	P	|	P	P	P
13	FA20040	HIMANSHI TYAGI	MANOJ KUMAR								A	P	P	P	P	P	|	P	P	P	P	P	P	|	P	P	P	P	|	P	|	P	P	P
14	FA20048	MOHD. SHAHID	MOHD. SHAZID								P	P	P	P	P	A	|	P	P	P	P	P	A	|	P	P	P	P	|	P	|	P	P	P
15	FA20050	KM. SOOCHI	PINDKU TYAGI								P	P	P	P	P	P	|	P	P	P	P	P	P	|	P	A	P	P	|	P	|	P	P	P

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Chairman
IQAC, Shri Ram College
Muzaffarnagar

Shri Ram College, Muzaffarnagar
Department of Fine Arts
Wedding and event Photography - 1st February 2023-24

S.N	REG.NO	STUDENTS NAME	FATHER'S NAME	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
1	FA20011	MUKUL SAINI	KRISHANPAL SAINI	P	P	P	|	P	P	P	P	P	P	|	P	P	P	P	P	P	|	P	P	P	P	P	P	|	P	P	P	P
2	FA20012	YASH SHARMA	SANJEEV SHARMA	P	P	P	|	P	P	P	P	P	P	|	P	A	P	P	P	P	|	P	P	P	P	P	P	|	P	P	P	P
3	FA20015	PRIYANSHI SHARMA	NARESH KUMAR SHARMA	P	P	A	S	P	P	P	P	P	P	S	P	P	P	P	P	P	S	P	P	P	P	P	P	S	P	P	P	P
4	FA20016	RAMAN BALIYAN	RAVINDRA KUMAR	P	P	P	U	P	P	P	P	P	P	U	P	P	P	P	P	P	U	P	P	P	P	P	P	U	P	P	P	P
5	FA20017	SUMIT TYAGI	BRIJESH TYAGI	P	P	P	N	P	P	P	P	P	P	N	P	P	P	P	P	P	N	P	P	P	P	P	P	N	P	P	A	P
6	FA20023	ANSHIKA TAYAL	ASHISH TAYAL	P	P	P	D	P	A	P	P	P	P	D	P	P	P	P	P	P	D	P	P	P	P	P	P	D	P	P	P	P
7	FA20025	SAIJEL GOEL	AJAY KUMAR GOEL	P	P	P	A	P	P	P	P	P	P	A	P	P	P	P	P	P	A	P	P	P	P	P	P	A	P	P	P	P
8	FA20028	AYESHA	ARIF	P	P	P	Y	P	P	P	P	P	P	Y	P	P	P	P	P	P	Y	P	P	P	P	P	P	Y	P	P	P	P
9	FA20029	SHOKEEN ALI	YUSUF ALI	P	P	P	|	P	P	P	P	P	P	|	P	P	P	P	P	P	|	P	P	P	P	P	P	|	P	P	P	P
10	FA20030	ANURADHA	ASHOK KUMAR	P	P	P	|	P	P	P	P	P	P	|	P	P	P	P	P	P	|	P	P	P	P	P	P	|	P	P	P	P
11	FA20037	SIMRAN TYAGI	NIRANKAR TYAGI	P	P	P	|	P	P	P	P	P	P	|	P	P	P	P	P	P	|	P	P	P	P	P	P	|	P	P	P	P
12	FA20039	HIMADRI TYAGI	ASHOK TYAGI	P	P	P	|	P	P	P	P	P	P	|	P	P	P	P	A	P	|	P	P	P	P	P	P	|	P	P	P	P
13	FA20040	HIMANSHI TYAGI	MANOJ KUMAR	P	P	P	|	P	P	P	P	P	P	|	P	P	P	P	P	P	|	P	P	P	P	P	P	|	P	P	P	P
14	FA20048	MOHD. SHAHID	MOHD. SHAZID	P	P	P	|	P	P	P	P	P	P	|	P	P	P	P	P	P	|	P	P	P	P	P	P	|	P	P	P	P
15	FA20050	KM. SOOCHI	PINDKU TYAGI	P	P	P	|	P	P	P	P	P	P	|	P	P	P	P	P	P	|	P	P	P	P	P	P	|	P	P	P	P

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Shri Ram College, Muzaffarnagar

Department of Fine Arts

Wedding and event Photography - 1st March 2023-24

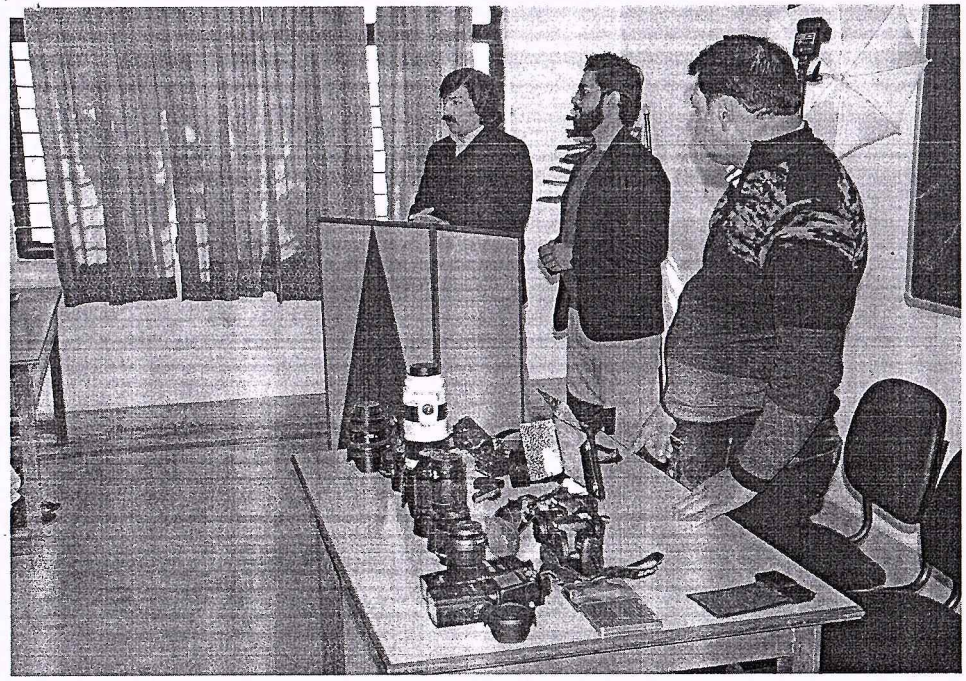
S.N	REG.NO	STUDENTS NAME	FATHER'S NAME	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1	FA20011	MUKUL SAINI	KRISHANPAL SAINI	P	P	|	P	P	P	P	P	P	|	P	P	A	P	P	P	|	P	P	P	A	P	P	|	|	P	A	P	P	P	|
2	FA20012	YASH SHARMA	SANJEEV SHARMA	P	P	|	P	P	P	P	P	P	|	P	P	P	P	P	P	|	P	P	P	P	P	P	|	|	P	P	P	P	P	|
3	FA20015	PRIYANSHI SHARMA	NARESH KUMAR SHARMA	P	P	S	P	P	A	P	P	P	|	P	P	P	P	P	P	|	P	P	P	P	P	P	|	H	P	P	P	P	P	|
4	FA20016	RAMAN BALIYAN	RAVINDRA KUMAR	P	P	U	P	P	P	P	P	P	S	P	P	P	P	P	P	|	P	P	P	P	P	A	|	O	P	P	P	P	P	|
5	FA20017	SUMIT TYAGI	BRIJESH TYAGI	A	P	N	P	P	P	P	P	P	U	A	P	P	P	P	P	S	P	P	A	P	P	P	J	L	P	P	P	A	P	S
6	FA20023	ANSHIKA TAYAL	ASHISH TAYAL	P	P	D	P	P	P	P	P	P	N	P	P	P	P	P	P	U	P	P	P	P	P	P	U	I	P	P	P	P	P	U
7	FA20025	SAIJEL GOEL	AJAY KUMAR GOEL	P	P	A	P	A	P	P	P	P	D	P	P	P	P	A	P	N	P	P	P	P	P	P	N	T	P	P	P	P	A	N
8	FA20028	AYESHA	ARIF	P	P	Y	P	P	P	P	P	P	A	P	P	P	P	P	P	D	P	P	P	P	P	P	D	H	P	P	P	P	P	D
9	FA20029	SHOKEEN ALI	YUSUF ALI	P	P	|	P	P	P	P	A	P	Y	P	P	P	P	P	P	A	P	P	P	P	P	A	D	O	P	A	P	P	P	A
10	FA20030	ANURADHA	ASHOK KUMAR	P	P	|	P	P	P	P	P	P	|	P	P	P	P	P	P	Y	P	P	P	P	A	P	Y	L	P	P	P	P	P	Y
11	FA20037	SIMRAN TYAGI	NIRANKAR TYAGI	P	P	|	P	P	P	P	P	P	|	P	P	P	P	P	P	|	P	P	P	P	P	P	|	I	P	P	A	P	P	|
12	FA20039	HIMADRI TYAGI	ASHOK TYAGI	P	P	|	P	A	P	P	P	P	|	P	A	P	P	P	P	|	P	P	P	P	P	P	|	|	P	P	P	P	P	|
13	FA20040	HIMANSHI TYAGI	MANOJ KUMAR	P	A	|	P	P	P	P	P	P	|	P	P	P	P	P	P	|	P	A	P	P	P	P	|	|	P	P	P	P	P	|
14	FA20048	MOHD. SHAHID	MOHD. SHAZID	P	P	|	P	P	P	P	P	P	|	P	P	P	P	P	P	|	P	P	P	P	P	P	|	|	P	P	P	A	P	|
15	FA20050	KM. SOOCHI	PINDKU TYAGI	A	P	|	P	P	P	P	P	P	|	P	P	P	P	P	P	|	P	P	P	P	P	P	|	|	P	P	P	P	P	|

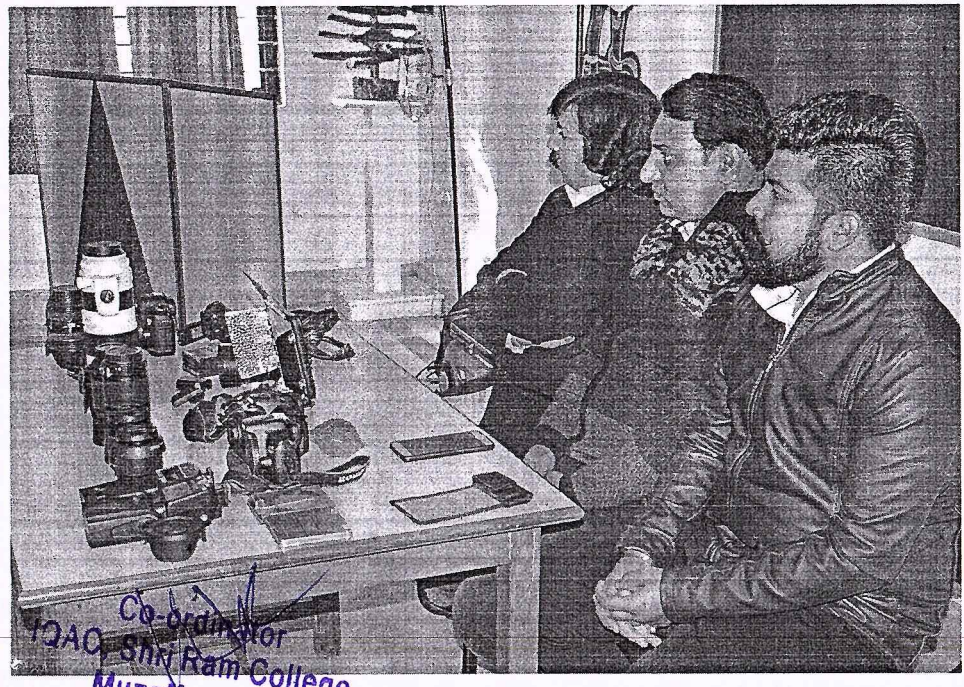
Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

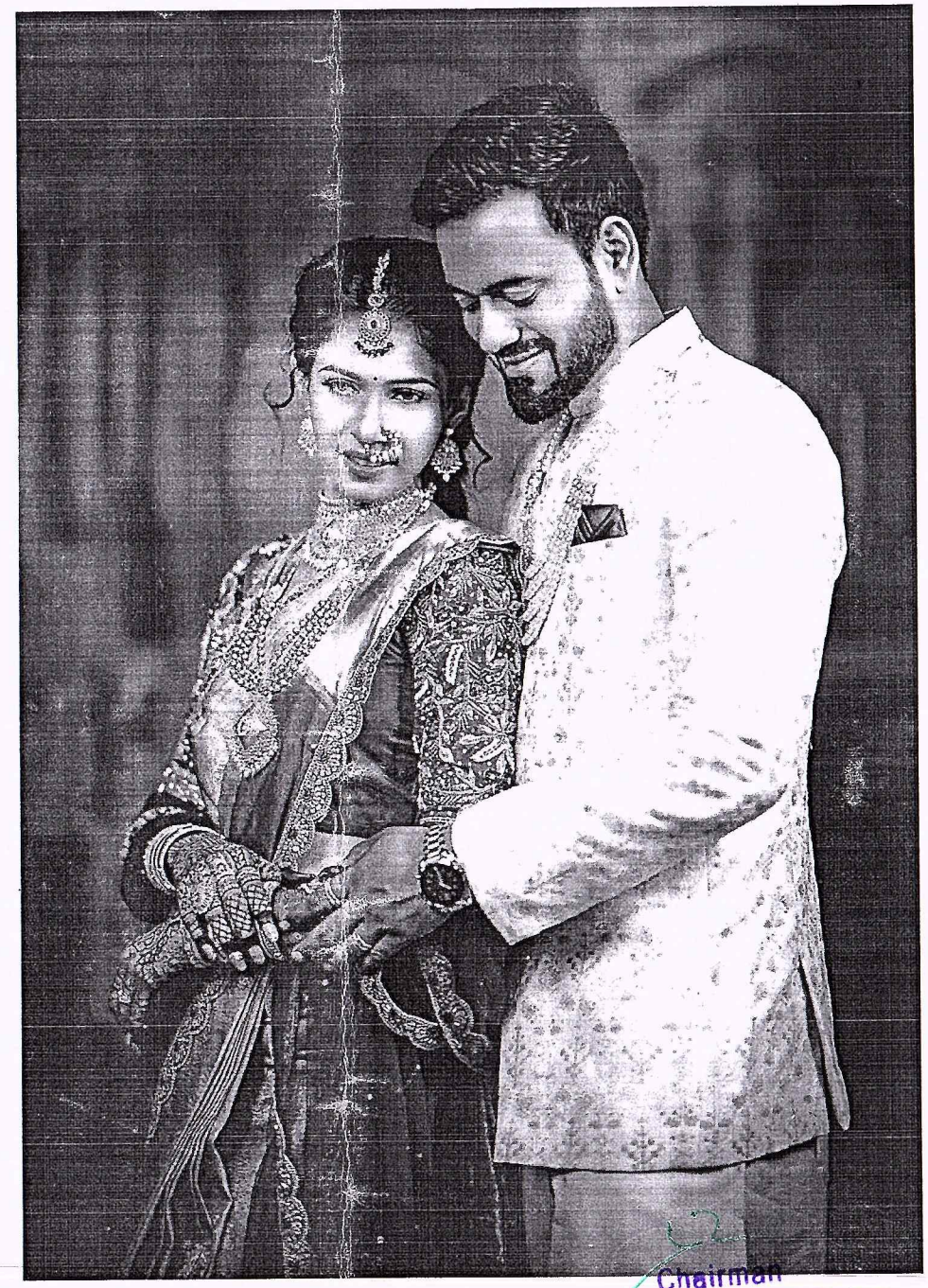
Chairman
IQAC, Shri Ram College,
Muzaffarnagar





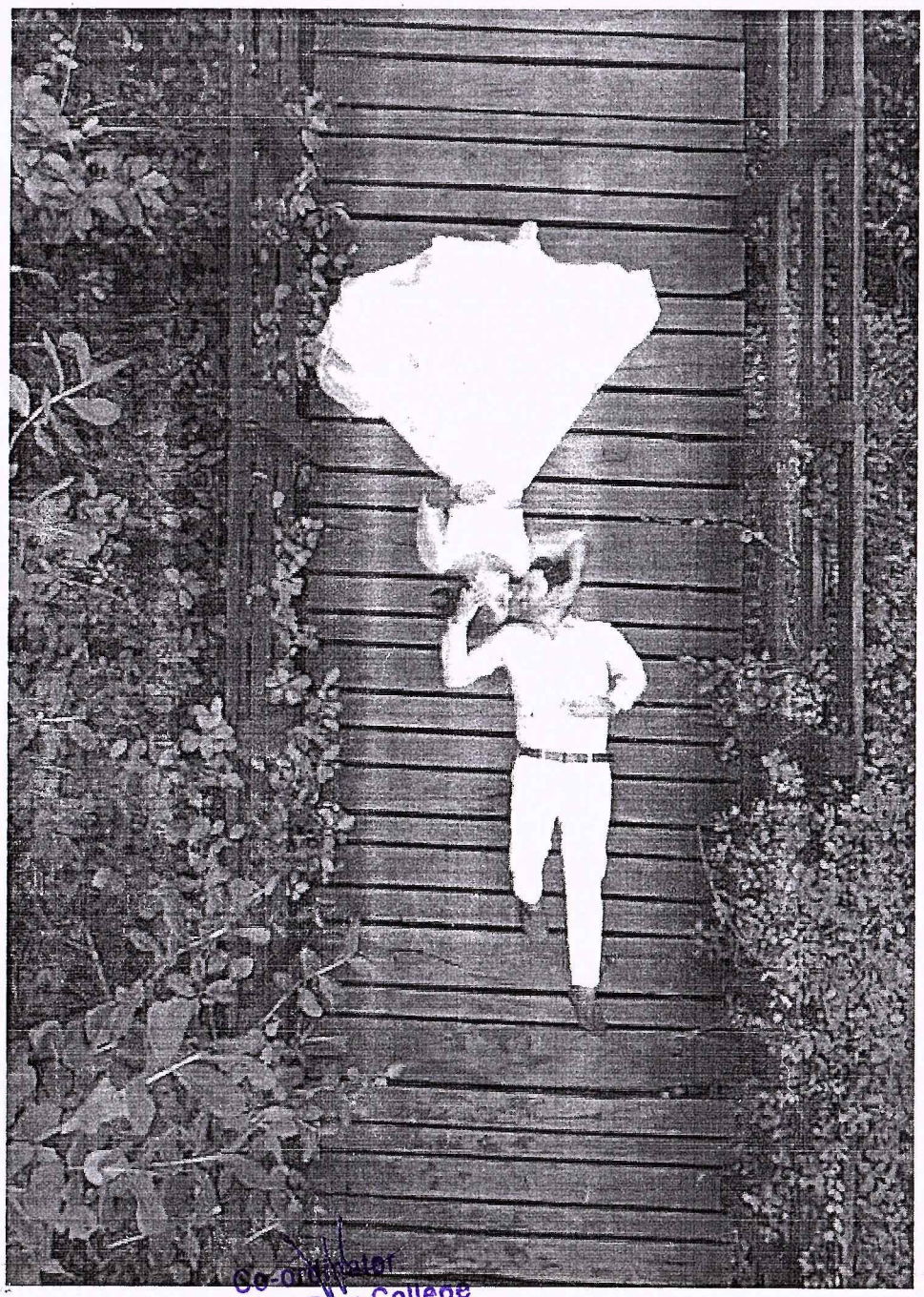
Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College
Muzaffarnagar

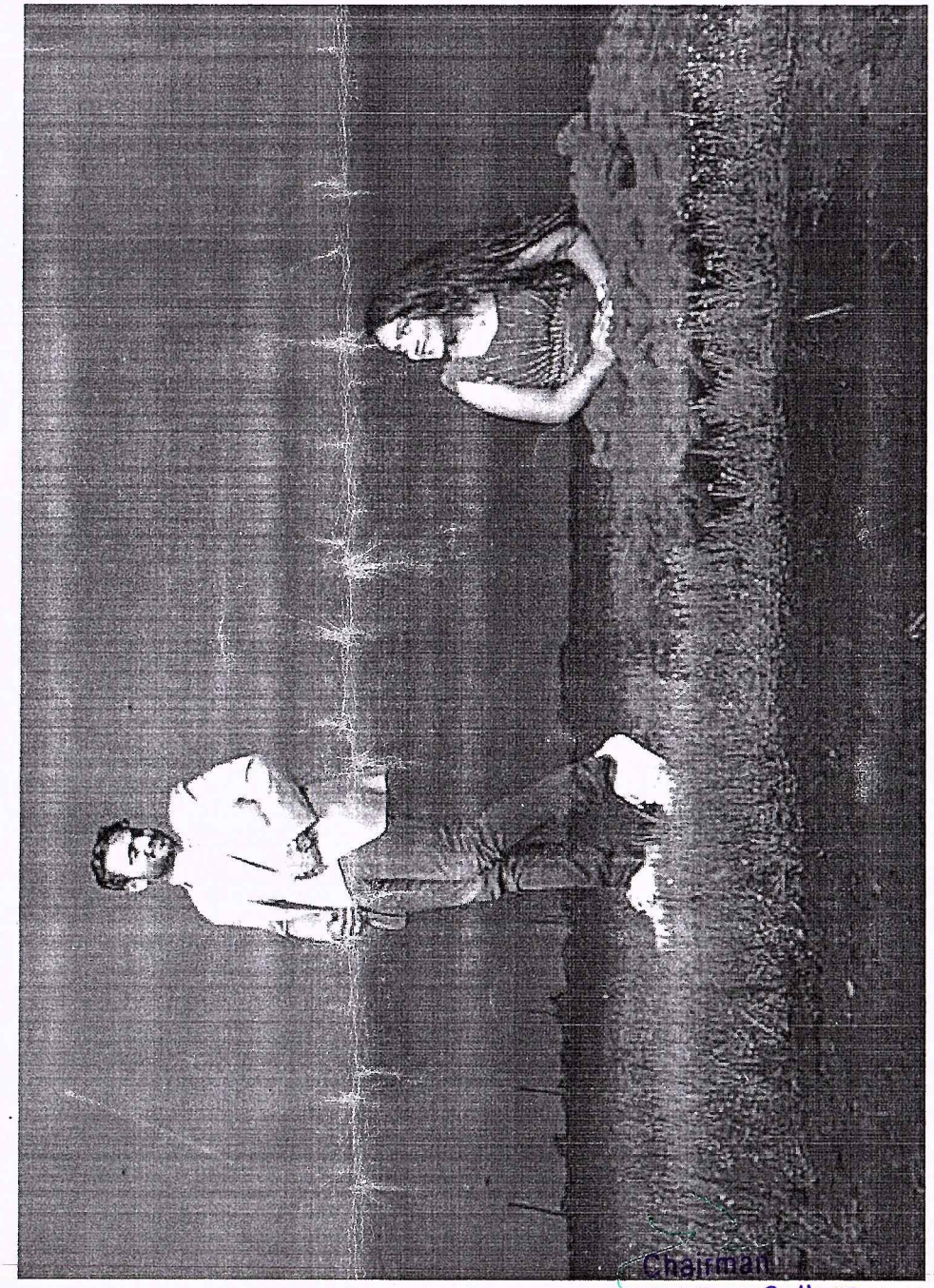


Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

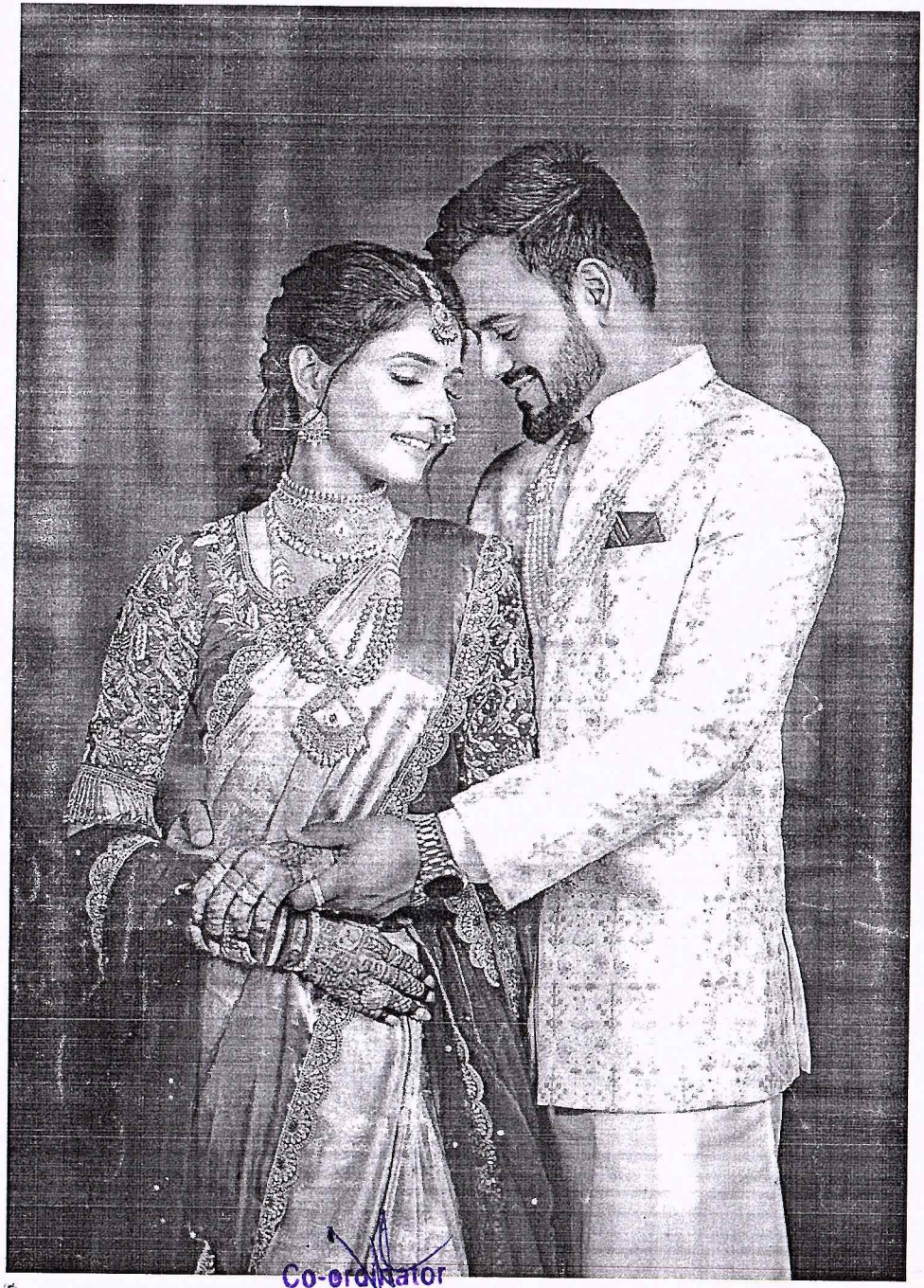
Chairman
IQAC, Shri Ram College,
Muzaffarnagar



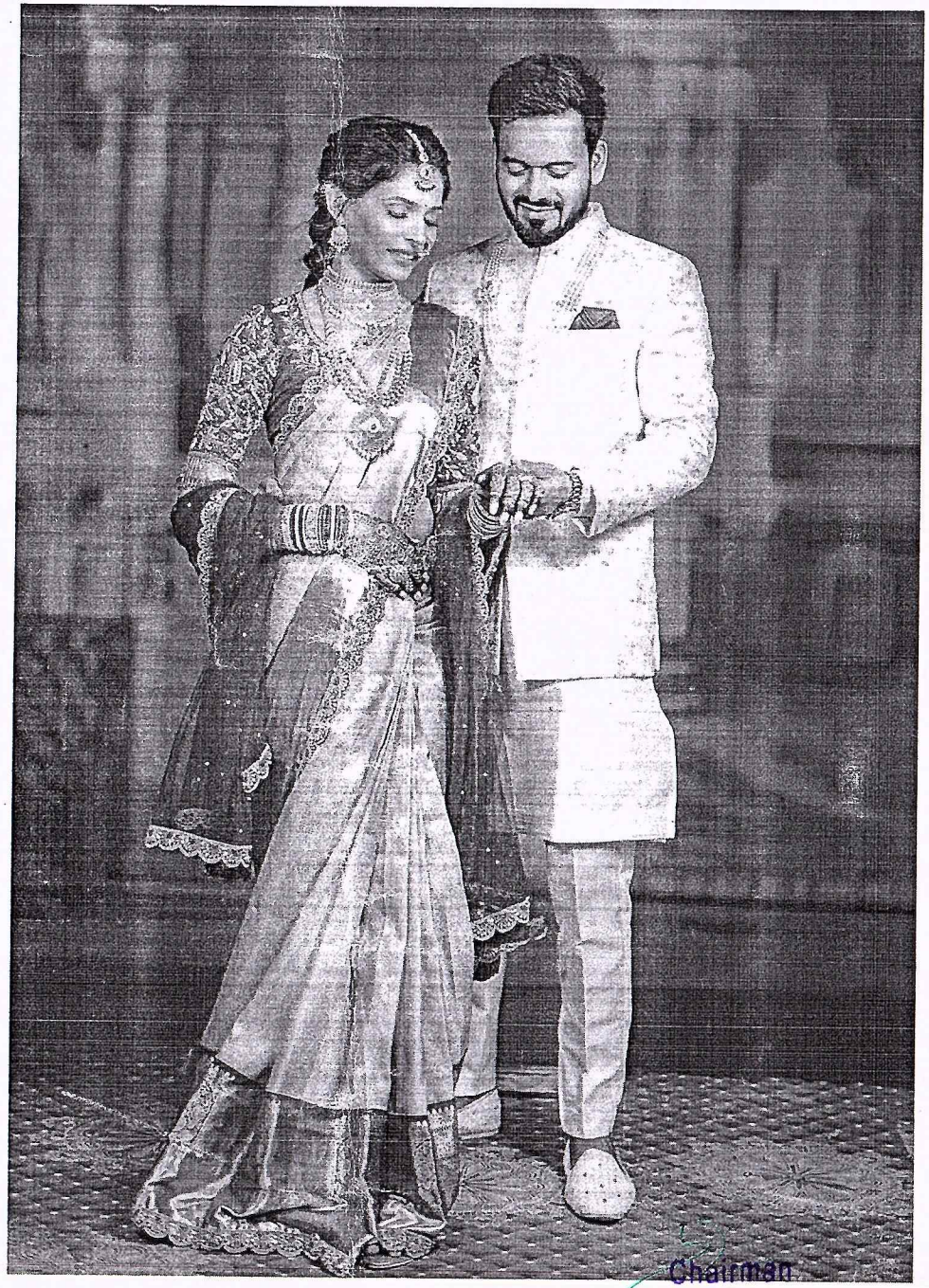
Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar



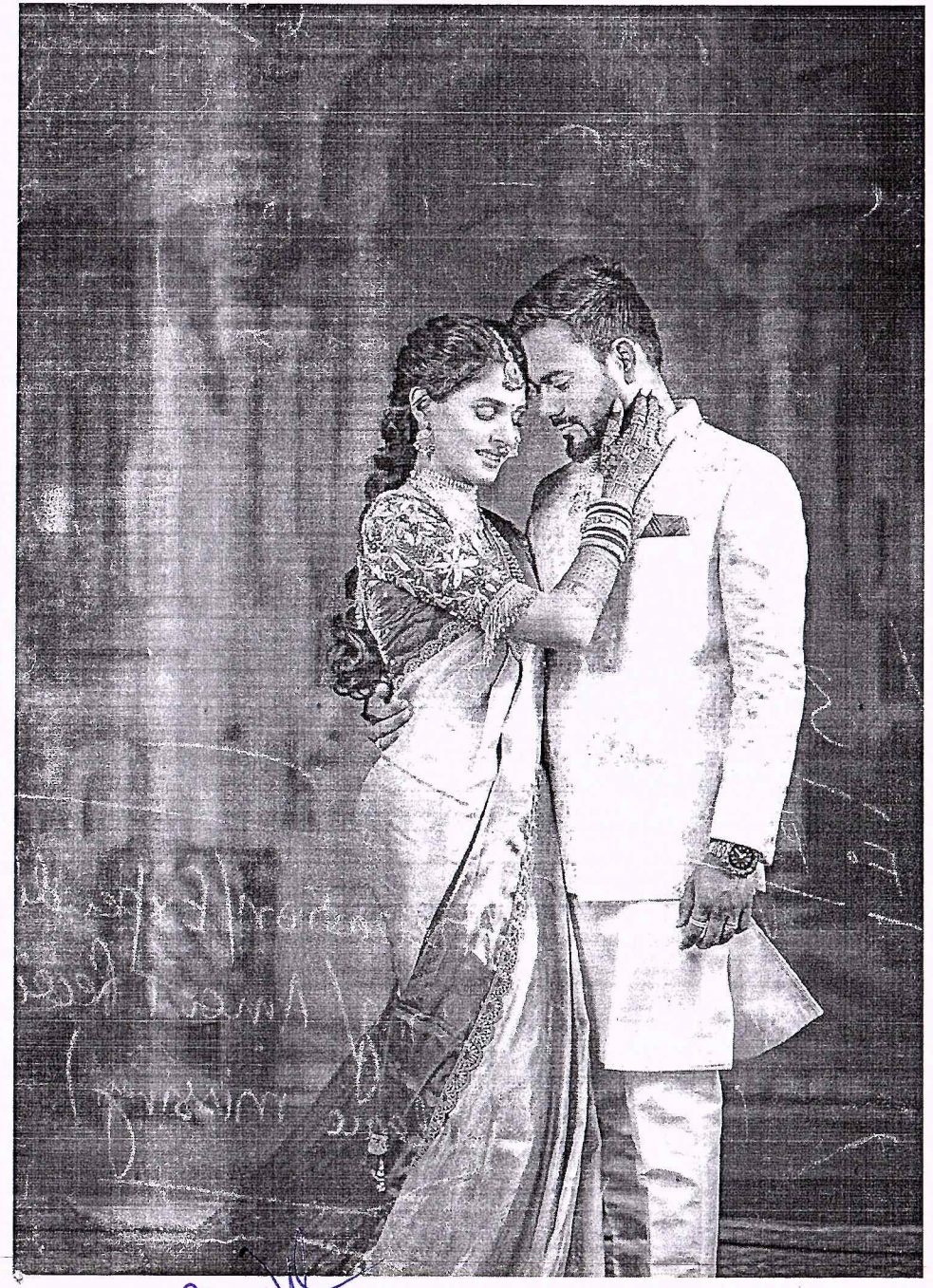
Chairman
IQAC, Shri Ram College,
Muzaffarnagar



Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar



Chairman
IQAC, Shri Ram College,
Muzaffarnagar



Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

PROJECT

ON

"Design and Development of Solar Biomass Hybrid Food Dryer"

SUBMITTED BY:

Dr. Mohd Nayeem Ali
HoD & Assistant Professor
Session – 2023-24

DEPARTMENT OF AGRICULTURE

SHRI RAM COLLEGE, MUZAFFARNAGAR

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

JAIHIND AGRO INDUSTRIES LTD.

Roorkee Road, Muzaffaranagar

To

The Principal,
Shri Ram College, Muzaffarnagar

Date: 25-10-2023

Respected Madam

Greetings

Jaihind Agro Industries, Muzaffarnagar is a prominent player in the agro-industrial sector, dedicated to providing high-quality agricultural equipment and services. Established with a vision to enhance agricultural productivity and sustainability, Jaihind Agro Industries focuses on innovative solutions that cater to the needs of farmers and the farming community. The company specializes in the production and distribution of a wide range of agro-based products, including fertilizers, pesticides, seeds, and modern farming equipment. In addition to these products, Jaihind Agro Industries is committed to promoting sustainable farming practices and providing technical support to farmers to improve yields and maximize their output. With a strong emphasis on research and development, Jaihind Agro Industries continually seeks to adopt the latest technologies and methods in agriculture. This commitment not only aids in boosting agricultural efficiency but also supports environmental conservation and responsible farming. Jaihind Agro Industries believes in the power of collaboration and actively engages with local farmers, agricultural institutions, and government bodies to foster growth in the agro sector. The company aims to empower farmers with knowledge and resources, enabling them to achieve sustainable agricultural success. Through its dedication to quality, innovation, and sustainable practices, Jaihind Agro Industries strives to make a meaningful impact on the agro-industrial landscape and contribute to the overall development of the agricultural sector. Jai Hind Agro always aims to make and provide new machinery as per the requirement of farmers. This time many farmers are in demand for solar natural dryer. So we want to create a positive solar natural dryer by Shri Ram College, Muzaffarnagar. So that Jai Agro Industries can provide this dryer to the farmers on time. Jai Agro Industries requests to Shri Ram College to take a step forward in fulfilling its social responsibilities by helping in this work. The Jai Agro Industries will always be ready to bear all the expenses incurred in this research.

Awaiting your reply on the above.

(Jaiveer Singh)
Secretary,
Jaihind Agro Industries,
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Roorkee Road, Opp Pal Dharmshala, Muzaffarnagar - 251001, Uttar Pradesh, India, Muzaffarnagar, Uttar Pradesh 251001, Contact Number: +91 0253 2990754

Shri Ram College
Approved by UGC, NCTE and Affiliated to MS University, Saharanpur
Muzaffarnagar - 251001, NCR (U.P.)
A++ Grade Accredited by NAAC

Date: 22-08-2023

To

The Secretary

Hind Agro Industries Ltd., Muzaffarnagar

Respected Sir

With reference to your letter, it gives me immense pleasure to informed you that Shri Ram College will be grateful to participate in Innovative contribution with **Jaihind Agro Industries Ltd.** through the conduct of this research. We nominate **Dr Mohd Nayeem,** HOD in the Department of Agriculture, as the Principal Investigator for the research.

Dr. Mohd Nayeem is a distinguished academician with extensive experience in teaching and research. His expertise in "Dairy & Food Processing and significantly worker for this project. Dr Mohd Nayeem has consistently demonstrated his ability to lead and deliver high-quality research outcomes. As the Principal Investigator, he will be responsible for overseeing the project, ensuring adherence to the proposed timeline and objectives, and contributing to the advancement of knowledge in the field. You are also requested to discuss regarding project expenses duration and total expected budget with him.

I am confident that Dr Mohd Nayeem is expertise and commitment will make this project a success and bring significant recognition to our institution.

We extend our best wishes to him for the successful execution of this research endeavour.

Chairman
IQAC, Shri Ram College
Muzaffarnagar

Regards,

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

(Dr Prerna Mittal)
Principal, SRC

Contact @ 9927028908, 9927011422
Website : www.srgcmzn.com E-Mail : src_mzn@rediffmail.com

JAIHIND AGRO INDUSTRIES LTD.

Roorkee Road, Muzaffaranagar

Date:29-08-2023

To
The Principal
Shri Ram College, Muzaffarnagar

Subject: Sponsorship for Research Project and Requirement for Fund Utilization Report

Honorable Madam

The **Jaihind Agro Industries Ltd., Muzaffarnagar**, is pleased to sponsor funds amounting to **1,50,000/-** for the research project titled **"Design and Development of Solar Biomass Hybrid Food Dryer"** undertaken by your esteemed college. This initiative aligns with our vision of fostering innovation and contributing to the advancement of knowledge in areas critical to industrial and societal development.

We request that these funds be utilized strictly for the purpose outlined in the approved project proposal, including but not limited to (mention broad categories such as research materials, development, assessment & analysis, and reporting).

To ensure transparency and proper accountability, we kindly ask you to provide a detailed utilization report upon the project's completion. This report should include:

1. A summary of activities and outcomes achieved.
2. A financial statement detailing the allocation and expenditure of funds.
3. Copies of invoices, receipts, and any supporting documentation.

We value this collaboration and trust that the institution will make the most effective use of this sponsorship to achieve the desired outcomes. Should you require any additional assistance or clarification, please do not hesitate to reach out to us.

We look forward to receiving the utilization report and wish your institution great success in this research endeavour.

Yours sincerely,

(Jaiveer Singh)
Secretary,
Jaihind Agro Industries,
Muzaffarnagar

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Shri Ram College
Approved by UGC, NCTE and Affiliated to MS University, Saharanpur
Muzaffarnagar - 251001, NCR (U.P.)
A++ Grade Accredited by NAAC

Project Fund and Completion Detail

Date: 31-03-2024

1. Title of Project: **"Design and Development of Solar Biomass Hybrid Food Dryer"**
2. Principal Investigator and Co-Investigator: **Dr Mohd Nayeem, Shri Ram College, Muzaffarnagar.**
3. Implementing College and Sponsored Body: **Department of Agriculture, Shri Ram College & Jaihind Agro Industries Ltd., Muzaffarnagar**
4. Sanctioned Project Amount by **Jaihind Agro Industries Ltd., Muzaffarnagar: Rs. 150,000/-**
5. Project Duration: **September 2023 to March 2024**
6. Project Completion Date: **March 31th, 2024**

Statement of Expenditure

Amount Received	**Rs.150,000/-**

Expenditure:

Non Consumable Materials	**20,000/-**
Consumable Materials	**1,10,000/-**
Printing & Stationary	**5,000/-**
Travels	**15,000/-**
Grand Total	**150,000/-**

(Dr. Mohd Nayeem)
Research Project Coordinator

(DrPrerna Mittal)
Principal Shri Ram College

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Contact @ 9927028908, 9927011422
Website : www.srgcmzn.com E-Mail : src_mzn@rediffmail.com

Utilization Certificate

S.N.	Detail of sanction of Fund with Project name and Duration	Amount
1.	7 months project on Design and Development of Solar biomass hybrid Food dryer Date of Sanction of Fund- 29-08-2023 as per Sanction Letter	150000.00 /-
	TOTAL	150000.00/-

It is Certified that out of Rs. 150000.00/- (One Lacs fifty Thousands only) of grants sanctioned by **Jai Hind Agriculture Industries, Muzaffarnagar** during the year 2023-2024 in favor of **Shri Ram College, Muzaffarnagar,** a sum of Rs. 150000.00 has been utilized for the purpose of the project for which it was sanctioned and that the balance of Rs. **Nil** remaining unutilized at the end of the year has been surrendered. The Extra amount (If any) is met out by Shri Ram College.

2. Certified that we have satisfied our self that the conditions on which the grant was sanctioned have been duly fulfilled/are being fulfilled and that we have exercised the following checks to see that the money was actually utilized for the purpose for which it was sanctioned.

Kinds of checks exercise-

1. Checking of cash book
2. Checking of payment vouchers.
3. Checking of salary register.
4. Checking of expense bill.

For Shri Ram College

Secretary
Date: 12-04-2024
Place: Muzaffarnagar

For Goel Rakesh & Co.
Chartered Accountants

GOEL RAKESH & CO. Muzaffar Nagar (U. P.) CHARTERED ACCOUNTANTS

Rakesh Kumar Goel
Proprietor

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

CHAPTER -1

INTRODUCTION

Dehydration and drying are simple low- cost ways to preserve food that might otherwise spoil. Drying to remove water and thus prevent fermentation or the growth of molds. It also slows the chemical changes that take place naturally in foods, as the case is when the fruit ripens, surplus grain, vegetables, and fruit preserved by drying can be stored for future use. People have been drying food for thousands of years by placing the food on mats in the sun, this simple method, however, allows the food to be contaminated by dust, air borne molds and fungi, insects, rodents, and other animals. Furthermore, open air drying is often not possible in humid climates. Although solar dryers involve an initial expense, they produce much better looking, tasting, and more nutritious foods, enhancing both their food value and their marketability; they are also faster, safer, and more efficient than traditional sun drying techniques.

In industrialized regions and sectors, open air-drying has now been largely replaced by mechanized dryers, with boilers to heat incoming air, and fans to force it through at a high rate. Mechanized drying is faster than open-air drying, uses much less land and usually gives a better quality product. But the equipment is expensive and requires substantial quantities of fuel or electricity to operate. **Rietz and Page (2002)**

Some of the advantages of drying as a food preservation technique include, low costs of production as compared to other methods of food preservation used today, being a very cheap and easy technique to avail, people in rural areas can still use this cheap source of energy in preserving food hence reducing food deterioration and insecurity in those areas where hunger and famine are common, drying improves the quality both physical and nutrition wise, in that the food becomes shelf stable, and the inner ingredients within the food are conserved, the overall quality and acceptability of the entire dehydrated food product is good and up to the required standard for example the texture and general appearance of the dry product is up to the mark. **Lorna et al. (2008)**

Solar drying is a common method of food preservation used by people since time in memorial, in this solar energy is utilized or simply the sun's rays are utilized to dry fresh food products in order to reduce the moisture content found in foods so as to improve on the quality and shelf life of the foods stopping or deterring the destructive process of deterioration and composition

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

of fresh foods and products, in the context of this technical brief, refers to methods of using the sun's energy for drying, but excludes open air sun drying.

The objective of most drying processes is to reduce the moisture content of the product to a specified value. Moisture content (wet basis) is expressed as the weight of water as a proportion of total weight. The moisture content of rice has typically to be reduced from 24% to 14%. So to dry one tone of rice, 100kg of water must be removed. If the heated air has an 'absorption capacity' of 8g/m3 then 100/0.0008= 12,500/m3 of air are required to dry one tone of rice. The heat required to evaporate water is 2.26kJ/kg. Hence, approximately 250MJ (70kWh) of energy are required to vaporize the 100kg water. There is no fixed requirement for solar heat input to the dryer. This is because the incoming ambient air can give up some of its internal energy to vaporize the water (becoming colder in the process). Indeed, if the ambient air is dry enough, no heat input is essential. **Werner and Josef (2005)**

Nevertheless, extra heat is useful for two reasons. First, if the air is warmer then less of it is needed. Second, the temperature in the rice grains themselves may be an important factor, especially in the later stages of drying, when moisture has to be 'drawn' from the centers of the grains to their surfaces. This temperature will itself depend mainly on the air temperature but also on the amount of solar radiation received directly by the rice.

In a natural convection system, the flow of air is caused by the fact that the warm air inside the dryer is lighter than the cooler air outside. This difference in density creates a small pressure difference across the bed of grain, which forces the air through it. This effect increases; the greater is the height of the bed above the inlet (h1) and the outlet above the bed (h2). The effect of an increased h2 is less than that of an increased h1 because the air is cooled as it passes through the bed.

Some of the significances of Solar Drying are being an easily adoptive form of food preservation technique in almost all the rural areas, easy to work with were in even the less educated and less trained personnel or individuals can easily use this form of energy to ensure proper food shelf life, compared to sun drying, solar drying can generate higher air temperatures and consequential lower relative humidity which are both conducive to improved drying rates and final moisture contents of the dried crops. As a result the risk of the spoilage is reduced both during the actual process and in subsequent storage, the higher temperatures

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

are also deterrent to insect and microbial infestation additionally protection against dust, insects and other animals. All these factors contribute to an improved and more consistent product quality; furthermore as throughput per unit area per unit area is increased due to higher drying rates and also to the higher bed loadings possible, the demand for suitable land is reduced. In many cases solar drying is an effective alternative in whole or in part to artificial drying although not capable of comparable throughput of providing such considerable savings in energy costs are still possible. It can also be a feasible alternative to those natural conventions dryers that use wood or agricultural waste products as fuel.

However, despite this apparent attractiveness solar drying is still far from being a widely used technology, apart from the widely used technology apart perhaps from the incorporation of solar collectors into grain drying and storage silos in North America, there is not one instance of the widespread and widely acceptable widely acceptance use of solar dryers for the drying of crops and food stuffs. Although solar drying has received worldwide in universities and technical institutes this have been mainly in the form of thermodynamic studies a comparison of sun and solar drying rates or in very recent years, computer modeling techniques, all performed in an academic environment. **Bala and Woods (1997, 1998)**

The justification for solar dryers is that they may be more effective than sun drying, but have lower operating costs than mechanized dryers. A number of designs are proven technically and while none are yet in widespread use, there is still optimism about their potential, through the incorporation of two energy sources like biomass energies; these include all waste products that can be used to produce the required energy for the drying processes.

Biomass drying is sometimes a requirement for preprocessing systems because dry biomass is needed during conversion, storage, or densification. However, biomass drying is an energy intensive and often expensive aspect of preprocessing. Most drying systems are designed for industrial scale, requiring significant construction, engineering and equipment costs. Current technology for drying biomass requires around 900-1100 BTU's of energy per pound of water dried. The two directions that engineers have gone to supply drying energy are the use of existing process energy from the conversion facility or the addition of energy through extra biomass or fossil fuel inputs. Several designs exist for using process energy in the form of steam, heated gases, or hot surfaces to transfer energy to the feedstock and drive off water. Depending on the system, this energy may be 'waste' heat that would have been released to the

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

atmosphere or it may require energy that could be used for another valuable purpose. The most common fossil fuel drying systems are large rotary drum units that tumble biomass inside a heated drum. These units often use natural gas or sometimes fuel oil to produce the heat which is ducted around the tumbling drum. Some dryers can also use biomass to drive the biomass dryer units. Though there are efforts to develop new, more efficient drying technology, it will always require some energy to remove water from biomass. It is safer since foodstuffs are dried in a controlled environment there less likely to be contaminated by pests, and can be stored with less likelihood of the growth of toxic fungi.

It is healthier; drying foods at optimum temperatures and in a shorter amount of time enables them to retain more of their nutritional value – especially vitamin A and C. It is cheaper, using biomass from agricultural wastes instead of conventional fuels to dry products. Biomass dryer has no climatic limitations, both winter-summer, rainy-sunny, day or night time, dehydration and drying of fruits and vegetables, can still be done. Its technology is applicable in villages and rural areas and can easily be used, due to the presence of abundant sunshine in and agricultural wastes for use as biomass. The cost of making biomass briquettes and fuels is low as compared to the large scale solar dryers. The hybrid solar dryer can be easily adopted by small scale food processing plants and be able to run it a profit. It is environmental friendly because it utilizes renewable energies and by products for its fuel hence no environmental destruction.

Feed stocks can also be undersized for handling systems, systems designed to move large wood chips may have difficulty working with the fine sawdust and wood shavings. Fine particles can accumulate and jam conveyors, as well as possibly being a fire and explosion hazard if not handled properly. While wood was used in both examples, the same size and shape considerations apply to non-woody biomass residues including agricultural materials.

Another preprocessing consideration which is somewhat related to size is texture. Texture in biomass refers to the surface feel of the material. The surface texture of biomass determines what equipment is best suited to moving it. Examples of materials with different texture would be shredded corn stover (leaves, stalks, and cobs) compared to wood chips. Good quality wood chips have clean cut surfaces with few strands of particles remaining on the chip. Shredded corn stover is comprised almost entirely of stringy strands of biomass which have a rough surface due to rigid structural components of the plant stalk. The texture variations

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

between stover and chips affect their flow ability. The differences mean that while wood chips can be moved using augers, shredded corn stover will plug most conventional auger systems. Flow ability is also important for moving material in storage bunkers or bins. Smooth, free-flowing material will easily drop to the floor of a bin or bunker with a little help from gravity as material is removed from the bottom of the bin. The strands of a fluffy or rough textured material tend to lock together and can form bridges or sheer walls of material in bins, bunkers, and storage piles. Changing the texture and flow ability characteristics of material can be difficult. In the case of corn stover, the material has to be reduced in size to almost a powder to break down the fibers and make it a flow able material. It is often less expensive and easier to change the handling and storage systems to function with the material's texture rather than change the texture. This can be a very effective solution as long as the texture does not limit the conversion process chemistry. **Grainger and Twidel (1981)**

Moisture is another important consideration for biomass preprocessing because it alters reaction chemistry and can be a problem with handling material as well. Moisture, or water, trapped in biomass has to be removed before the actual thermo-conversion of biomass to energy. Removing water consumes heat energy from the conversion process; therefore, the net heat energy gained from biomass conversion is reduced as the amount of moisture in the biomass increases. Consider the difference between putting wet leaves on a campfire versus putting dry leaves on a campfire. The wet leaves will smolder, producing little extra heat, but lots of steamy white smoke. Dry leaves immediately burst into flames and make a hotter fire, with relatively translucent smoke, that has little water vapor. Exactly the same principle occurs in biomass energy systems, with dry materials producing significantly more net energy (heat) as the same volume of material with higher moisture content. Incorrect moisture ranges can cause damage to equipment due to temperature range issues and may also limit energy production. Most manufacturers will specify the moisture range at which their equipment will properly operate.

Keeping this in mind, the project was undertaken in order to justify the importance of Solar-Biomass Hybrid Dryer systems in this a portable solar biomass hybrid dryer system was designed in the department, fabricated and its performance evaluation was carried out to determine its efficiency.

All in all during the entire project the following objectives were observed as the basis on

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

which the project was undertaken.

1. To design, and fabricate a solar hybrid dryer (solar heating-biomass furnace).
2. To evaluate and determine the performance of the fabricated solar hybrid dryer (solar heating-biomass furnace).
3. To determine the cost effectiveness of the fabricated solar hybrid dryer.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

CHAPTER-2

REVIEW OF LITERATURE

In this section various reviews and literature proposed by various scientists, researchers and engineers are discussed and explained in brief basing them on the current project topic being executed, various researchers, scientists and engineers have over the years reported many practical findings basing them on what is on ground in the field of drying and dehydration, in most of the reviews attached herein, the findings of most of these scholars verify the importance of solar drying of food products in order to increase their shelf life, utilization of biomass wastes for fuel, and further more practical applications as regards solar biomass hybridization process, incorporating two energy sources in order to achieve a given goal of drying and dehydration of foods in a limited amount of time and yet maintaining most of the nutritional qualities of the given food product being studied, most of the research papers quoted below have been used to come up with remarkable results that have been based on to produce good results.

2.1 Drying and Dehydration

Burden, (1989) reported that food loses in the developing world are estimated to be about 50% of the fruits and vegetables grown and 25% of harvested food grain, this comes as a result of failing to utilize naturally given energy resources like the sun in drying and dehydration techniques of food preservation.

Ekechukwu and Norton (1999) reported that drying is basically a phenomenon of removal of liquid by evaporation from a solid. Mechanical methods for separating a liquid from a solid are not generally considered drying. In the following section an attempt is made to provide a concise overview of the fundamental principles of drying process for agricultural products. These principles are applied, in general, to mechanical conventional drying and here concerned mainly with solar drying. However in general, must be noted that conventional drying principles and phenomena are independent of the type of energy used.

Gauhar et al. (2002) reported that drying is an essential process in the preservation of agricultural products. Various drying techniques are employed to dry different food products; each technique has its own advantages and limitations, industrial drying offers quality drying whereas its high cost limits its use. Open sun drying suffers from quality considerations though it enjoys cost advantage.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Choosing the right drying system is thus important in the process of drying agricultural products. Especially, in the tropical regions, where some crops have to be dried during rainy season, special care must be taken in choosing the drying system.

Grabowski et al. (2003) suggested that keeping the product fresh is the best way to maintain its nutritional value, but most storage techniques require low temperatures, which are difficult to maintain throughout the distribution chain. On the other hand, drying is a suitable alternative for post harvest management especially in countries like India where exist poorly established low temperature distribution and handling facilities. It is noted that over 20% of the world perishable crops are dried to increase shelf-life and promote food security.

Bialobrzewski and Markowski (2004) reported that in fruits and vegetables drying, diffusion transport mechanism has a significant role, especially during the falling rate period, which is controlled by the mechanism of liquid and vapor diffusion. This behavior indicates an internal mass transfer-type drying with moisture diffusion as the controlling step. The water diffusion coefficient reflecting the whole complexity of water transport is referred to as an effective coefficient. Generally, it is difficult to predict the effective mass diffusion coefficient values theoretically; therefore, experimental techniques based on sorption/desorption kinetics, moisture content distribution, or porosity can be used.

Farkas et al. (2004) stated that various investigations have shown that solar drying can be an effective means of food preservation since the product is completely protected during drying against rain, dust, insects and animals. In the last decades, the technological development based in alternative energy sources has been increased.

Clary et al. (2005), Zhang et al. (2003, 2005) stated that growth in popularity of convenient foods in many Asian countries has stimulated increasing demand for high-quality dehydrated vegetables and fruits. This trend is expected to continue and even accelerate over the next decade in all emerging economies of the world. Dehydration offers a means of preserving foods in a stable and safe condition as it reduces water activity and extends shelf-life much longer than that of fresh fruits and vegetables. Many conventional thermal methods, including air flow drying, vacuum drying, and freeze-drying, result in low drying rates in the falling rate period of drying.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

CHAPTER-3

MATERIALS AND METHODS

In this section, all the materials and methods that were used in the design, fabrication performance evaluation and the entire project execution are mentioned keeping in mind of the various parts, the solar biomass hybrid dryer was fabricated at the Workshop of Shri Ram College, Muazafafrnagar and its performance evaluation and further testing was done in the Department of Agriculture, the details of the materials and methods that were used in this study have been listed below.

3.1 MATERIALS

3.1.1 Stainless Steel

Stainless steel also known as inox steel or from french "inoxydable", is defined as as steel alloy with a minimum of 10.5 or 11% chromium content by mass. Stainless steel does not stain, corrode or rust as easily as ordinary steel (it stains less, but it is stain proof). It's also called corrosion resistant steel, when the alloy type and grade are not detailed, particularly in the aviation industry. There are different grades and surface finishes of stainless steel to suit the environment to which the material will be subjected in its life time. Stainless steel is used were the properties of steel and resistance to corrosion are required.

In this case stainless steel was used in the entire outer body fabrication of the solar biomass hybrid dryer, this was later painted black to aid in maximum heat retainance capacity and also corrosion, stainless steel is also hard and hence durable, being a class-1 type of metal favored when it comes to durability of metals, the heat absorption capacity of the entire dryer is basically dependent on the type of metal used in the fabrication of the entire machine.

3.1.2 Glass Adhesive

A solid type of glass adhesive was used to attach the glass into the solar biomass hybrid dryer framing at the front surface, it takes some time to dry but when dry it holds strong and firm, it has some paraffin mixed with it to increase its holding capacities.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

3.2 COMPUTER AIDED SIMULATION SOFTWARES

In the initial preparation of the machine designs and engineering drawings certain softwares were used in this case, these softawares included AutoCADD, Pro-Engineering, Ansys softwares and so on, these were the main designing guides.

3.2.1 AutoCAD

This was derived from a 1977 program called Interact CAD, which was written in a proprietary language (SPL) by inventor Michael Riddle who later co-founded Autodesk to market AutoCAD. The modern AutoCAD includes a full set of basic solid modeling and 3D tools. The release of *AutoCAD 2007* included the improved 3D modeling that provided better navigation when working in 3D. Moreover, it became easier to edit 3D models. The mental ray engine was included in rendering and therefore it is possible to do quality renderings AutoCAD *2010* introduced parametric functionality and mesh modeling. The latest AutoCAD releases are *AutoCAD 2014* and *AutoCAD 2013 for Mac*. The 2014 release marked the 28th major release for the AutoCAD for Windows. The 2013 release marked the third consecutive year for AutoCAD for Mac.

3.2.2 Pro-Engineering

Companies use Creo Elements/Pro to create a complete 3D digital model of their products. The models consist of 2D and 3D solid model data which can also be used downstream in finite element analysis, rapid prototyping, tooling design, and CNC manufacturing. All data is associative and interchangeable between the CAD, CAE and CAM modules without conversion. A product and its entire bill of materials (BOM) can be modeled accurately with fully associative engineering drawings, and revision control information. The associatively functionality in Creo Elements/Pro enables users to make changes in the design at any time during the product development process and automatically update downstream deliverables. This capability enables concurrent engineering – design, analysis and manufacturing engineers working in parallel – and streamlines product development processes, Creo Elements/Pro offers a range of tools to enable the generation of a complete digital representation of the product being designed. In addition to the general geometry tools there is also the ability to generate geometry of other integrated design disciplines such as industrial

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

and standard pipe work and complete wiring definitions, tools are also available to support collaborative development.

3.3 DESIGNS AND FABRICATION MODULE

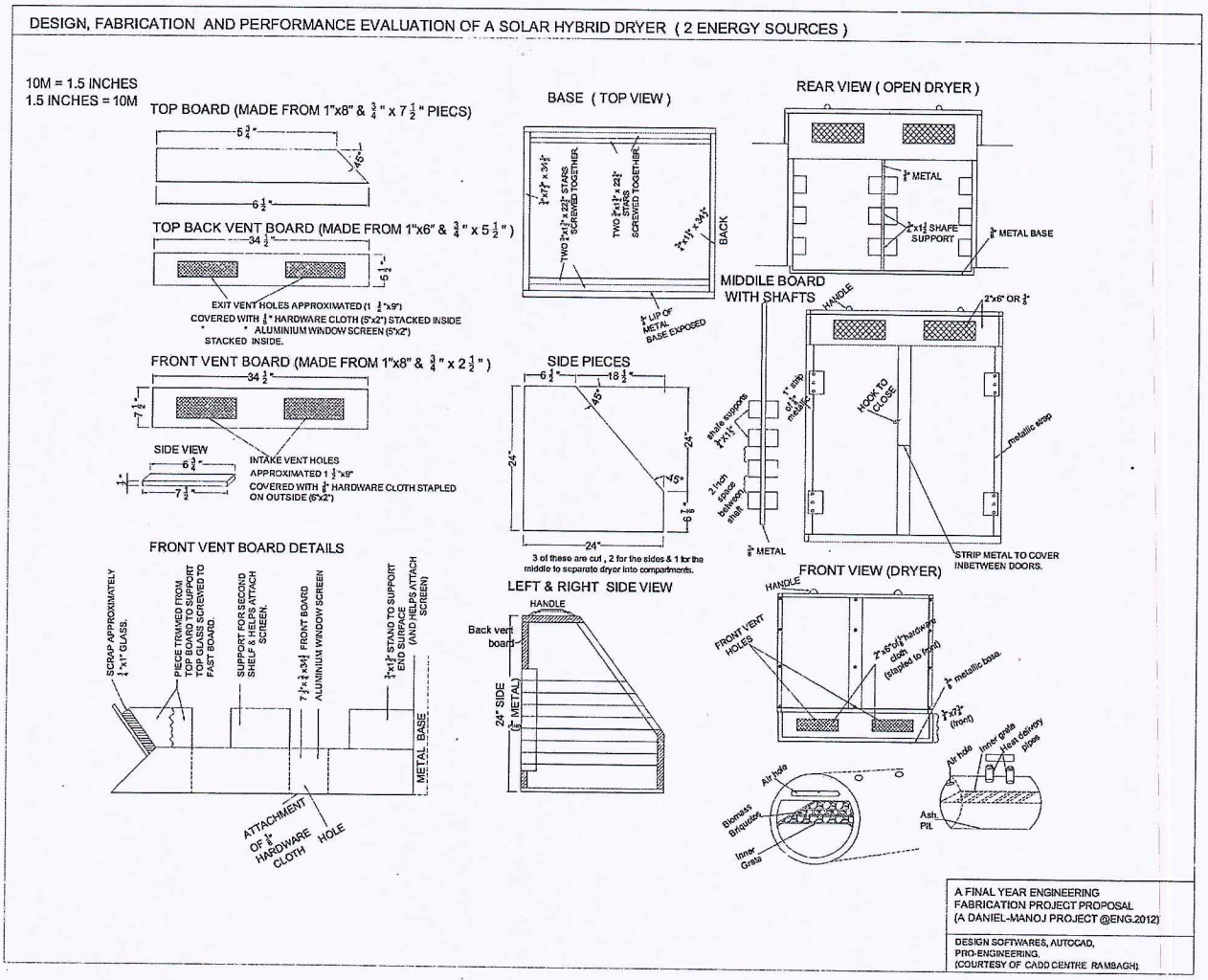


Fig. 3.3.1 OVERALL MACHINE DESIGN

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

3.4 VARIOUS PARTS OF THE SOLAR BIOMASS HYBRID DRYER INCLUDE

3.4.1 Glass

The type of glass used as in the fabrication of the solar biomass dryer is a normal plane glass inclined at an angle of 45° in most areas and cases but the angle of glass inclination is dependent on the area's sun rays and the solar intensity, when placing the solar glass it's advisable to install it in a inclined adjustable position and format in order to aid in continuous adjustment of the glass basing it on the prevailing solar intensity and positioning of the sun in the skies.

A plane glass is used because it captures the sun's rays in limited amounts required for the entire process of fruit and vegetable drying protecting fruits and vegetable slices from excessive sunshine intensity, due to the fact that plane glasses have no converging or diverging properties as it is in the convex and concave glass or mirrors, with no converging properties the glass receives the rays and does not converge them creating excessive heat, neither diverge them reducing almost all the heat but rather captures and lets the rays pass through in the straight format producing a moderate heat temperature required for drying of foods.

3.4.2 Metallic Frame Work

These metallic pipings were used in the provision of a fame work on which the welding was done, made out of stainless steel these pipes are strong enough endure any type of welding more so gas welding, which makes them much favored in fabrication of machine parts, the machine frame work basing on the design on paper and plan was made and the metal sheet welding comes next, the metal sheet was welded on to a metallic frame work following the desired shape and sizing.

3.4.3 Wire mesh

Wire mesh made out of thick stainless mesh of gauge 30 metallic rods was used in the manufacture and fabrication of fruit and vegetable drying trays and air manifolds both in top back side and bottom front side of the machine, these trays were fabricated on a metallic frame made of hard metallic stainless steel based on the fabrication machine design and as for the manifold wire mesh was welded directly on the stainless steel metal sheet body covering, the wire mesh in both cases (tray and manifold) was painted with a silver color paint to aid in

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

rust prevention.

3.4.4 Metallic Gasification Chamber

This gasification tank or chamber is placed at the bottom of the solar biomass hybrid dryer, its major aim is to aid in gasification process of the biomass briquettes, the briquettes placed inside the gasifier are fired from within the chamber, in this case the briquettes used were generally of two types, cow dung rice and saw dust briquettes and saw dust, rice husk and babool gum briquettes in the first case as shown above the briquette is made using cow dung as the major binder, in the second case however the briquette is made using babool gum as the binder, though all these briquettes were made, we found the cow dung bound briquette more efficient and cost effective for use by all people more so in the villages areas and hence the gasification in all instances was done using cow dung bound briquettes.

The metallic gasification chamber has three main parts for aiding in firing and combustion and these are; the door and lower air inlet manifold at the bottom of the door, the inner biomass and combustion firing grate or plate, the lower ash collecting section, the heat transfer pipe from the bottom to the top chamber. The door opens and closes giving access to the combustion chamber during times of biomass feeding, and firing plus inspection activities, the air inlet manifold attached at the bottom of the door, grants entry air (oxygen) and exit of flue gases at the bottom of the solar dryer, this is much crucial as it allows the process of complete and incomplete burning to take place, the inner biomass and combustion firing or plate has surface perforation that guarantee the flow of air during firing and also help in the leaking the ash to the bottom were it can be collected and disposed of, the metallic grate also handles or holds the briquettes during firing of the biomass and combustion, the lower ash collecting section, in this section ash from the combustion at the combustion grate is collected and disposed of, from the gasifier, the heat transfer pipe, this act as a connecting pipe, from the lower part or combustion chamber to the top part or drying chamber and it's also used in aiding the removal of flue gases and smoke during incomplete burning.

3.4.5 Metallic Separating Plate

This plate aids in separating the lower gasification chamber from the upper solar drying chamber, it further assist to stop the flow of flue gases to the top of the chamber, by sloding it in it acts as a barrier stopping the ascension of flue gases from the gasifier to the top solar

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

chamber.

4.6 Black Petroleum paint

Black petroleum paint was used to paint the entire top portion of the dryer, black paint was used because it's a good absorber of heat and its heat absorbing qualities and abilities have been studied and utilized for quite some time now, another advantage of black petroleum paint is that it does not corrode easily as other types of paints.

3.4.7 Trays

Trays on which the fruits and vegetables to be dried were put, were made of steel and coated with aluminum paint to aid in clean and safer food dehydration and also to deter the process of corrosion, further still it was done to improve on the heat absorption capacities of the trays.

The trays are of three major sizes, small, medium and large sizes arranged from the top to the bottom of the dryer in the drying chamber respectively, the tray sizes and dimensions were divided into three sizes and given as:

A = (L=15, W=6) inches

B = (L=15, W=10) inches

C = (L=15, W=12) inches

Each tray handles different amounts of quantities of products to be dried.

3.5 PERFORMANCE EVALUTAION OF SOLAR BIOMASS HYBRID DRYER

Various fruits were used in the performance evaluation and various tests carried out on the hybrid dryer to determine its performance evaluation but carrot and banana (ripe banana) were taken, with carrot representing vegetables and ripe banana representing the fruits, in this particular evaluation carrot were given priority as compared to the ripe bananas.

3.5.1 Carrot

The carrot (*Daucus carota* subsp. *sativus*; etymology: from Late Latin *carōta*, from Greekκαρότον *karōton*, originally from the Indo-European root *ker-* (horn), due to its horn-like shape) is a root vegetable, usually orange in color, though purple, red, white, and yellow varieties exist. It has a crisp texture when fresh. The most commonly eaten part of a carrot is a taproot, although the greens are edible as well. It is a domesticated form of the wild carrot -*Daucus carota*, native to Europe and southwestern Asia. Nutrition, the carrot gets its characteristic and bright orange color from β-carotene, and lesser amounts of α-

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

carotene and γ-carotene. α and β-carotenes are partly metabolized into vitamin A in humans β-carotene is the predominant carotenoid, although there are lesser amounts of α-carotene and γ-carotene.

3.6 THE BIOMASS USED

In the above analysis, mainly two types of waste product biomass was used in the entire project to fire the biomass gasifier , rice husks a waste product of rice threshing was used, a cheap source of fuel, and common one in rural areas as a waste bi-product of threshing rice, added to it was saw dust which is also another cheap source of fuel coming as a result of saw milling and its incorporation in the briquette helped improve the gasification properties of the entire briquette and its thermal and calorific capacity, the briquettes are compressed at 650 cu per given period of time but in this case briquettes were made using binders like cow dung and babool gum, though cow dung proved more efficient..

3.6.1 Rice husk

A waste product of rice milling was used in the making of briquettes, it was cheap in that 1kg cost 5-6 rupees which was a good source of fuel for gasification, rice husks produced considerable amounts of energy when used, but also had a drawback of producing too much smoke, this was however reduced through incorporation of saw dust in the rice cow dung mixture during briquette formation.

3.6.2 Saw Dust

Saw dust was used as a waste product of wood cutting and sawing, the produced waste product during this process was known as saw dust and can was utilized in the process of gasification, this was done through briquetting in that the rice husk and saw dust were mixed together and bound by cow dung to aid in briquette formation.

3.6.3 Cow dung

Cow dung was as a natural binder to aid in binding saw dust and rice husk, it was a medium in which a mixture of saw dust and rice husk were bound, after the briquettes were sun dried and hardened, the cow dung further contained the methane components that aided in the quick

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

firing of the briquettes through the processes of incomplete and complete burning stages in the biomass gasification chamber, the cow dung burned well along side rice husk and saw dust and produced amazing amounts of heat and energy.

3.7 INSTRUMENTS AND EQUIPMENT USED

3.7.1 Electronic Weighing Scale

An electronic weighing scale is an electronic digital device used in measuring micro sensitive weights below 1000 g or half kilograms, the electronic weighing scale is so sensitive to detect even the lightest weights with moving air inclusive, in most cases its used in laboratories and most internal research centers and enclosures and small scale minute tests done on mobile labs e.g. in farming and agricultural chemistry sectors.

3.7.2 Solar Biomass Hybrid Dryer

The fabricated solar biomass hybrid dryer model and prototype were used to test for the performance evaluation and many various parameters like thermal efficiency, drying time, drying rate, moisture removed etc. A solar biomass hybrid dryer is basically a dryer having mainly two energy sources being solar energy and biomass gasification energy, during days of less sunshine or rainy days, the biomass portion of the dryer is activated through biomass firing in order to supplement the heat required for drying and dehydration of foods, its one of the most feasible techniques in that, it saves time, costs less because agricultural wastes are used for this process, its environmental friendly because it reduces on the rate of tree felling to provide fuel as in its case it utilizes farm wastes like rice husk, saw dust from carpentry workshops, cow dung from farms etc.

3.7.3 Thermometer

Thermometers utilize a range of physical effects to measure temperature, temperature sensors are used in a wide variety of scientific and engineering applications especially measurement systems, temperature systems are primarily either electrical or mechanical; occasionally inseparable from the system which they control (as in the case of a mercury-in-glass thermometer) the temperature is usually measure in Celscius scale or Fahrenheit scale, when

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

the temperature rises, liquid (mercury) inside the thermometer's glass tube expands at a known rate filling up more of the capillary inside the thermometer. When the temperature falls, the liquid (mercury) contracts, occupying less volume inside the thermometer capillary, this expansion or contraction can be seen by watching the level of the mercury change inside the tube, since the tube walls are marked in graduations (or degrees), we can read the temperature.

3.7.4 Hot Air Oven

Hot air ovens are electrical devices used in sterilization, they were originally developed by Pasteur, the oven uses dry heat to sterilize articles generally, they can be operated from 50 to 300 °C (122 to 572 °F) there is a thermostat controlling the temperature they are digitally controlled to maintain the temperature, their double walled insulation keeps the heat in and conserves energy, the inner layer being a poor conductor and outer layer being metallic, there is also an air filled space in between to aid insulation, an air circulating fan helps in uniform distribution of the heat, these are fitted with the adjustable wire mesh plated trays or aluminum trays and may have an on/off rocker switch, as well as indicators and controls for temperature and holding time, the capacities of these ovens vary, power supply needs vary from country to country, depending on the voltage and frequency (hertz) used, temperature sensitive tapes or other devices like those using bacterial spores can be used to work as controls, to test for the efficacy of the device in every cycle.

Therefore when the test is done we use the following formula to calculate moisture content.

$$MC = \frac{\text{Initial weight} - \text{Oven dry weight}}{\text{Oven dry weight}} \times 100\% \quad \ldots\ldots 1.0$$

3.7.5 Hot Plate

In laboratory settings, hot plates are generally used to heat glassware or its contents. Some hot plates also contain a magnetic stirrer, allowing the heated liquid to be stirred automatically.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

In a student laboratory hot plates are used because baths can be hazards if they spill, overheat or ignite, because they have a high thermal inertia (meaning they take a long time to cool down) and mantles can be very expensive and are designed for specific flask volumes.

In our course of project execution, the hot plate was used during the process of rehydration of dehydrated carrot slices.

3.7.6 Bomb Calorimeter

A bomb calorimeter is a type of constant-volume calorimeter used in measuring the heat of combustion of a particular reaction, bomb calorimeters have to withstand the large pressure within the calorimeter as the reaction is being measured. Electrical energy is used to ignite the fuel; as the fuel is burning, it will heat up the surrounding air, which expands and escapes through a tube that leads the air out of the calorimeter, when the air is escaping through the copper tube it will also heat up the water outside the tube the temperature of the water allows for calculating calorie content of the fuel. Basically, a bomb calorimeter consists of a small cup to contain the sample, oxygen, a stainless steel bomb, water, a stirrer, a thermometer, the dewar or insulating container (to prevent heat flow from the calorimeter to the surroundings) and ignition circuit connected to the bomb. By using stainless steel for the bomb, the reaction will occur with no volume change observed.

3.8 Glass Ware

Various glass wares were used during the course of project execution especially during Rehydration Ratio calculations, and these include.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

3.9 METHODS

3.9.1 PERFORMANCE EVALUATION OF THE HYBRID DRYER

3.9.2 Formulas and Procedures used in Calculation of the various parameters under study:

3.9.3 The fuel consumption rate

The fuel consumption rate of the hybrid dryer is the ratio of the amount of fuel fed in the biomass gasifier for combustion to the amount of time taken for the total drying of the food sample being dried in the solar biomass dryer, it's a necessary parameter required in the efficiency and cost effectiveness determination procedure of the entire solar biomass hybrid dryer, the fuel consumption of the dryer shall be calculated and determined using the formula;

$$f = \frac{q'a}{\eta\, \eta_b\, \eta_{ex}\, Cn} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1.1$$

Were:

f = Fuel rate in (kg/hr) (biomass fuel used)

q´a = Total heat required to heat the drying air (kcal/hr)

Cn = Calorific value of fuel (kcal/hr)

η = Efficiency of the heating system

η_{ex} = Efficiency of the heat exchanger

η_b = Efficiency of boiler if any

3.9.4 Drying Efficiency (η_d)

Energy efficiency in drying is of obvious importance as energy consumption is such a large component of drying costs. Basically it is a simple ratio of the minimum energy needed to the energy actually consumed. But because of the complex relationships of the food, the water, and the drying medium which is often air, a number of efficiency measures can be worked out, each appropriate to circumstances and therefore selectable to bring out special features important in the particular process. Efficiency calculations are useful when assessing the performance of a dryer, looking for improvements, and in making comparisons between the various classes of dryers which may be alternatives for a particular drying operation.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

The dryer Drying Efficiency is calculated and determined using.

The overall drying efficiency of the dryer shall be calculated and determined using the formula:

Assuming that the loss of heat from the dryer to the ambient air is negligible and there is heat utilized to increase the temperature of the product and there is heat utilized to evaporate moisture from the product.

$$\eta d = \frac{(Ww \times L + mf \times C\rho \times \Delta T)}{A \times It \times th} \quad \ldots\ldots\ldots\ldots\ldots 1.2$$

Latent heat of vaporization is always expressed as a function of temperature.

In the formula above the unknown used have been expressed as:

Were:

ηd = drying efficiency (%)

L = latent heat of vaporization

t_h = desired time period (3600 sec)

A = Surface area of air heater (m^2)

Ww= amount of water evaporated during a specific time interval (kg)

mf = mass of fruits taken for drying during a specific drying time interval (kg)

Cp = specific heat of fruits taken as 2.243 kJ/Kg

ΔT = temperature difference between temperature in the hybrid solar box dryer and the ambient air temperature.

It = total solar intensity on the horizontal solar surface (W/m^2)

3.9.5 Capacity of the hybrid dryer;

This was calculated basing on the day to day input of fruit in the hybrid dryer judged according to the number and size of trays, the amount of carrot slices that can fit on the trays according to their sizes, the small tray at the top, medium tray in the middle and the largest tray at the bottom of the dryer.

3.9.6 Moisture Content (M.C):

The moisture content of the fruits on dry basis was calculated and determined, using basically two main methods and these are, moisture content on wet basis, moisture content on dry basis. Moisture content on dry basis is given by the formulae

The moisture content of the sample on dry basis was calculated using the following equation:

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

$$\%M.C \text{ (on dry basis)} = \frac{\text{Initial weight (A)} - \text{Final weight (B)}}{\text{Initial weight (A)}} \times 100 \quad \ldots\ldots\ldots\ldots 1.3$$

This in most cases is calculated using the Hot Air Oven, in which the sample whose moisture content is to be determined are kept in the hot air oven for 16 - 24 hours at a temperature of 100 -120 °C.

3.9.7 Rehydration Ratio

Simply stated, rehydration ratio is the weight of rehydrated sample to that of the dehydrated sample

$$\text{Rehydration ratio} = \frac{\text{Weight of Rehydrated sample}}{\text{Weight of Dehydrated Sample}} \quad \ldots\ldots\ldots\ldots\ldots\ldots 1.4$$

3.9.7.1Procedure for calculating the rehydration ratio of a given dried sample.

A known amount of dehydrated sample was taken.

Water ten times the size of sample was taken.

Boiling was done for 5 minutes on an electronic kettle or hot plate.

The sample was poured in the chemical lab filter paper placed in the funnel till the last drop of water was removed

Remove carefully the rehydrated sample and weigh it.

Rehydration ratio is important in determining the amount of water reconstituted after drying and dehydration of given food samples.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

It aids in regaining the physical attributes and properties of a given dried or dehydrated food sample.

3.9.9 Experimental Procedures

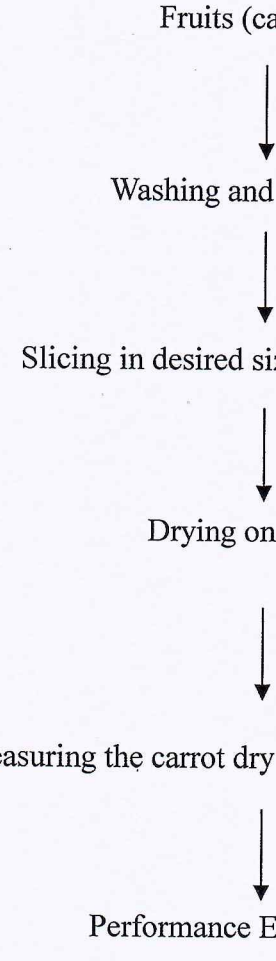


Fig.3.1 Flow Chart for Process Evaluation of a solar a dryer

3.9.9.2 Fruits

Carrots of good size, appearance and quality were purchased in the local fruit and vegetable market in Mahewa.

3.9.9.3 Washing and Cleaning

The carrots were washed thoroughly to ensure that all the soil particles and blemishes present are removed.

3.9.9.4 Slicing

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

The carrots were sliced in a round shape with the required thickness being 0.5mm, during slicing proper care was taken to maintain a round like structure of the slices.

Placing on muslin cloths and trays

The carrot slices were then placed on clean muslin cloths and placed on the metallic aluminum coated trays for drying.

3.9.9.5 Drying in the solar biomass hybrid dryer

The trays holding the carrot slices where placed in the drying chamber for drying, at a temperature of 65-75°C for solar and 85-95°C for solar and biomass combined.

3.9.9.6 Removal and measuring

The trays were being removed every after 30 minutes of drying and the carrot slices weighed to determine the loss in weight of the carrot slices and also determine the amount of moisture content removed every after 30 minutes.

3.9.9.7 Determination of the different parameters

Various parameters like Drying Rate, Moisture Content were determined and results recorded.

4.0 Experimental Analysis Table

SR. NO.	PARAMETER
1.	**Dependent variable** Time Temperature Initial moisture content (M. C.) of sample Energy source (Biomass and Solar)
2.	**Independent variable** Moisture content (M.C) during drying
3.	**Calculated parameters** Drying efficiency Capacity of dryer Cost effectiveness.

The graphical mathematical models shall be plotted from the data got from the dependent and independent variables as shown below.

Moisture Content against Drying Time. (M.C/D.T)

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Drying Rate against Drying Time. (D.R/D.T)

Drying Time against Moisture Content. (D.T/M.C)

CHAPTER 4

RESULTS AND DISCUSSIONS

The current study/resects was executed basically to design, fabricate and analyze the performance evaluation of a solar biomass hybrid dryer and be able to compare it with the usual solar dryer, in order justify its better qualities and performance efficiency , in this course of study carrots slices were taken a representative fruit to study the amount moisture content removed during drying, drying efficiency of t dryer, rehydration ratio of the dried carrots, drying rate and the time taken for drying in both the solar a solar hybrid dryer. Saw dust, rice husk and cow dung biomass briquettes were used as sources of fuel f combustion chamber to provide the required heat needed for drying and dehydration of fruits.

Tables have been given to display the comparative study thus carried out, the major objectives on whic whole study was based were to design, fabricate a solar biomass hybrid dryer, study and analyze its performance evaluation and determination of the machine cost effectiveness all these objectives have b mentioned, explained and justified herein.

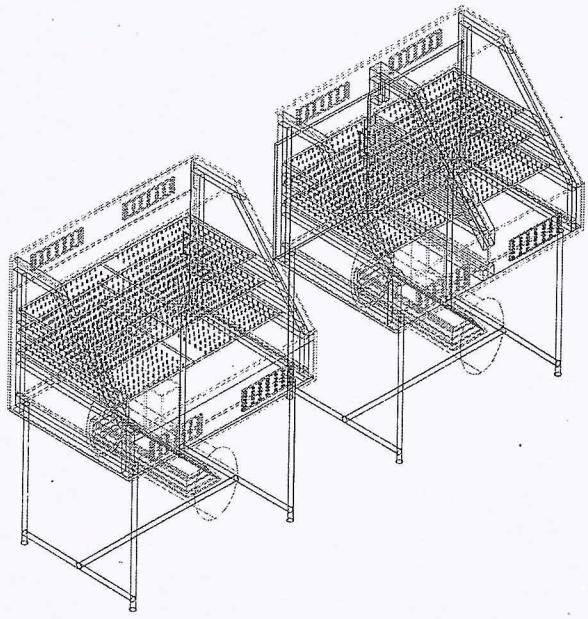
6.1 Design and Fabrication of the solar biomass hybrid dryer

A solar biomass hybrid dryer having basically two chambers or sections viz. the top solar drying chamb and the lower combustion chamber for combusting or gasifying the in fed biomass as fuel to the solar hybrid dryer to aid in solar biomass heating was designed and fabricated, a metallic separating plate wa placed in between the two chambers of the solar dryer in order to separate the top and lower bottom of solar dryer the tray aided during the firing of the gasifying tank, the top chamber has a door opening to inner drying chamber were the meshed trays on which the fruits to be dried were placed on muslin clotl for drying and dehydration.

Co-ordinater
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

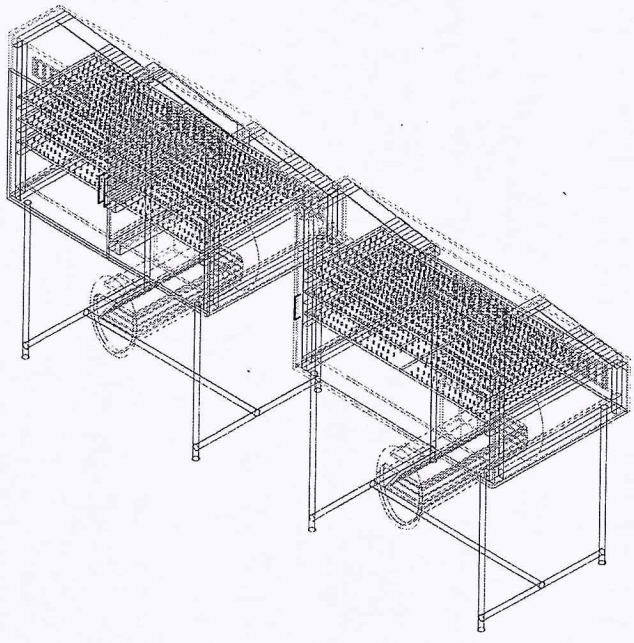
The Designs.



FRONT CLOSED ISOMETRIC VIEW

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

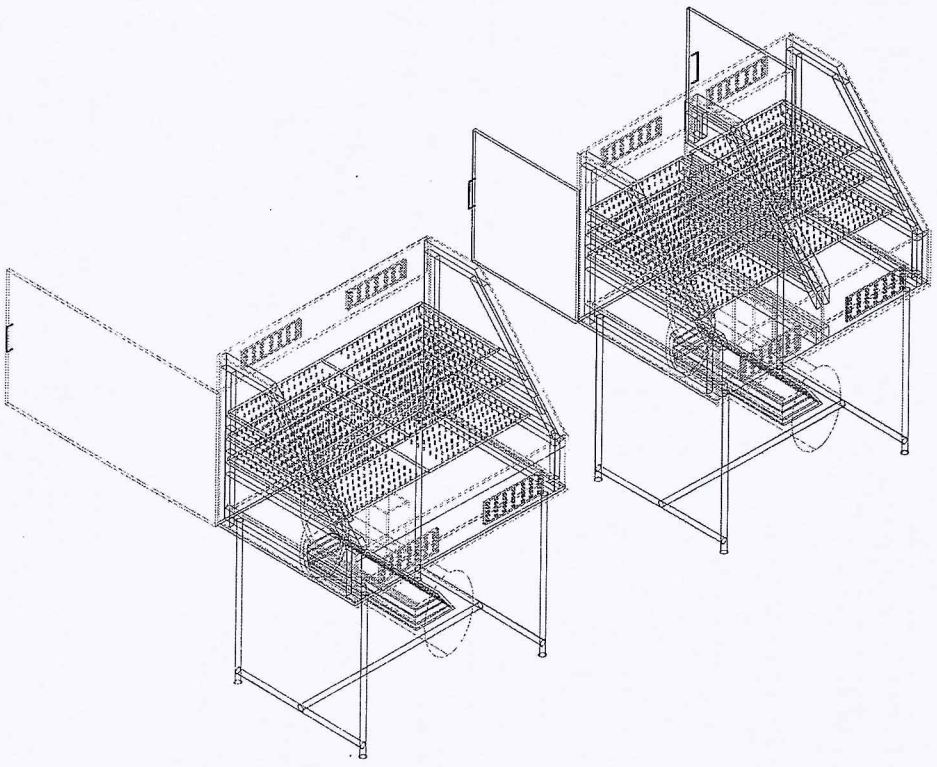
Chairman
IQAC, Shri Ram College,
Muzaffarnagar



BACK CLOSED ISOMETRIC VIEW

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

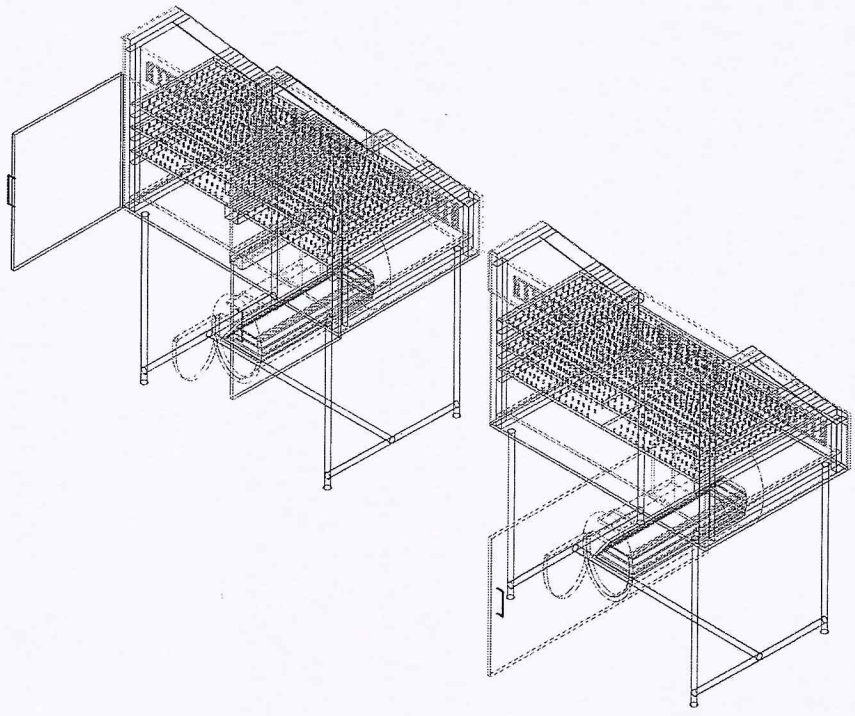
Chairman
IQAC, Shri Ram College,
Muzaffarnagar



FRONT OPEN ISOMETRIC VIEW

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

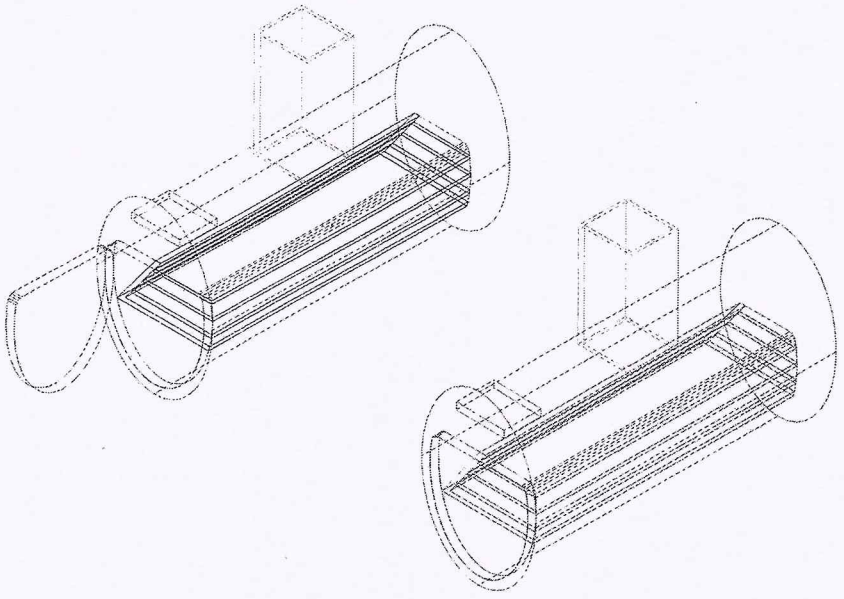
Chairman
IQAC, Shri Ram College,
Muzaffarnagar



BACK OPEN ISOMETRIC VIEW

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

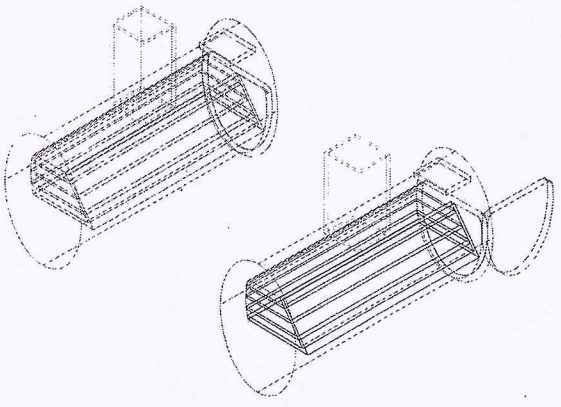
Chairman
IQAC, Shri Ram College,
Muzaffarnagar



OPEN AND CLOSED CYLINDER FRONT ISOMETRIC VIEW

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

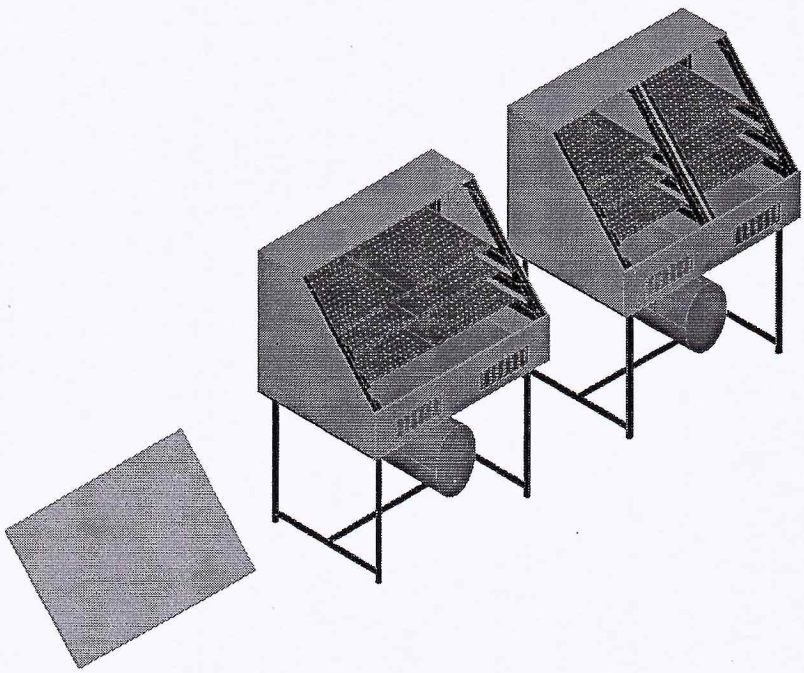
Chairman
IQAC, Shri Ram College,
Muzaffarnagar



OPEN AND CLOSED CYLINDER BACK ISOMETRIC VIEW

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

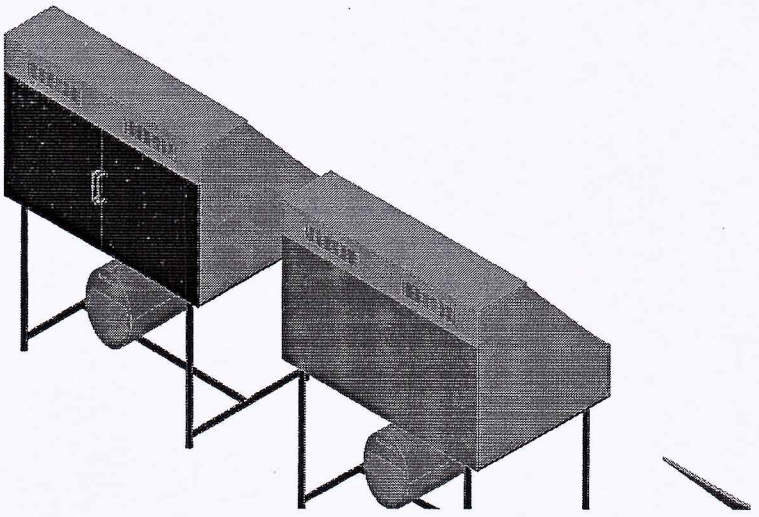
Chairman
IQAC, Shri Ram College,
Muzaffarnagar



FRONT CLOSED 3D VIEW

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

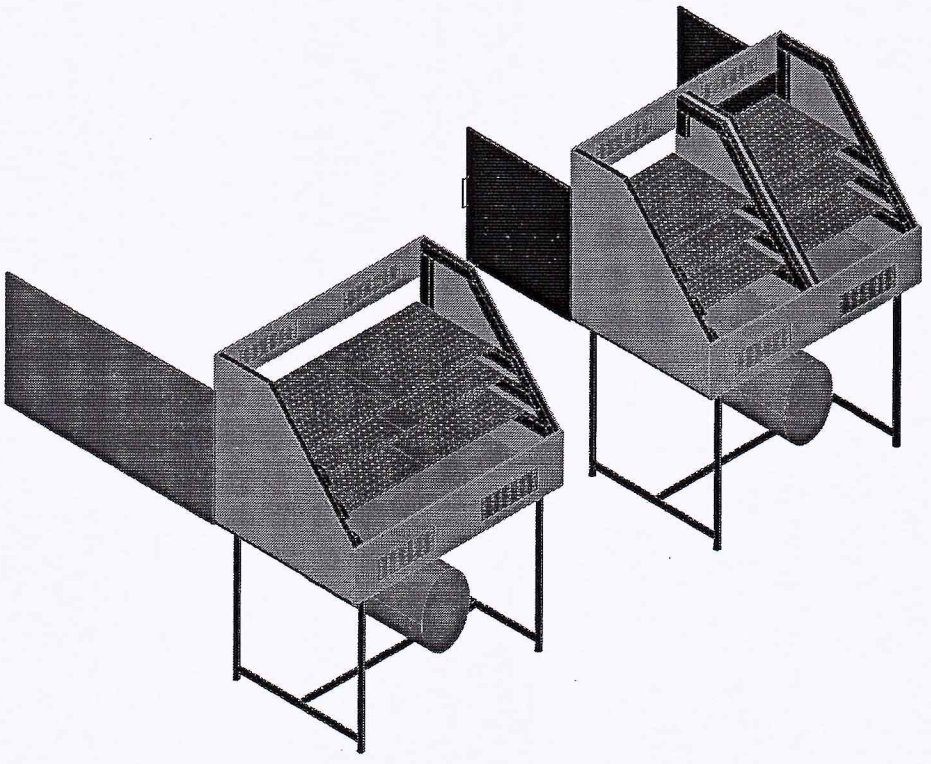
Chairman
IQAC, Shri Ram College,
Muzaffarnagar



BACK CLOSED 3D VIEW

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

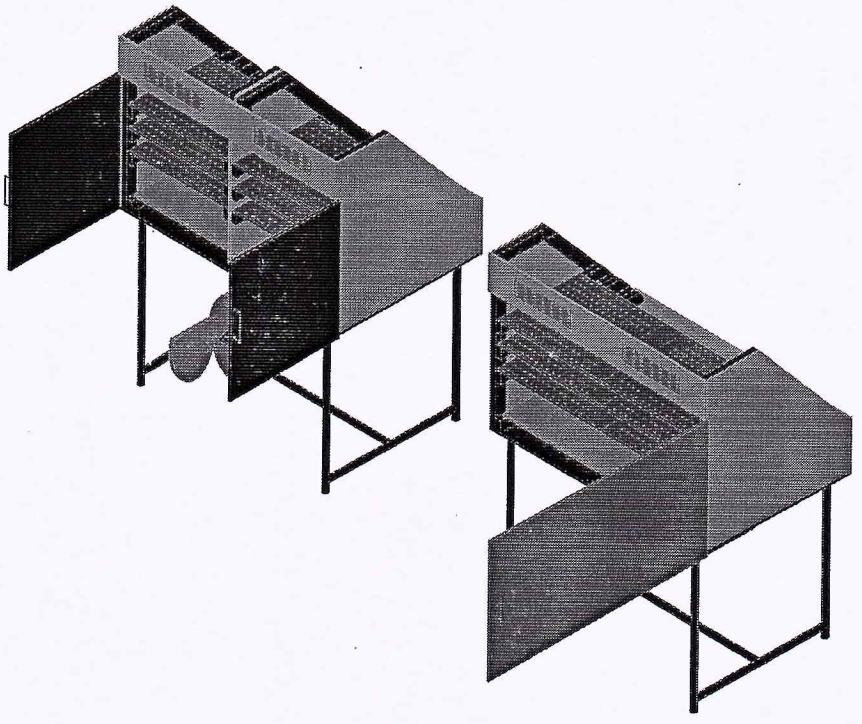
Chairman
IQAC, Shri Ram College,
Muzaffarnagar



FRONT OPEN 3D VIEW

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

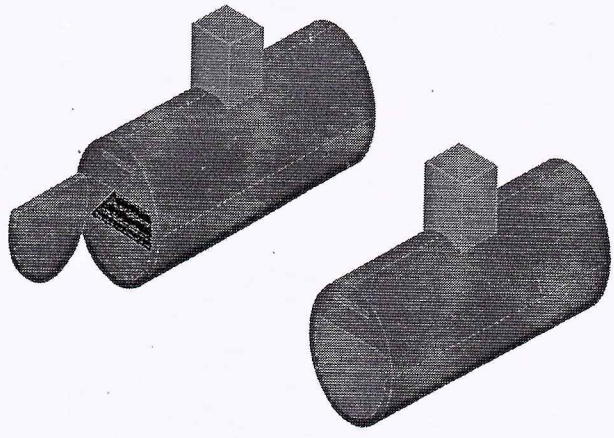
Chairman
IQAC, Shri Ram College,
Muzaffarnagar



BACK OPEN 3D VIEW

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

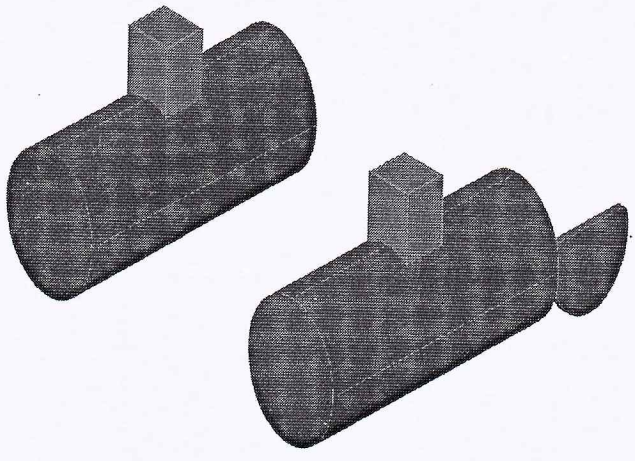
Chairman
IQAC, Shri Ram College,
Muzaffarnagar



OPEN AND CLOSED BACK CYLINDER 3D VIEW

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar



OPEN AND CLOSED FRONT 3D VIEW

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College
Muzaffarnagar

5.0 Various plates for the solar biomass hybrid dryer

PLATE NO.1: INTERNAL FRAME

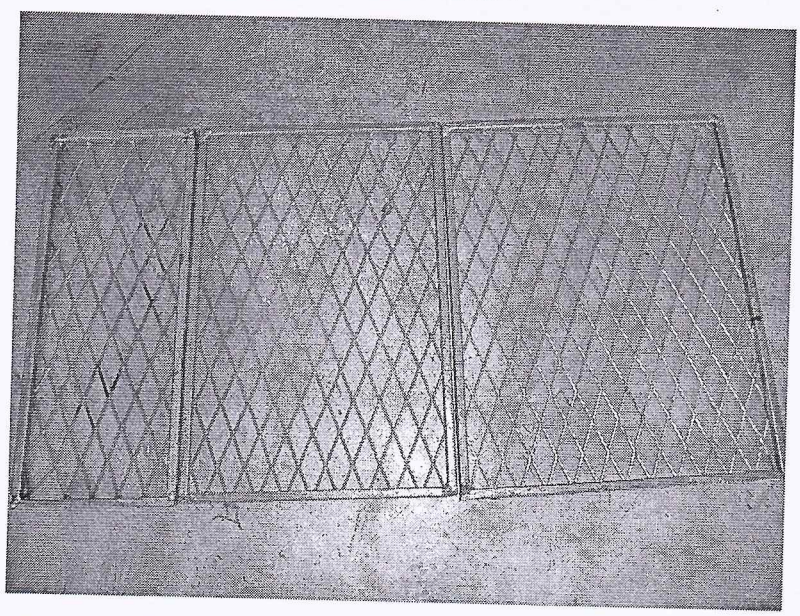


PLATE NO.2: TRAYS

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

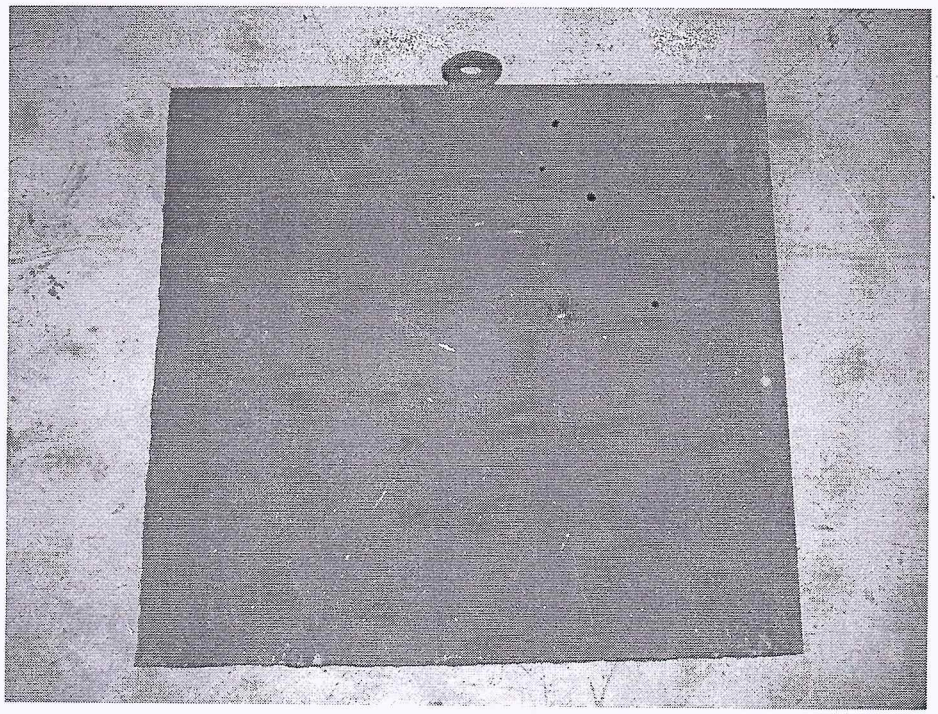


PLATE NO.3: SEPARATING PLATE

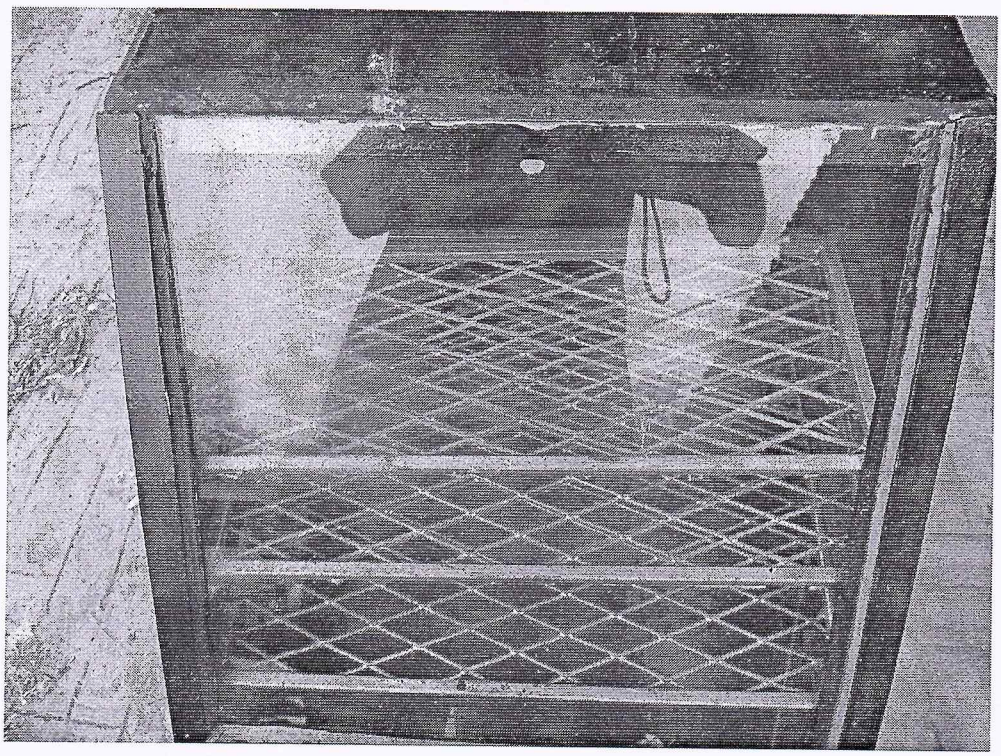


PLATE NO.4: GLASS OR FRONT SCREEN

Co-ordinater
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

PLATE NO.5: BIOMASS BRIQUETTES

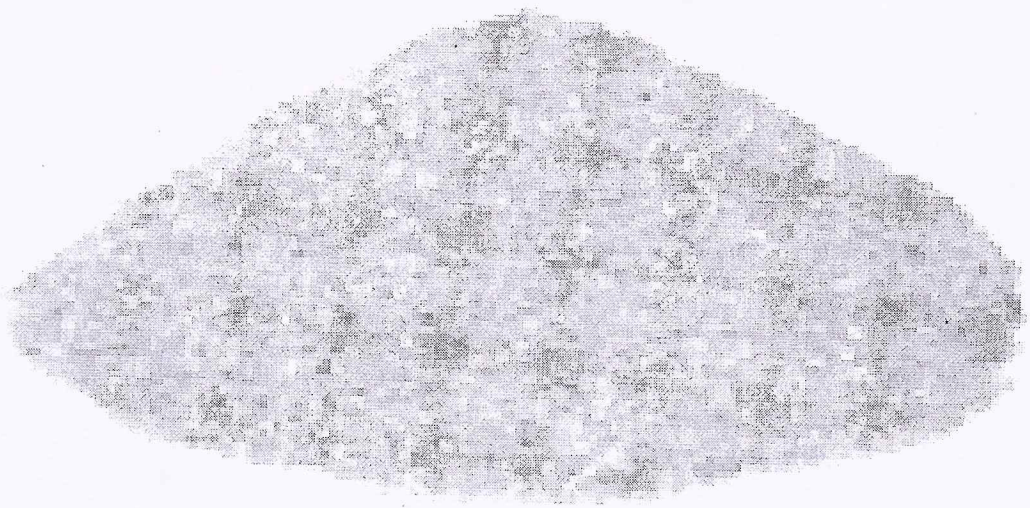


PLATE NO.6: SAW DUST

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

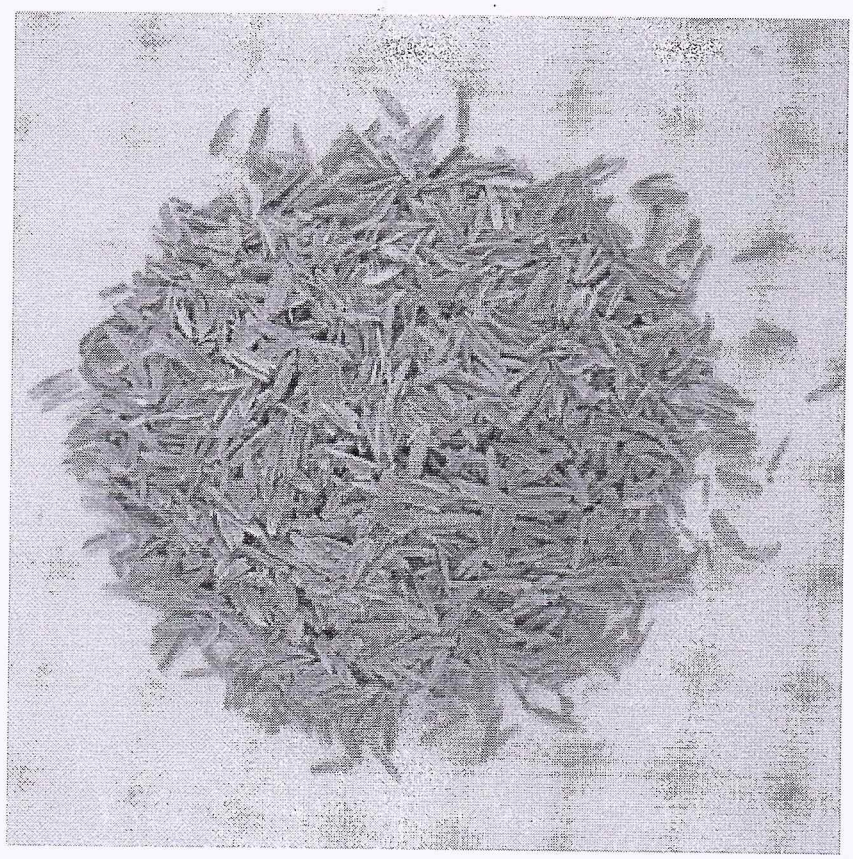


PLATE NO.7: RICE HUSKS

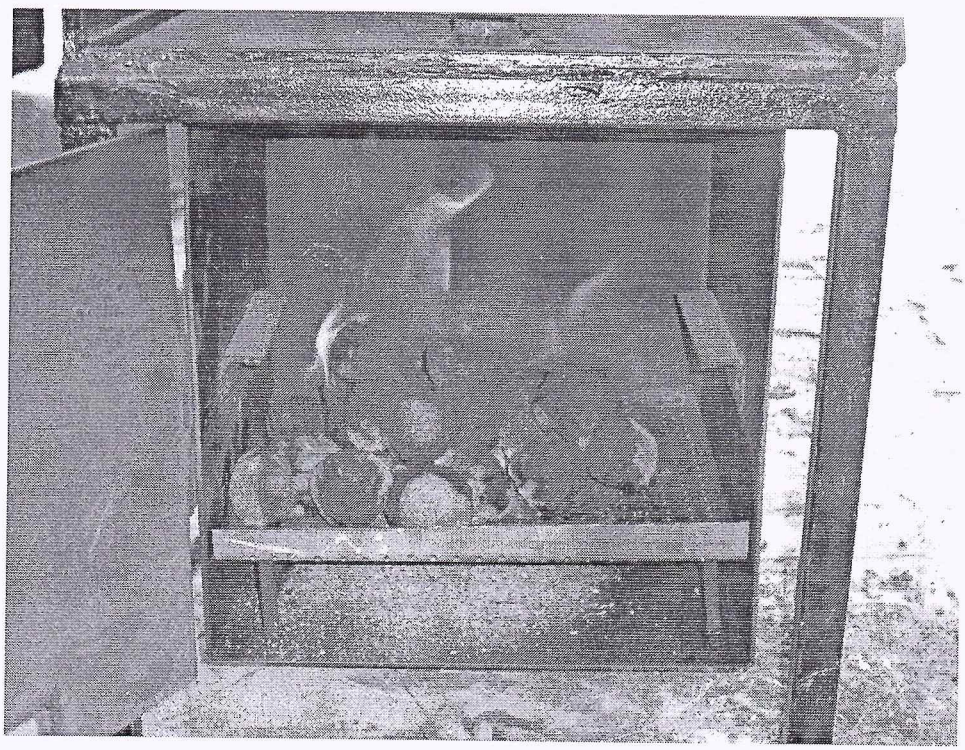


PLATE NO.8: GASIFICATION CHAMBER

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

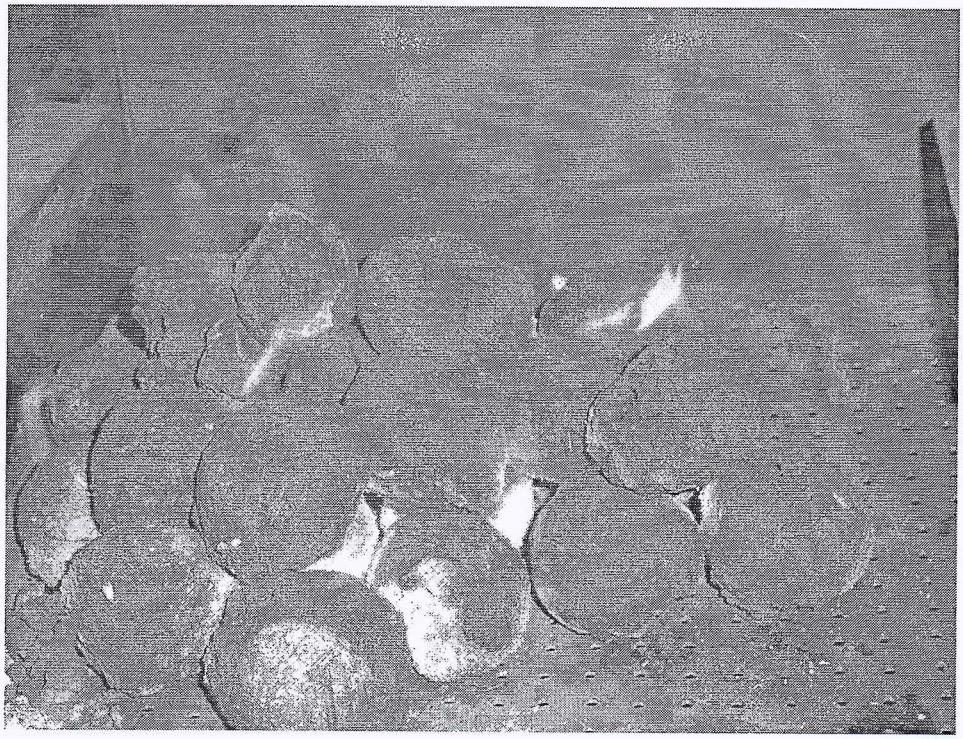


PLATE NO.9: FIRED BIOMASS BRIQUETTES

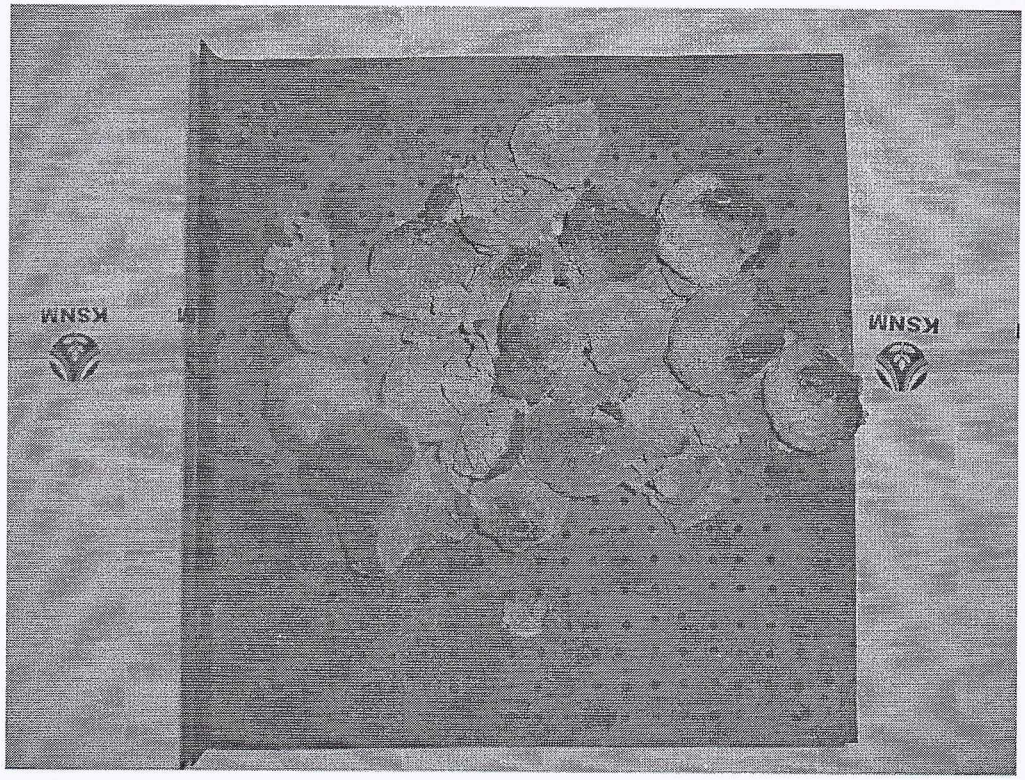


PLATE NO.10: ASH TRAY

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

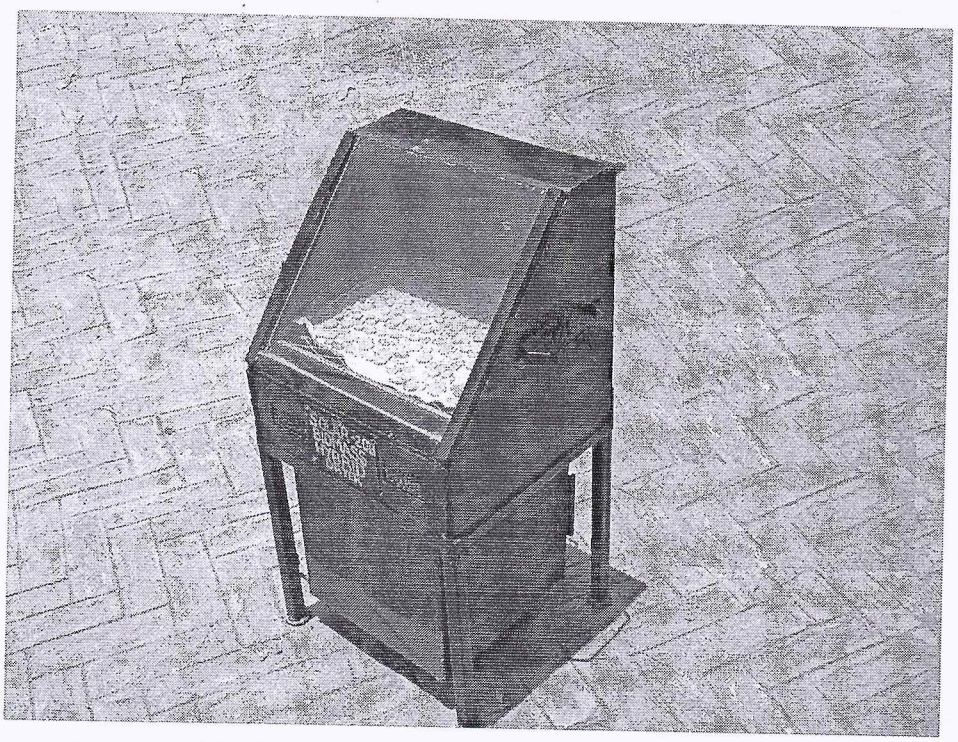


PLATE NO.11: VIEW OF SOLARBIOMASS HYBRID DRYER

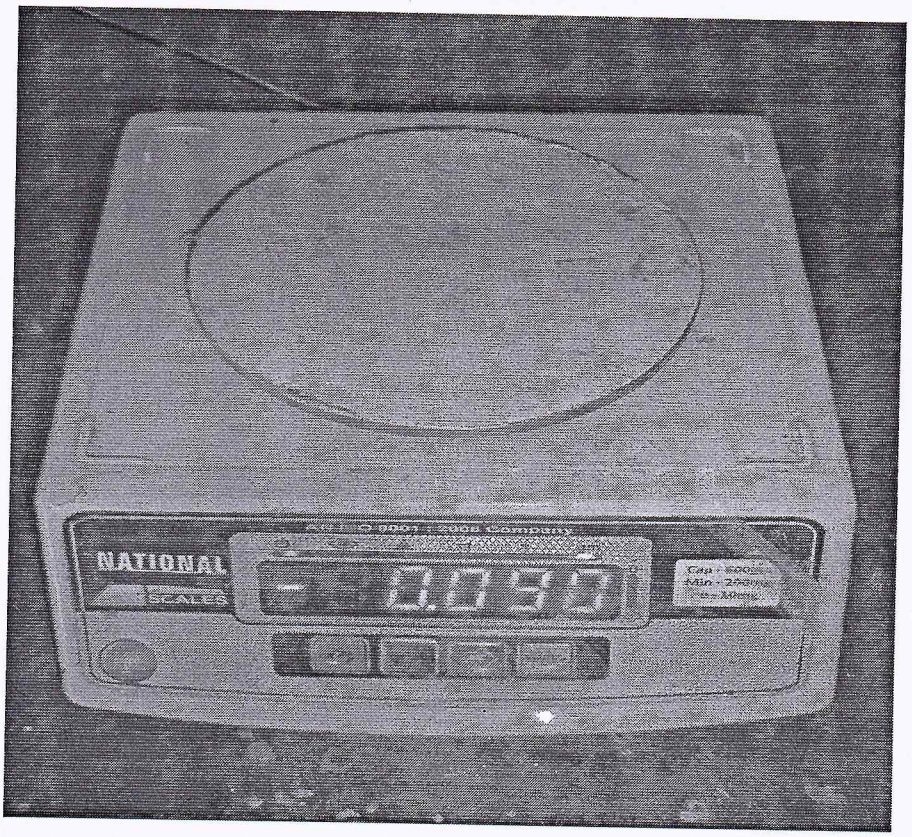


PLATE NO. 12: ELECTRONIC WEIGHING SCALE

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

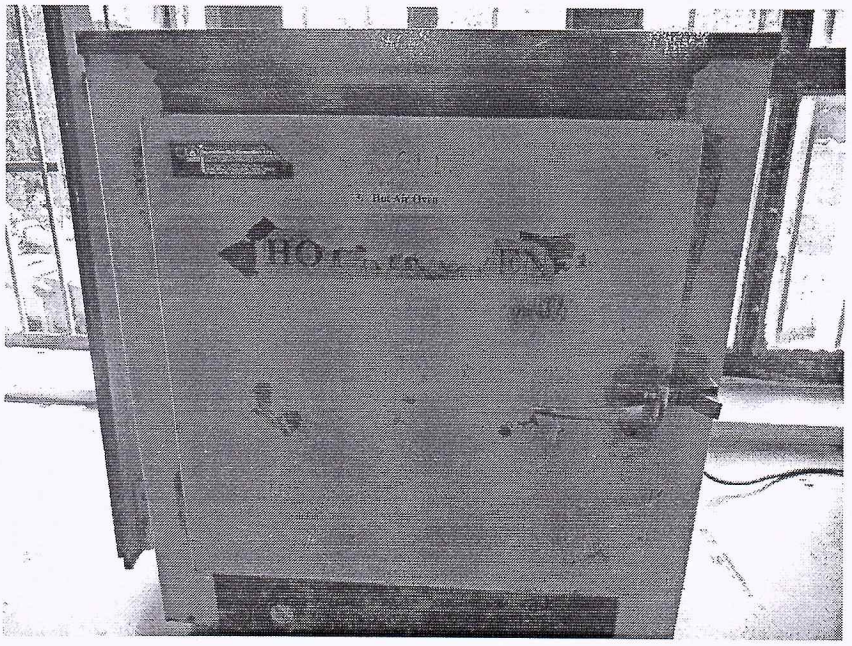


PLATE NO. 13: HOT AIR OVEN

PLATE NO. 14: HOT PALTE

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

PLATE NO. 15: LABORATORY THERMOMETER

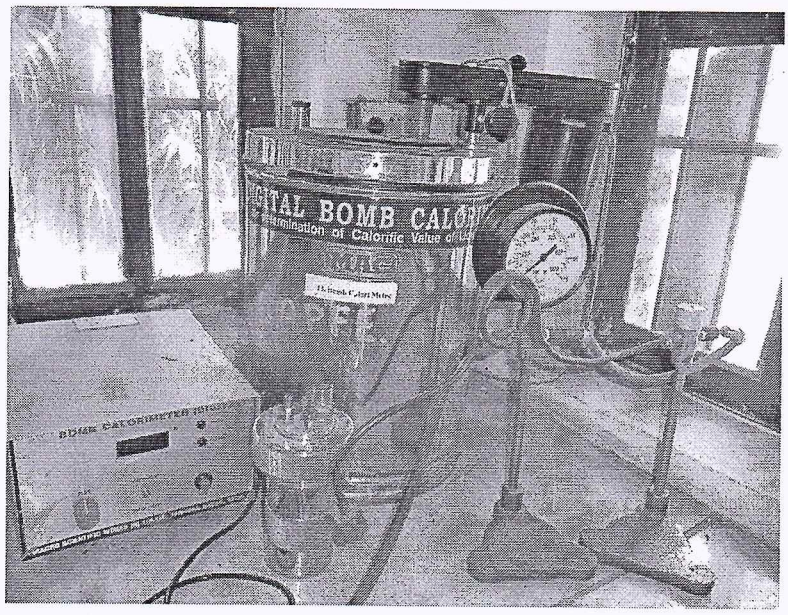


PLATE NO.16: BOMB CALORIMETER

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

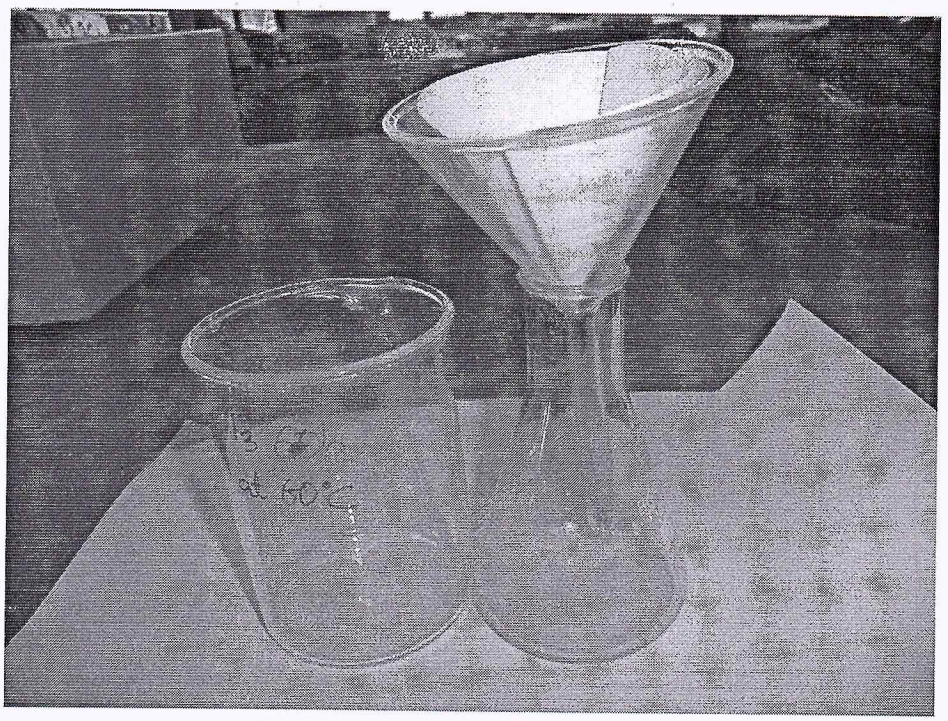


PLATE NO.17: GLASS WARES

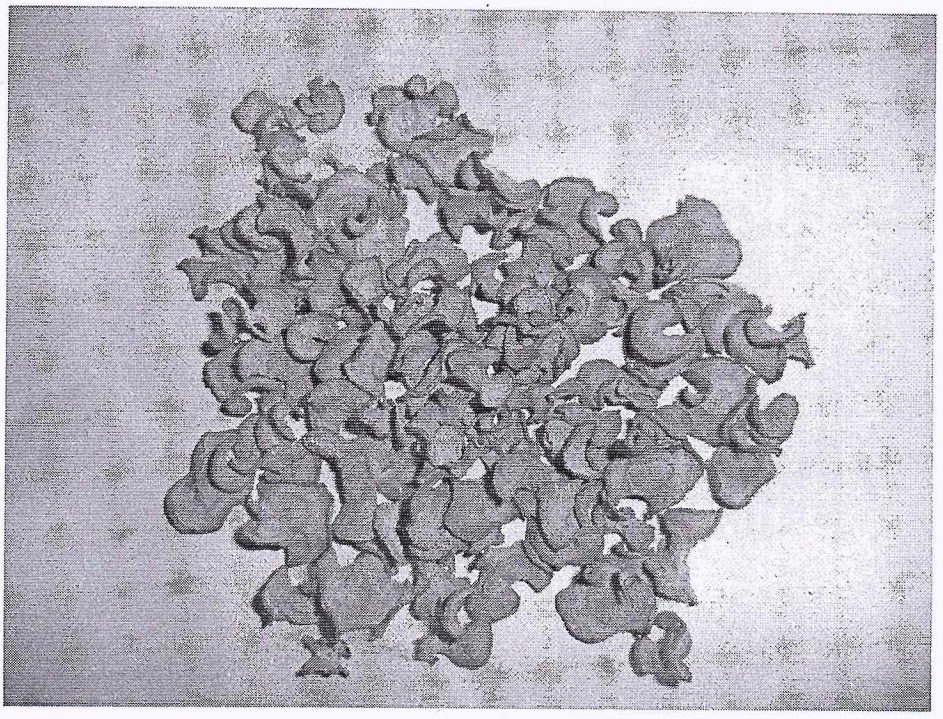


PLATE NO.18: SOLAR DRIED CARROT SLICES

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

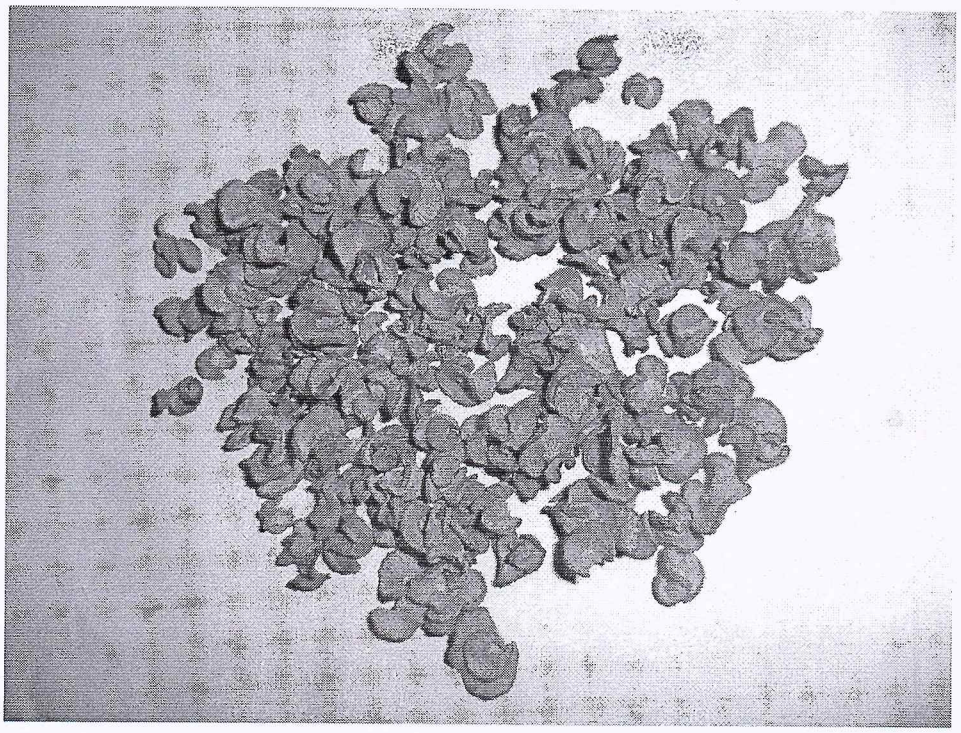


PLATE NO.19: SOLAR BIOMASS DRIED SLICES

PLATE NO. 20

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

The current study/resects was executed basically to design, fabricate and analyze the performance evaluation of a solar biomass hybrid dryer and be able to compare it with the usual solar dryer, in order to justify its better qualities and performance efficiency , in this course of study carrots slices were taken as a representative fruit to study the amount moisture content removed during drying, drying efficiency of the dryer, rehydration ratio of the dried carrots, drying rate and the time taken for drying in both the solar and solar hybrid dryer. Saw dust, rice husk and cow dung biomass briquettes were used as sources of fuel for the combustion chamber to provide the required heat needed for drying and dehydration of fruits. Tables have been given to display the comparative study thus carried out, the major objectives on which the whole study was based were to design, fabricate a solar biomass hybrid dryer, . study and analyze its performance evaluation and determination of the machine cost effectiveness all these objectives have been mentioned, explained and justified herein.

6.2 Performance Evaluation

The performance evaluation of the solar hybrid dryer was done through running carrot slices of a know amount in the solar biomass hybrid dryer, exposing the slices on both solar drying and a combination of the two energy sources solar and biomass drying, then determining the amount of time taken and amount of moisture content removed, the drying rate and drying efficiency of the dryer. Various results were obtained during performance evaluation, five samples were taken for both solar drying and solar biomass hybrid drying, of the five samples taken, 3 best done samples having consistent results were taken in order to determine the performance of the solar biomass hybrid dryer. Plotting of the various line graphs of the drying data observed basing on the drying efficiency of the hybrid dryer.

6.2.1 Data representation on graphs

Line graph is a mathematical representation of statistical data using mathematical concepts and language. The process of developing a line graph model is termed mathematical modeling.), a model may help to explain a system and to study the effects of different components, and to make predictions about behavior different outcomes. Line graphs between **Moisture Content Vs Drying Time (M.C /D.T), Drying Rate Vs Drying Time (D.R/D.T)** and **Drying Time Vs Moisture Content (D.T/M.C)**

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

6.2.2 Rehydration ratio

The rehydration ratio for the dry carrot slices was done and results found to be:

6.2.2.1 For solar dried

$$A.R = \frac{\text{Rehydration ratio for (Sample 1+ Sample 2+Sample 3)}}{\text{Total number}}$$

$$= \frac{5.23+4.5+4.8}{3} = 4.843$$

6.2.1.2 For solar biomass hybrid dried

$$A.R = \frac{\text{Rehydration ratio for (sample 1+sample 2+ samples 3)}}{\text{Total number}}$$

$$= \frac{4.3+4.5+4.4}{3} = 4.40$$

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

6.1.3 Results for solar drying

S.No	Time (min)	Wt of Sample	M.C (wb)	Amount of M.C removed	Amount of M.C present	Drying Rate
1	0	100	89.48	0	89.0	0
2	30	67.73	84.46	32.27	57.27	0.122
3	60	44.81	76.52	55.19	34.29	0.087
4	90	22.50	53.24	77.50	11.98	0.069
5	120	11.74	10.39	88.26	01.22	0.056

Fig. Solar drying for Sample 1

Moisture content by hot air oven method = 89.48%

Temperature taken during drying in solar hybrid dryer was 60 °C

S.No	Time (min)	Wt of Sample	M.C (wb)	Amount of M.C removed	Amount of M.C present	Drying Rate
1	0	100	86.0	0	86.0	0
2	30	64.42	78.26	35.58	50.42	0.080
3	60	39.05	64.14	60.94	25.05	0.072
4	90	20.25	30.86	79.76	06.25	0.063
5	120	14.04	08.28	85.96	02.04	0.051

Fig. Solar drying for Sample 2

Moisture Content by hot air oven method was 86.0%

Temperature taken during drying in solar hybrid dryer was 60 °C

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

S.No	Time (min)	Wt of Sample	M.C (wb)	Amount of M.C removed	Amount of M.C present	Drying Rate
1	0	100	86.66	0	86.66	0
2	30	59.51	77.58	40.49	46.17	0.101
3	60	37.81	64.77	62.13	24.53	0.077
4	90	27.84	52.08	72.16	14.50	0.060
5	120	20.36	34.47	79.64	07.02	0.049

Fig. solar drying for sample 3

Moisture Content by hot air oven method was 86.66%

Temperature taken during drying in solar hybrid dryer was 56 °C

With the above given results for solar drying in the tables 1, 2, 3 for sample number 1, 2, 3 respectively, using Microsoft excel software line graphs to represent the above data mathematically were plotted as shown.

Moisture content Vs Drying time

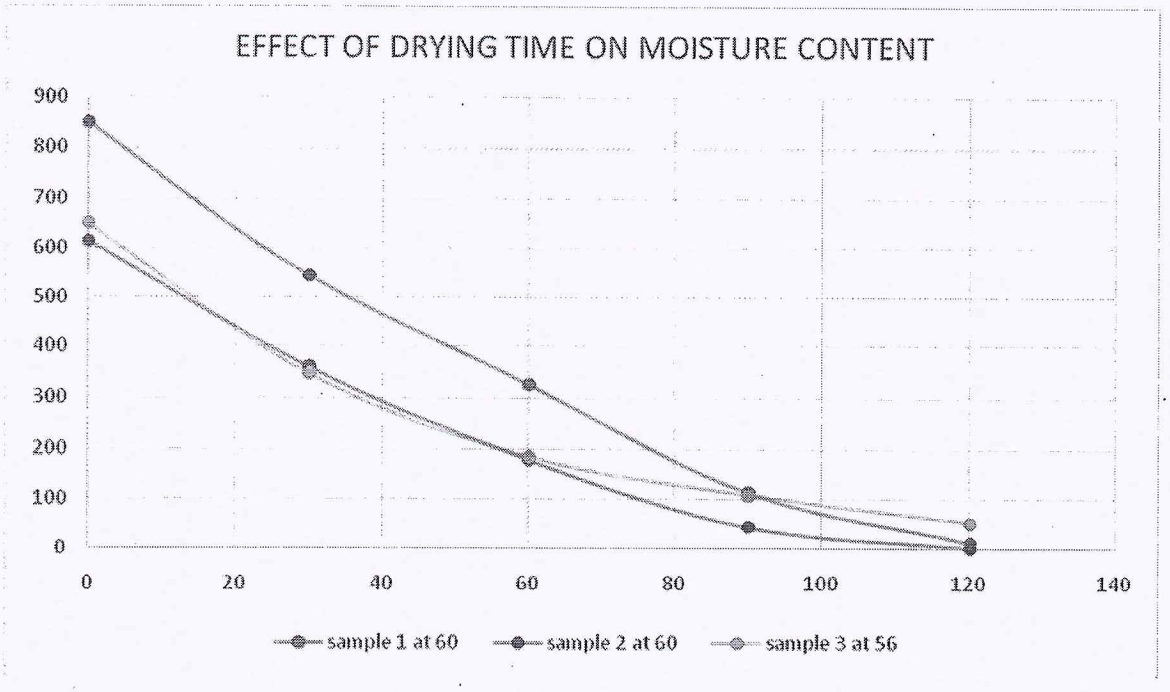


Fig EFFECT OF DRYING TIME ON THE MOISTURE CONTENT

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

As shown in the line graph, sample 1 had 89.48% as its moisture content on wet basis, this serves to explain that at temperature of 60°C used for its drying, the amount of moisture removal was rapid and steady per 30 minute time interval, this was due to the high solar intensity of the day, the initial amount of free and unbound water embedded in the carrot inner cells.

As shown in Fig.no.2 and graph, sample 2 had 86.0% as its moisture content on wet basis, at temperature of 60°C at which the drying was done, the amount of moisture removal was gradual in the beginning and decreases as the drying rate of the carrot slices continued, every after 30 minutes the weights were taken and recorded and it was found that the decrease in weight was indirectly proportional to the increase in the amount of moisture removed from the samples.

As shown in Fig.no.3 and the graph, sample 3 had 86.66% as its moisture content on wet basis, at a temperature of 56°C at which the drying was done, the amount of moisture removal was gradual in the beginning and went on decreasing as the drying rate of the carrot slices continued every after 30 minutes, the decrease in weight of the carrot slices, is indirectly proportion to the increase in the amount of moisture removed.

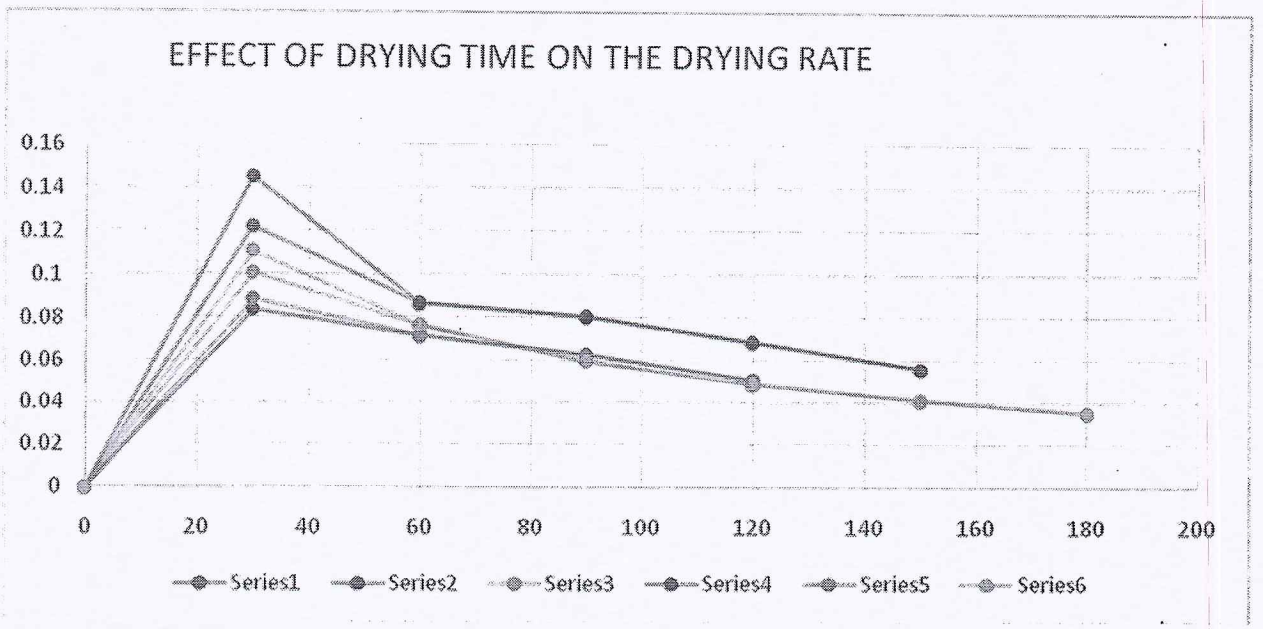


FIG.NO.5 EFFECT OF DRYING TIME ON DRYING RATE

As shown in the line graph above the rate of drying increases constantly in the first 30 minutes, this is due to the free moisture that is present in the cells of the carrot slices, as the drying continues, the amount of moisture present in the carrot slices as unbound moisture is removed in the next 30 minutes but the rate of drying at this time is low or so, the rate of drying with respect

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

to time slightly slows down in the next 30 minute phase due to un bound moisture removal in the cells of the carrots slices, the moisture is finally removed from carrot slices and the rate of drying drops or decreases in accordance with the time taken for drying, the longer the time of drying, the lower the drying rate and the higher the amount of moisture removed from the cells or tissues hence drying. This takes place for all the samples and at different temperatures and moisture content.

6.1.4 Results for Solar biomass hybrid drying

S.No	Time (min)	Wt of Sample	M.C (wb)	Amount of M.C removed	Amount of M.C present	Drying rate
1	0	100	88.00	0	88.00	0
2	30	63.01	80.95	36.99	51.01	0.141
3	60	47.75	74.86	52.25	35.75	0.072
4	90	34.34	65.05	65.66	22.34	0.060
5	120	25.13	52.24	79.87	13.13	0.055

Fig. RESULTS FOR SOLAR BIOMASS HYBRID DRYING OF SAMPLE 1
Moisture content by hot air oven drying was 88.0%
Temperature taken for drying in solar hybrid dryer was 75°C

S.No	Time (min)	Wt of Sample	M.C (wb)	Amount of M.C removed	Amount of M.C present	Drying rate
1	0	100	91.40	0	9.40	0
2	30	39.00	77.94	61.00	30.40	0.236
3	60	17.92	52.00	82.08	09.32	0.158
4	90	12.22	29.46	87.80	03.60	0.113
5	120	08.70	01.14	91.30	00.10	0.088

FIG.NO.7 RESULTS FOR SOLAR BIOMASS HYBRID DRYING OF SAMPLE 2
Moisture content by hot air oven drying was 91.4%

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Temperature taken for drying in solar biomass hybrid drying was 85

S.No	Time (min)	Wt of Sample	M.C (wb)	Amount of M.C removed	Amount of M.C present	Drying rate
1	0	100	90.00	0	90	0
2	30	51.10	80.43	48.90	41.10	0.163
3	60	30.20	66.88	69.80	20.20	0.116
4	90	18.50	45.94	81.50	08.50	0.090
5	120	12.77	21.69	87.23	02.77	0.038

Fig. RESULTS FOR SOLAR BIOMASS HYBRID DRYING FOR SAMPLE 3

Moisture content by hot air oven drying was 90.0%

Temperature taken for drying in solar biomass hybrid drying was 85°C

With the above given results for solar biomass hybrid drying in the tables 1, 2, 3 for sample number 1, 2, 3 respectively, using Microsoft excel software line graphs to represent the above data mathematically were plotted as shown

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

6.3 Determination of the Cost-effectiveness of the solar biomass hybrid dryer

In this, the costs relating to the entire fabrication and performance evaluation of the above project was calculated.

6.3.1 Fabrication costs

The cost of stainless steel was Rs. 200 per meter (1mx1m), 1 meters were purchased (3x200) = 600 Rs.

The costs of pipes was 180

The costs of glass or front screen were Rs.70 per (15 x 15) inches.

The cost of wire mesh Rs.10 (0.5m) was used

The cost of black petroleum paint, brush, petrol (for mixing paint) was Rs.98

The cost of fabricating the biomass combustion chamber was Rs.200

The fabricator stipend was Rs.1000

The cost of the glass adhesive was Rs. 10

Fabrication costs were Rs. 1968 which rounds off to Rs.2000

6.3.2 Costs for fuel (biomass used) in performance evaluation

The cost of 1kg of rice husk is Rs. 5

The cost of 1kg saw dust was Rs. 2

The cost of worker services was Rs. 50

6.3.3 Costs for carrots used for performance evaluation

The cost of 1kg carrot was Rs.12 and 5kgs were purchased during the course of project execution and performance evaluation which is (5x12) = 60 Rs.

Result

The overall costs of fabrication were found to have been Rs.1968 which when rounded off come to Rs.2000.

The costs of biomass, and carrots used in the performance evaluation were found to be Rs.117

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Overall Total Costs of the entire project were:

Particulars	Cost (Rs.)	Total (Rs.)
1.Fabrication costs	1968	1968
2.Performance Evaluation	117	117
Total		2085

FIG.NO.11

The entire cost of the project was Rs. 2085

The cost effectiveness of the entire project entailing, fabrication costs and, performance evaluation costs, and costs for various miscellaneous expenses were calculated and the project found to be economically viable especially when adapted in rural life setting

6.4 Calculation and determination of Fuel consumption rate and Drying efficiency of the Solar biomass hybrid dryer.

6.4.1 Drying Efficiency of the Solar biomass hybrid dryer

The drying efficiency of the solar biomass hybrid dryer was calculated and determined as follows:

Amount of water evaporated during a specific time interval (Ww)

$$Ww = \frac{(79.87+91.30+87.23)}{3}$$

$$\frac{258.4}{3}$$

= 86.1333 kg moisture.

The amount of product to be dried or feed, mf = 100gm

The specific heat of fruits taken, Cp = 2.24 kg/kg

The average temperature taken during gasification and drying,

$$Av.temp = \frac{(75+85+85)}{3} = 81.66\ ^{\circ}C$$

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

The change in the inner temperature of the dryer and the ambient air temperature,

Ambient air is taken as 27.0°C for the overall day

$\Delta t = 81.66 - 27.0$

$= 54.66°C$

$\Delta t = 54.66\ °C$

To Kelvin

$54.66 + 273 = 327.66°K$

The desired time period is given by, th = 7200 sec (for 2 hours of gasification)

Solar intensity is a calculated given constant. It = 985.7 W/hr

The area of the entire surface of the solar biomass hybrid dryer is given by,

$A = L \times W$, $A = 1 \times 1 = 1ft$ but $1ft = 0.305$ m

$A = 0.305 \times 0.305$

$A = 0.0930\ m^2$

Now the drying Efficiency

The drying efficiency is calculated using the above data;

$$\eta d = \frac{(86.13 \times 2331.5) + 0.1 \times 2.24 \times 327.66}{(0.0930 \times 985.7 \times 7200)}$$

$= 0.30436$

$= 30.43\%$

From the above dryer efficiency, the fuel consumption rate can be calculated.

Using the above formula;

$$q'a = \frac{\text{amount of water removed x latent heat}}{\text{Dryer efficiency}}$$

$$= \frac{86.133 \times 574}{0.3}$$

$= 164801.1$

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

The fuel consumption rate is calculated as;

$$F = \frac{164801.14}{0.3 \times 476.75}$$

$$= \frac{1152.254}{1800}$$

0.6 gm/hr

The fuel consumption rate of the hybrid dryer was 0.6gm per hour

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

CHAPTER 5

CONCLUSION

In this chapter, a well summarized conclusion on the entire project is given citing all the objectives under which the above project was executed; the justification as shown above in the overall project is summarized.

A solar biomass hybrid dryer was designed using engineering design software like AutoCAD and Pro-engineering into a theoretically synchronized machine prototype on paper, basing on the engineering design the machine prototype was fabricated into a solar biomass hybrid dryer at the Work shop of Estate Division of Shiats and its performance evaluation carried out at the Department of Food Process Engineering, Vaugh School of Agricultural Engineering and Technology.

During the performance evaluation, various parameters were analyzed and proved worthy, parameters like Drying efficiency, Cost effectiveness, Moisture content, Rehydration ratio, fuel consumption rate etc were determined, the cost effectiveness of the dryer was proved through monetary expenditures and expenses.

The results are all presented herein as follows,

The fuel consumption was found to be 0.6 gm/hr

The drying efficiency of the solar biomass hybrid dryer was found to be 0.3043 or 30.43%

The capacity of the solar biomass hybrid dryer was found to be 200gm when full.

Justification

According to the above data and results taken from various test parameters it was found that the solar biomass hybrid dryer out performs the normal single energy solar dryer, the solar biomass hybrid dryer has a drying efficiency of

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

30.43% while the solar drier has been estimated to have 16% drying efficiency according to Unit Operations of Agricultural Processing by Singh and Sahay. The time taken for drying of samples in a solar hybrid dryer as compared to duo energy drying is less, with duo energy the drying time is reduced greatly and product quality good.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

REFERENCES

Acedo , A. L. J. and K. Weinberger (2006). Postharvest Technology Training and Development of Training Master Plan. Cambodia, Lao PDR and Viet Nam, RETA 6208

Akanbi, C. T., R. S. Adeyemi, et al. (2006). "Drying characteristics and sorption isotherm of tomato slices." Journal of Food Engineering 73(2): 157-163.

Arinze, E. A., S. Sokhansanj, et al. (2007). "Experimental evaluation, simulation and optimisation of a commercial heated-air batch hay drier: Part 1, dryer functional performance, product quality and economic analysis of drying." Agricultural Engineering Research 63: 301-314.

Augustus Leon, M., S. Kumar, et al. (2008). "A comprehensive procedure for performance evaluation of solar food dryers." Renewable and Sustainable Energy Reviews (4): 367-393.

Basunia, M. A. and T. Abe (2008). "Thin layer solar drying characteristics of rough rice under natural convection." Journal of Food Sciences 47(4): 295-301.

Brenndorfer, B., L. Kennedy, et al. (2006). Solar dryers—their role in post-harvest processing. Commonwealth Science Council, London.

Crapiste , G. H. and **E. I. E. Rotstein** , , Editors,, **CRC Press,(2007)** ISBN: , **Eds. (2008).**

Design and performance evaluation of dryers. Handbook of food engineering practice. New York

FAO (2005). Production of Fruits and Vegetable and Share in world. ROMA.

Farkas, I., Ed. (2004). Solar -drying of materials and biological origin. Dehydratation of Products of Biological Origin. Enfield, USA, Science Publisher,Inc.

Fodor, E. (2006). "Build a SOLAR FOOD Dehydrator Preserve your harvest with free energy from the sun." MOTHER EARTH NEWS.

Dhanuskodi.S1*, R.Sukumaran*2, Vincent .H.Wilson*3 (2002) Investigation Of Solar Biomass Hybrid System For Drying Cashew.International Journal of ChemTech ResearchCODEN(USA): IJCRGG ISSN : 0974-4290 Vol.5, No.2, pp 1076-1082,AprilJune

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Gauhar A. Mastekbayeva, Chandika P. Bhatta, M. Augustus Leon and S. Kumar (2009) Energy Program, Asian Institute of Technology EXPERIMENTAL STUDIES ON A HYBRID DRYER

Bechoff, A..2010. Investigating carotenoid loss after drying and storage of orange-fleshed sweet potato. A thesis submitted in partial fulfilment of the requirements of the University of Greenwich for the Degree of Doctor of Philosophy, 222pp.

Best, R..1979. Cassava Drying. Cali, Colombia: Centro International de Agricultura Tropical. p. 24

Curran C. L. and Trim, D. S. 1982. Comparative study of solar and sun drying of fish. Paper presented at IPFC Workshop on Dried Production and Storage.

Eliçin, A. K.and Saçilik, K. 2005. An experimental study for solar tunnel drying of apple. Ankara University Faculty of Agriculture Journal of Agricultural Sciences 11, 207-211.

Farhat, A., Kooli, S., Kerkeni, C., Maalej, M., Fadhel, A. and Belghith, A. 2004. Validationof a pepper drying model in a polyethylene tunnel greenhouse.International Journal of Thermal Sciences 43, 53-58.

Mastekbayeva, G. A., Chandika, P. B., Augustus, L. and Kumar, S. 1999. Experimental studies on a hybrid dryer. Paper presented at the ISES Solar World Congress. Israel. 4-9 July 1999.

Gnanaranjan, N. P., Rakwchian, W., Donoghue, J. O. and Kumar, S. 1997. Field Performance of a solar tunnel drier. Proceedings of ISES (Solar World Congress).

ITDG, 1988. Intermediate Technology Development Group. Practical answers to poverty. Drying of Foods.NRI.Technical Brief. NRI, UK. http://practicalaction.org/ practicalanswers/product_info.php?products_id=88%7B1%7D 1andattrib=1.

Jensen, S. O. And Kristensen, E. F. 1999. Solar dryers for drying of food and wood in Ghana. Survey Report to the Danish Technological Institute, Denmark. 42pp.

Sanni., L., Alenkhe., B., Edosio, R., Patino, M. and Dixon, A. 2007. Technology transfer in developing countries : Capitalizing on Equipment Development. Journal of Food, Agriculture & Enviroment 5 (2) : 88-91.

Sanni, L., Dixon, A., Ezedinma, C., Ilona, P., Okechukwu, R. And Tarawali, G.2006a Casava Enterprise Development Project (CEDP)-synergy betweenmarketing,territorial opportunities, capacity building and sustainability. Presented durning the CRS-WARO-CARO/CIAT Learning alliance on Agro-Enterprise.

Development , 2nd Workshop, 12-18 Feb2006,Banju, The Gambia.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Lawand TA. A description of two simple solar agricultural dryers. In: Cooperation Mediterraneene pour
l'Energie Solair. Bull. no 9, 1965:51±6.

Lawand TA. The potential of solar agricultural dryers in developing areas. UNIDO Conf 5, Tech for Solar Energy Utilization, 1977:125±32.

Nahlawi M. The drying of yams with solar-energy. Technical report, Brace Research Institute, St James, Barbados, West Indies, 1966;No. T.27.
Saulnier B. Survey of solar agricultural dryers. Joint Conf Amer Section ISES & Solar Energy Soc Canada Inc 1976;17:7±21.

Anon . How to make solar cabinet dryer for agricultural produce. In: DIY Lea¯et. Brace Res Inst Canada,1965:L6.

Bailey PH, Williamson WF. Some experiments on drying grain by solar radiation. J Agric Engng Res1965;10:191±6.

.Ezekwe CI. Crop drying with solar air heaters in tropical Nigeria. ISES, Solar World Forum, Brighton, UK, Pergamon Press, Oxford, 1981:997±1005.

Gustafsson G. Solar assisted grain drying in hot and humid areas. Rapport, Sveriges Lantbruksuniversitet, Lund, **1982;20**

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Shri Ram College, Muzaffarnagar

Department of Journalism and Mass Communication

10-05-2024

PROJECT REPORT

On

Digital Promotion

From the last year Department of Journalism and Mass Communication, Shri Ram College Muzaffarnagar took an initiative for the professional skills development of JMC students like news reporting, news writing, news editing, publicity approach, public relations vision and advertising skills and developed a start-up with the name "Namaskar Bhaarat". Taking this objective forward, we worked for the digital promotion of The Wayside inn in the session of 2022-23. After observing effective working efforts by our team, the management of 'The Wayside inn' show their desire to work forward with us for the next session 2023-2024. In which they required for the creation and operation of a new YouTube channel, some Google reviews and promotion of social media.

For working on this project, we selected final year Journalism and Mass Communication students of UG and PG courses, for developing their skills and prepare their minds for professional media culture. Five students of Second year of BAJMC namely Param Singhal, Ashutosh Tyagi, Sagar Kumar, Hardik Sharma, Kartik Sehrawat and first year of MAJMC Narayan Sharma did the promotional work for The Wayside Inn through various platforms of digital media in a very professional manner under the supervision of Dr. Ravi Gautam (Principal investigator) and Mr. Mayank Verma (Co- investigator of project).

Through this project JMC students learned about the basics required in digital media and enhanced their knowledge. Kartik Sehrawat was the team leader was this project and working with The Wayside Inn Manager throughout the project and understood their requirements and satisfied them and conveyed the message to the promotional team for effective output and their satisfaction. While Param Singhal and Ashutosh Tyagi created SEO friendly content for social media and Google reviews as per the requirement, Sagar Kumar and Hardik Sharma posted reviews on social media platforms and Google listings, Narayan Sharma created YouTube Channel and also create backlinks and shared on The Wayside Inn's social media platforms. Narayan

Co-ordinator
IQAC, Shri Ram College,
Muzaffarnagar

Chairperson
IQAC, Shri Ram College,
Muzaffarnagar

Sharma had the responsibility for maintaining the YouTube Channel too. All the students did their work with professional attitude and dedication they learned a lot throughout this project. For the promotional work we have charged 75000 Rupees as our service.

Objective of Project:-

- To provide professional platform to the JMC students.
- To enhancing the professional skills among the JMC student.
- To develop the opportunity of entrepreneurship.
- To make the JMC student self reliance.

Outcome of the Project:-

Our project yielded outstanding results! We successfully executed a promotional project for The Wayside Inn, which led to a significant increase in their Google listing ranking and visibility in Google search. By consistently posting engaging content across their social media platforms, we achieved a 75% increase in their online reach, leaving them thoroughly satisfied with our services.

Furthermore, we created a YouTube channel for them, titled "sir adamjee peerboy moharram ashra waiz", which they had commissioned us to develop. This project provided our students with invaluable hands-on experience in digital marketing, enabling them to learn about digital media promotion, understand market requirements, and hone their skills.

This project was a resounding success for us, and we are confident that it will benefit our students in their future careers. By leveraging our expertise in digital marketing, we were able to deliver tangible results for our client, while also providing our students with a unique learning opportunity.

In which we have got success and the team of 6 JMC students learn allot with this professional activity. They got knowledge about the basics of digital media promotion and understood the market requirement with their experience.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Expense Report for Digital Promotion

Project Duration- 6 Months

From 04-11-2023 to 03-05-2024

Total Budget: ₹75,000/-

Expenses Breakdown

1. **Marketing Expenses**		
- Advertising	-	₹8,000/-
- Content Creation	-	₹12,000/-
- Total	-	**₹20,000/-**
2. **Technology Expenses**		
- Domain	-	₹2,500/-
- Hosting	-	₹5,000/-
- Data Security	-	₹2,500/-
- Total	-	**₹10,000/-**
3. **Miscellaneous Expenses**		
- Travel	-	₹5,000/-
- Training	-	₹7,000/-
- Internet	-	₹5,000/-
- Other	-	₹8,000/-
- Total	-	**₹25,000/-**
4. **Personnel Expenses**		
- Student volunteers	-	₹12,000/-
- Refreshment	-	₹8,000/-
- Total	-	**20,000/-**
Total Expenses	-	**75,000/-**
Remaining Budget	-	Nil

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Utilization Certificate

S.N.	Detail of sanction of Fund with Project name and Duration	Amount
1.	6 months project on Digital promotion Date of Sanction of Fund- 04-11-2023 as per Sanction Letter	75000.00 /-
	TOTAL	75000.00/-

It is Certified that out of Rs. 75000.00/- (Seventy Five Thousands only) of grants sanctioned by **The Way Side Inn** during the year 2023-2024 in favor of **Shri Ram College, Muzaffarnagar,** a sum of Rs. 75000.00 has been utilized for the purpose of the project for which it was sanctioned and that the balance of Rs. **Nil** remaining unutilized at the end of the year has been surrendered. The Extra amount (If any) is met out by Shri Ram College.

2. Certified that we have satisfied our self that the conditions on which the grant was sanctioned have been duly fulfilled/are being fulfilled and that we have exercised the following checks to see that the money was actually utilized for the purpose for which it was sanctioned.

Kinds of checks exercise-

1 Checking of cash book
2 Checking of payment vouchers.
3 Checking of salary register.
4 Checking of expense bill.

For Shri Ram College

Secretary

Date: 12-05-2024
Place: Muzaffarnagar

For Goel Rakesh & Co.
Chartered Accountants

GOEL RAKESH & CO. CHARTERED ACCOUNTANTS Muzaffar-Nagar (U.P.)

Rakesh Kumar Goel
Proprietor

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College.
Muzaffarnagar

The list of persons who engaged in Digital Promotional Project

Sl.No	Name Of Person	Assign Work
1	Kartik Sehrawat	Team Leader
2	Param Singhal	Creating SEO friendly Content
3	Ashutosh Tyagi	Creating SEO friendly Content
4	Sagar Kumar	Posting the post & Reviews over the social media
5	Hardik Sharma	Posting the post & Reviews over the social media
6	Narayan Sharma	Create & Maintain Youtube Channel Sharing & Generating Back links

Principal Investigator:- Dr. Ravi Gautam

Contact No. 9927668855

Email: ravigautam81@gmail.com

Co- Investigator:- Mr. Mayank Varma

Contact No. 9997308688

Email :vermamayank609@gmail.com

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College
Muzaffarnagar

Namaskar Bhaarat

Loktantra Ki Awaaz

Date: 16-10-2023

To
Mr. Abbas Ali
Manager,
The Way Side Inn
Mumbai, Maharashtra

Subject: Offer for Digital Promotion Services

Dear Sir,

I am pleased to submit this offer letter for providing digital promotion services to your esteemed organization. Our company, Namaskar Bhaarat, based in Muzaffarnagar, specialize in digital promotion and marketing. We can provide the following promotional and marketing services in the session 2023-24 to your organization:

- YouTube Channel Creation and Management
- Social Media Campaign Management
- Google Ads Management
- Website Optimization
- Content Marketing

Our services can help you enhance your online presence and connect with your customers.

Our Pricing is for six months as follows:

- YouTube Channel Creation and Management: ₹30,000
- Social Media Campaign Management: ₹20,000
- Google Ads Management: ₹10,000
- Website Optimization: ₹5,000
- Content Marketing: ₹10,000

If you are interested then, please do not hesitate to contact me. I am available to discuss your requirements and create a customized digital marketing plan for your organization.

Thank you,

Mayank Verma
Marketing Head
Namaskar Bhaarat

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

162/2 Brhampuri, Near Prathviraj Chauhan Marg,Behind Arora Quarter Muzaffarnagar 251002
Telephone No: 0131-3140583, Mob No: 9997308688,7302917974, 6398111321

THE WAYSIDE INN

Date:- 27-10-2023

To
The Mr. Mayank Varma
Marketing Head
Namaskar Bhaarat
Subject: Acceptance Letter for Digital Promotion

Dear Sir,

We got your offer letter. It is impressive and we appreciate your offer for digital promotion for 6 month. We are pleased to accept your offer and look forward to working with your team.

We have reviewed and accepted the terms and conditions outlined in your proposal, and we are confident that your company will meet our online promotional needs.

Please find below the details of our acceptance:

-Duration of Digital Marketing Services: 6 months
-Price of Digital Marketing Services: 75000/-
-Payment Mode: UPI & Cashe

We look forward to a successful partnership and appreciate the opportunity to work with your team.

Thank you,

Abash Ali
Manager
The WaySide Inn
Matheran, Mumbai, Maharashtra

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Namaskar Bhaarat

162/2 Brahampuri
Muzaffarnagar U.P- 251001

Phone: 730-291-7974
Fax:

vermamayank609@gmail.com
www.Namaskarbhaarat.com

Bill To: **The Waysidelnn**

Address: M.G Road Matheran,
Neral - Matheran Rd, Main, road,
Maharashtra 410102

Phone: **9927668855 / 9997308688**

Email: **ravigautam81@gmail.com**

Invoice #: **2**

Invoice Date: **8/11/2023**

Contact: **Ravi Gautam**

Date	Item #	Description	Qty	Unit Price	Discount	Total
8/11/2023	Youtube Channel Creation and Management		1			30000
	Social Media Campaign Management					20000
	Google ads Management					10000
	Website Optimization					5000
	Content Marketing					10000

Invoice Subtotal	75000
Tax Rate	0%
Sales Tax	0
Shipping	0
Deposit Received	0
Total	75000

MAKE ALL CHECKS PAYABLE TO NAMASKAR BHAARAT.

TOTAL DUE IN 10 DAYS. OVERDUE ACCOUNTS ARE SUBJECT TO AN INTEREST CHARGE OF 2% PER MONTH.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

SHRI RAM COLLEGE

Research Project of Khelo India Programme

Session 2023-24

Department of Physical Education

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Shri Ram College
Approved by UGC, NCTE and Affiliated to MS University, Saharanpur
Muzaffarnagar - 251001, NCR (U.P.)
A++ Grade Accredited by NAAC

Date: 10/07/2023

To

The Manager

Sports: A Way of Life.

Dear Sir,

As We have organizing a collaborate event on theme **"Khelo India Programme"**at **Shri Ram College, Muzaffarnagar**. This is beneficial for students and society as development of Sports.

We propose to complete the project within 01 year ensuring timely delivery without compromising on quality. The detail of estimated cost for the project is attached herewith.

We are excited about the possibility of working with your organization on this project.

Hope you find the document in order. Kindly accept the proposal and release the fund accordingly.

Thanks and regards

Principal

Shri Ram College, Muzaffarnagar

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Contact @ 9927028908, 9927011422
Website : www.srgcmzn.com E-Mail : src_mzn@rediffmail.com

Sports: A Way Of Life
An NGO Sports Literacy Mission
606 C, Gulmohar Green Apartment, Mohan Nagar, Ghaziabad (UP) - 201007

Date:14/07/2023

To

Mr. Bhupendra Kumar

Dept of Physical Education

Shri Ram College, Muzaffarnagar

Subject: Approval for Project

Dear Mr.Bhupendra Kumar,

I hope you are doing well. You will be delighted to know that the "Khelo India Programme" has been approved. I am pleased to inform you that a grant of Rs 2,40,000 has been approved for the research project. You have mentioned that it will take 1 year to complete the project. We wish you all the best to accomplish the task. You will need to submit report regarding the project's progress and how it is being completed. We wish you all the best.

Yours Sincerely,

Authorized signatory

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Detail of proposed Activities in 2023-24 at **SHRI RAM COLLEGE,MUZAFFARNAGAR** and Estimated cost under the research project of **'KHELO INDIA PROGRAM'**

S.No.	Activity	Proposed Month	Estimated Cost
1.	Fitness Camp a) Physical Fitness Activity b) Balance Diet c) Training recreational & Sporting Activities d) Environment Friendly Lifestyle e) Awareness from Disease f) Sports Facilities g) Data Collection h) Data Analysis	July-23 to June-24	2,40000/-
		Total	2,40000/-

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Utilisation Certificate

Title of the Project: Khelo India Programme

Investigator: Mr. Bhupendra Kumar

Funded Agency: Sports: A Way of Life (NGO)

Duration: One Year

Sanction Amount: Rs. 240,000/-

Session: 2023-24

Date: 29-06-2024

S. No.	Activity/item	Amount in Rs.
1	Physical Fitness Activity	32,100/-
2	Balance Diet	98,600/-
3	Training Recreational & Sporting Activity	54,000/-
4	Environmental Friendly Lifestyle	2,600/-
5	Awareness from Disease	4,300/-
6	Sports Facilities	48,500/-
7	Other	1,890/-
Total Expenditure		**2,41,990/-**
Fund given by funded agency (Sports: A Way of Life)		**2,40,000/-**
Extra Expenditure borne by College		**1,990/-**

Mr. Bhupendra Kumar
Project Investigator

Dr. Prerna Mittal
Principal, Shri Ram College

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Utilization Certificate

S.N.	Detail of sanction of Fund with Project name and Duration	Amount
1.	12 months project on Khelo India Programme in Model Sports village Date of Sanction of Fund- 14-07-2023 as per Sanction Letter	240000.00 /-
	TOTAL	240000.00/-

It is Certified that out of Rs. 240000.00/- (Two Lacs Forty Thousands only) of grants sanctioned by **IMT Ghaziabad and SAWOL** during the year 2023-2024 in favor of **Shri Ram College, Muzaffarnagar,** a sum of Rs. 240000.00 has been utilized for the purpose of the project for which it was sanctioned and that the balance of Rs. **Nil** remaining unutilized at the end of the year has been surrendered. The Extra amount (If any) is met out by Shri Ram College.

2. Certified that we have satisfied our self that the conditions on which the grant was sanctioned have been duly fulfilled/are being fulfilled and that we have exercised the following checks to see that the money was actually utilized for the purpose for which it was sanctioned.

Kinds of checks exercise-

1 Checking of cash book
2 Checking of payment vouchers.
3 Checking of salary register.
4 Checking of expense bill.

For Shri Ram College

Secretary
Date: 30-06-2024
Place: Muzaffarnagar

For Goel Rakesh & Co.
Chartered Accountants

Rakesh Kumar Goel
Proprietor

GOEL RAKESH & CO. CHARTERED ACCOUNTANTS Muzaffar-Nagar (U. P.)

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College.
Muzaffarnagar

khelo India Programme in Model Sports

Khelo India: National Programme for Development of Sports, branded as Khelo India (transl. Play India), aims at improving India's sports culture at the grass-root level through organized talent identification, structured sporting competitions and infrastructure development.

The Khelo India Programme is the flagship Central Sector Scheme to revive the sports culture in India at the grass-root level by building a strong framework for all sports played in the country and establishing India as a great sporting nation. It was launched in 2018 by then Sports Minister Col. Rajyavardhan Singh Rathore under the Ministry of Youth Affairs and Sports. It also focuses on developing sports infrastructure, coaching, and support systems for athletes to help them achieve their full potential.

Eligibility Criteria For Khelo India Scheme

There are no such big official criteria but the respective state governments and authorities have set some general criteria. Some of the general criteria for the Khelo India programme are listed below.

1. Candidates applying for Khelo India must be a resident of India.\
2. The candidate must be studying in school or college.
3. There are two categories listed in the scheme.
4. Candidates who are less than the age of 17 years can participate in the under 17 category.
5. Candidates who are less than the age of 21 years can participate in the under 21 category.

Features Of Khelo India Scheme

Some of the important features of the Khelo India Scheme are listed below.

1. The Khelo India training programme is given to young athletes who are interested in sports and want to explore further in Khelo India games.
2. Each year, 1000 of the best young athletes in the selected sports will get scholarships as part of the Khelo India Programme.
3. Each athlete selected for this programme will be given an annual scholarship of Rs. 500000 for the following 8 years.
4. Twenty Indian colleges have been designated as "centres of sporting excellence," where talented athletes combine their love of learning sports with competing at various levels.

Khelo India Centres of Excellence

1. To elevate the current center to a KISCE, the central government will provide "Viability Gap Funding" for sports science and technology support.
2. This funding will address needs like sports equipment, expert coaches, and high-performance managers.
3. The Sports Ministry's support for Khelo India State Center of Excellence will primarily focus on Olympic sports.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Effect of Khelo India Programme

The Khelo India Programme has a wide-ranging impact on various aspects of the sports environment in India, including facilities, coaching, recognition programmes, effective functioning, sports economics, and competitive structure.

1. The Khelo India Scheme has established a framework for fostering a sporting culture in India by providing annual competition platforms and creating sports infrastructure nationwide.
2. The Khelo India Youth Games, Khelo India Winter Games, and Khelo India University Games provide a platform for young athletes in the under 17 and 18 age categories to compete at the national level. Through these games, young athletes can showcase their skills and talent and compete with other athletes from different parts of the country.
3. The scheme provides financial assistance for developing sports infrastructure, such as playgrounds, stadiums, and training facilities.
4. The Khelo India Programme has implemented specific programmes to support and empower women in sports, giving them equal opportunities to showcase their talent and excel in their chosen sport.
5. The Khelo India Programme provides various benefits to athletes, including out-of-pocket allowances and access to training resources for indigenous sports in elite facilities.
6. Further, improved training facilities and cash assistance provided to divyangs or physically challenged people have contributed to a more inclusive and supportive environment for these athletes.
7. The Khelo India Programme also aims to improve coaching standards by providing training to coaches at various levels.

Conclusion

Khelo India Programme is related to the promotion of sports development. It is a central sector scheme. India is taking essential steps in promoting sports and athletes; therefore, it's time to encourage youthful talent and provide them with the best facilities and training available. Sports participation must be strongly encouraged in order for players to reach their full potential; only then can India fulfil its dream of becoming a sports superpower-dominated country.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

4. However, support in sports science and related fields may extend to other sporting disciplines at the center.
5. States and UTs will manage the KISCE, aiming to transform it into a world-class sports facility.
6. They will handle all aspects, including boarding, lodging, and maintenance.
7. Funds for crucial requirements like expert coaches, support staff, equipment, and infrastructure will come from the Khelo India Scheme.

Verticles of Khelo India Programme

There are 12 vertices included in the Khelo India scheme. The list of the vertices is given in the table below.

S.No.	Verticles
1	Play Field Development
2	Annual Sports Competitions
3	Support to National/Regional/State Sports Academies
4	Promotion of Sports among persons with disabilities (PWDs)
5	Community Coaching Development
6	Talent Search and Development
7	Physical Fitness of School going Children
8	Sports for Peace and Development
9	State Level Khelo India Centres
10	Utilization and Creation / Upgradation of Sports Infrastructure
11	Sports for Women
12	Promotion of rural and indigenous/tribal games

Benefits Of Khelo India Programme

1. The benefits of the Khelo India programme are listed below.
2. Khelo India scheme strengthens and revamps the sports culture of India at the grassroots level.
3. Khelo India Programme promotes "sports for all" and "sports for excellence".
4. It is a Pan-Indian sports scholarship programme that annually awards funding to the 1000 most talented players across all sports.
5. Sporting culture is developed by identifying, developing and encouraging talent in sports discipline.
6. Athletes who got selected are given scholarships of Rs. 5 lakhs for 8 consecutive years.
7. This scheme encourages schools and colleges to organize sports events and competitions of a high standard.
8. It advertises 20 universities across the nation as a centre for athletic achievement.
9. The program facilitates deprived and poor youth to engage in sports rather than in unproductive work.
10. The scheme covers around 200 million children between 10 to 18 years under a massive National Physical Fitness Drive.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

SHRI RAM COLLEGE ,MUZAFFARNAGAR

DEPARTMENT OF PHYSICAL EDUCATION

Khelo India Programme Project

Session (2023-24)

Event Name	S. No.	NAME OF STUDENT	FATHER NAME
Athletics	1	VANSH BALIYAN	PRAVEEN KUMAR
	2	VANSH CHOUDHARY	VIJAY KUMAR
	3	VANSH PANWAR	JEET SINGH
	4	VARDHAN KUMAR	HARENDRA SINGH
	5	VIKRANT CHAUDHARY	PRAVEEN KUMAR
	6	VINAY	JIRENDER
	7	VINAY KUMAR	KUDERAM
	8	VINAY PARMAR	VICKY PARMAR
	9	VINIT BALIYAN	CHANDRA PAL SINGH
	10	VIRAT BALIYAN	RAKESH KUMAR
	11	VISHAL	CHANURAM
	12	VISHAL KUMAR	AMIT KUMAR
	13	VISHAL SOM	RADHEY SHYAM
	14	YOGENDRA SINGH	VIRENDRA SINGH
	15	VIBHOR CHOUDHARY	SUSHIL KUMAR
	16	VIJYANT RATHI	HARSHDEV RATHI
	17	VIPIN KUMAR	RAM KUMAR
	18	VISHAKHA	SUBHASH
	19	YASH SHANDILYA	VIJAY KUMAR SHARMA
	20	YUVANK	SANJAY CHAUDHARY
	21	YUVRAJ DAHIYA	JITENDRA SINGH
	22	YUVRAJ TYAGI	NEERAJ TYAGI
	23	ROHIT KUMAR	MANGU SINGH
	24	SAGAR	ARUN KUMAR
	25	SAGAR KUMAR	RAM MEHAR
	26	SHEKHAR KUMAR	SATENDRA KUMAR
	27	SHIKHA PANWAR	VINAY PANWAR
	28	SHIKHAR RANA	VISHAL RANA
	29	SHIVAM MALIK	JITENDRA MALIK
	30	SIDDHARTH SAINI	SH. PAWAN KUMAR
	31	SONIYA QURESHI	VAKEEL AHMED
	32	SURAJ RATHI	ANIL KUMAR
	33	TANMYA RATHI	UPENDRA RATHI
	34	TANU	KRISHAN KUMAR
	35	TANUJ KASHYAP	SHIV KUMAR
	36	TUSHAR BALIYAN	SUNIL KUMAR BALIYAN
	37	UDAY PRATAP TYAGI	VINEET TYAGI
	38	UDIT CHAUDHARY	JITENDRA KUMAR
	39	UJJWAL AHLAWAT	ANAND AHLAWAT
	40	UMA	PAPU SHAH
	41	URVASHI	SURAJPAL SINGH
	42	VASU CHAUDHARY	SUNIL KUMAR
	43	VIDHAN DESHWAL	ANIL DESHWAL
	44	VIKRANT CHAUDHARY	PAWAN SINGH
	45	VIKUL CHAUDHARY	MAHIPAL SINGH
	46	VIMAL	OMBEER SINGH
	47	VINIT KATARIYA	MANGAL SINGH
	48	VIPUL RATHI	RAJEEV KUMAR
	49	VISHANK LAMBA	BRIJ BHUSHAN LAMBA
	50	VISHU GANDHRAV	SUNIL KUMAR

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

SHRI RAM COLLEGE ,MUZAFFARNAGAR

DEPARTMENT OF PHYSICAL EDUCATION

Khelo India Programme Project

Session (2023-24)

Event Name	S. No.	NAME OF STUDENT	FATHER NAME
Volleyball	1	YOGESH	GULAB SIMGH
	2	SAURABH	KAILASH CHAND
	3	SAURABH	SUKH PAL SINGH
	4	SAURABH PANWAR	SATYA PRAKASH
	5	SHIVAKAR	RAVINDRA KUMAR
	6	SUBHAM BALIYAN	NARINDER KUMAR
	7	SHUBHAM TANWAR	SANJEEV KUMAR
	8	UMANG CHOUHAN	SANJEEV CHOUHAN
	9	UTKARSH KUMAR	RAKESH KUMAR
	10	VIKAL BALIYAN	VINAY BALIYAN
	11	ZIGYAASU CHOUDHARY	AJAY KUMAR
	12	PRIYANKA RANA	RAJENDRA SINGH RANA
	13	RAKHI KUSHWAHA	ARVIND SINGH
	14	RAVITOSH	VINOD KUMAR
	15	REKHA	SATYAWAN
	16	RESHU ARYA	SATISH ARYA
	17	RISHABH AHALAWAT	ASHOK AHALAWAT
	18	SHAN MOHMAD	NOOR MOHMAD
	19	SHIVAM KUMAR	SUDHIR KUMAR SHARMA
	20	SHRADHA NAMDEV	VINOD KUMAR
	21	SHUBHAM TOMAR	SUSHIL KUMAR
	22	SONU SAINI	ISHWAR SINGH SAINI
	23	VAZID ALI	SAID HASAN
	24	VIKASH YADAV	RAM YADAV
	25	VISHAKHA	TEJINDER
	26	VISHAL KUMAR	DESHVEER SINGH
	27	YASH	SURESH KUMAR
	28	YASH CHOUDHARY	SUBHASH CHOUDHARY
	29	RAHUL KUMAR	BALKISHAN
	30	REENA GUPTA	RAM JIAWAN GUPTA
	31	SANDEEP MOR	JAGBIR SINGH
	32	SAURAV RATHI	Mr RAJENDRA SINGH
	33	SHALU	RAVINDRA
	34	SHASHANK	PRAVEEN TYAGI
	35	JYOTI	GAJPAL
	36	KM PRIYA PAL	RAKESH KUMAR PAL
	37	SHIKHA RANI	Mr MAN SINGH
	38	SHIMANT BISHT	Mr SUNIL KUMAR BISHT
	39	SUBHAM TANWAR	Mr SANJEEV KUMAR
	40	UMANG CHOUHAN	Mr SANJEEV CHOUHAN
	41	VICKEY KUMAR	ABNIKANT SINGH
	42	VIKAL BALIYAN	VINAY BALIYAN
	43	SAURAV RAGHUVANSHI	SATENDRA SINGH
	44	TANU CHOUDHARY	ASHOK KUMAR
	45	VAISHALI BALIYAN	Mr ASHOK KUMAR
	46	VISHAKHA CHAUDHARY	Mr SH. ANANG PAL
	47	MONIKA SAINI	NARENDRA
	48	KM NAINA KASHYAP	SHANKAR LAL
	49	NEELKAMAL	SHAUKINDAR
	50	KM MANSI	KANWARPAL VERMA

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

SHRI RAM COLLEGE ,MUZAFFARNAGAR

DEPARTMENT OF PHYSICAL EDUCATION

Khelo India Programme Project

Session (2023-24)

Event Name	S. No.	NAME OF STUDENT	FATHER NAME
	1	ANKUSH KUMAR	ARJUN SINGH
	2	ABHISHEK	AMIT KUMAR
	3	ADITYA CHOUDHARY	UPENDRA KUMAR
	4	ADITYA SHARMA	DEEPAK SHARMA
	5	AJAY SAINI	RAJPAL SAINI
	6	AKASH DHARIWAL	ROHTASH SINGH
	7	AMAN NISHAD	PATIRAJ NISHAD
	8	ANANT BHATNAGAR	ANIL BHATNAGAR
	9	ANIKET	ASHWANI KUMAR
	10	ANITA	SHRIPAL
	11	ANKIT AARYA	MADAN KUMAR
	12	ANKUSH KUMAR	ARJUN SINGH
	13	ANSH RATHI	RUPAK KUMAR
	14	ANSHIKA SHARMA	RAJNEESH KUMAR
	15	ANUJ DHAKA	Mr LOKENDRA DHAKA
	16	ANUJ KUMAR	Mr RAM PAL SINGH
	17	ANUPAM	SATYADEV
	18	ARNAV BALIYAN	SUNDER PAL
	19	ARSHAD ALI	TANVEER HASAN
	20	ARUN KUMAR	DHARAM PAL SINGH
	21	ARYAN BALIYAN	SANJAYVEER
	22	ARYAN CHOUDHARY	PRDEEP CHOUDHARY
	23	ARYAN DHIMAN	MANOJ KUMAR
	24	ARYAN KUMAR	Mr SANDEEP

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

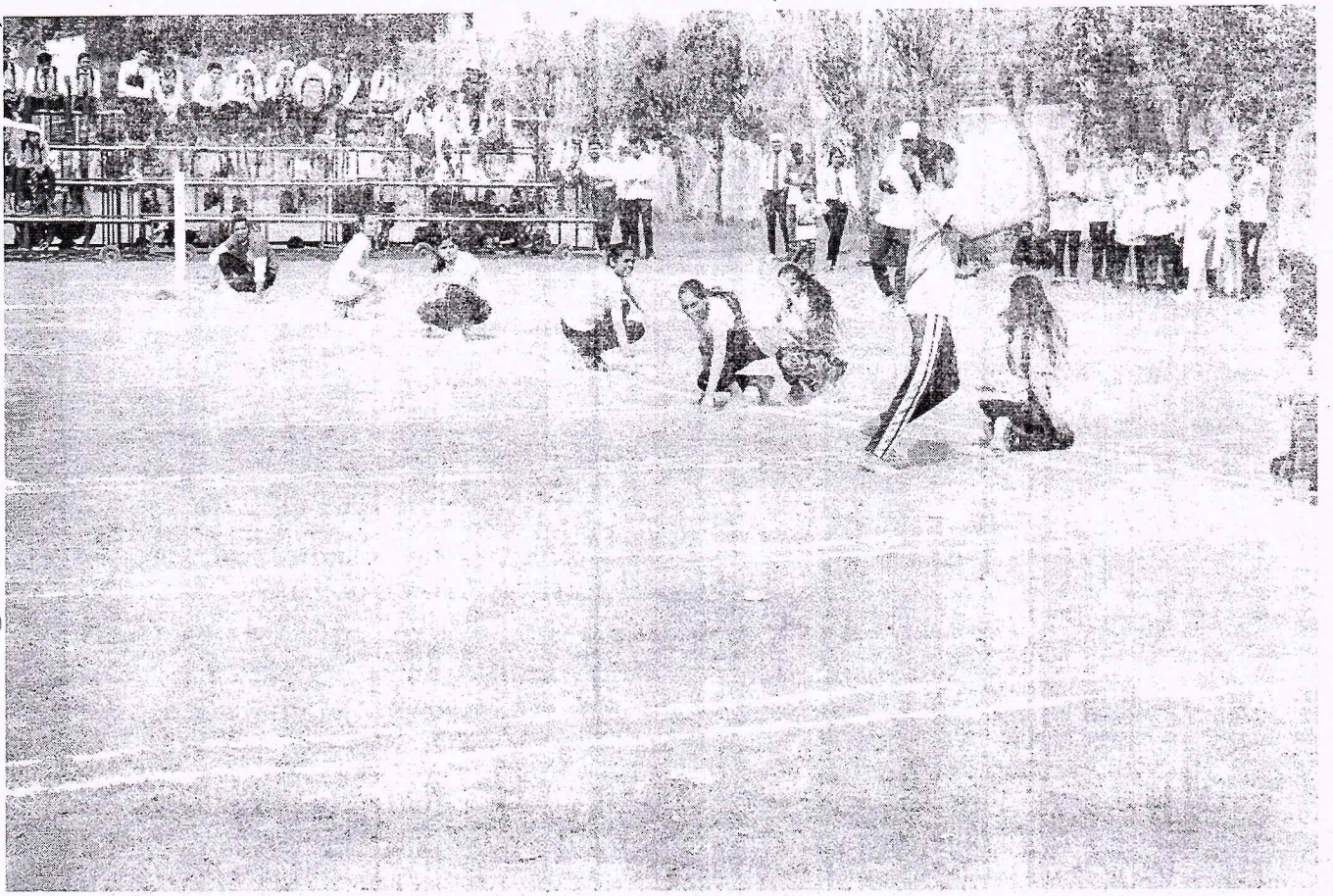
Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Kho-Kho

25	ARYAN TOMAR	Mr PRADEEP KUMAR
26	BOBY	RAM NARAYAN
27	DANISH CHAUDHARYH	SHARAFAT ALI
28	ATHAR RANA	MEHFOOZ RANA
29	AVANTIKA	PANKAJ KUMAR
30	AVI PAL	SUBHASH CHAND
31	AYUSHI	MANOJ KUMAR
32	BHAVYA BAGEL	BANI RAM
33	ABHEET TYAGI	P.K.TYAGI
34	ADARSH	Mr PRAVEEN KUMAR
35	AMANJEET	SUBODH KUMAR
36	ANUPAM CHAUDHARY	SUMAN PAL
37	ASHISH	KALAM SINGH RAMOLA
38	CHANDAN KUMAR	MUSHAFIR RAM
39	CHANDRESH SHARMA	Mr RAJEEV KUMAR SHARMA
40	DEVESH ARYA	Mr BIRMESH ARYA
41	DUSHYANT KUMAR SHARMA	DEVENDRA KUMAR
42	HARSHIT KUMAR	JESHVIR SINGH
43	AAYUSH TALIYAN	RAJIV KUMAR
44	ABHISHEK DHAKA	SANJAY DHAKA
45	ADITYA BHAL	JAIDEEP SINGH
46	AKASH KUMAR SHARMA	HARENDRA SINGH
47	AKSHIT DESHWAL	NEERAJ KUMAR
48	AKSHIT SAHRAWAT	JITENDAR KUMAR
49	AMAN	BABURAM
50	ANIL KUMAR	PATRAM

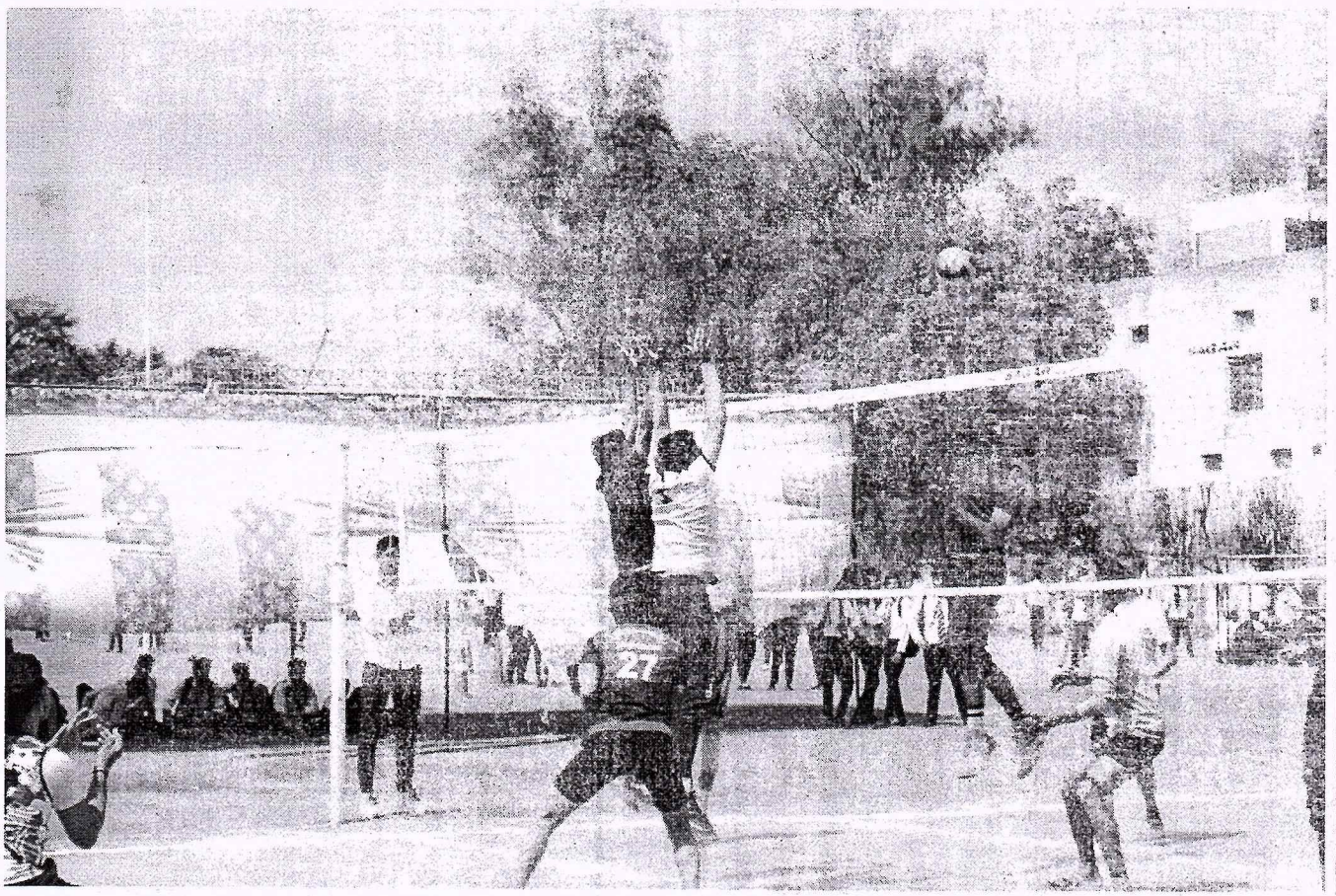
Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

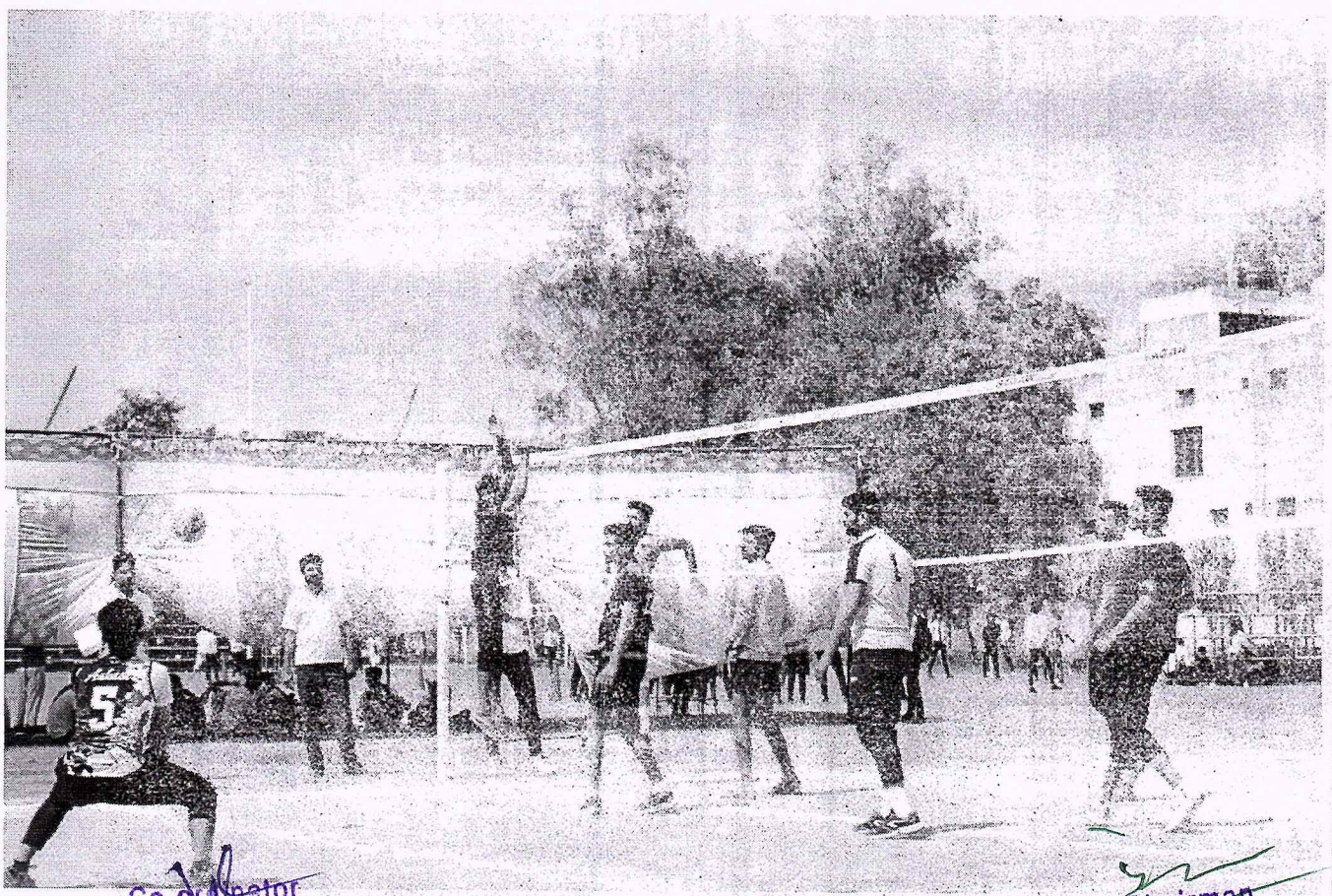
Chairman
IQAC, Shri Ram College,
Muzaffarnagar



Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

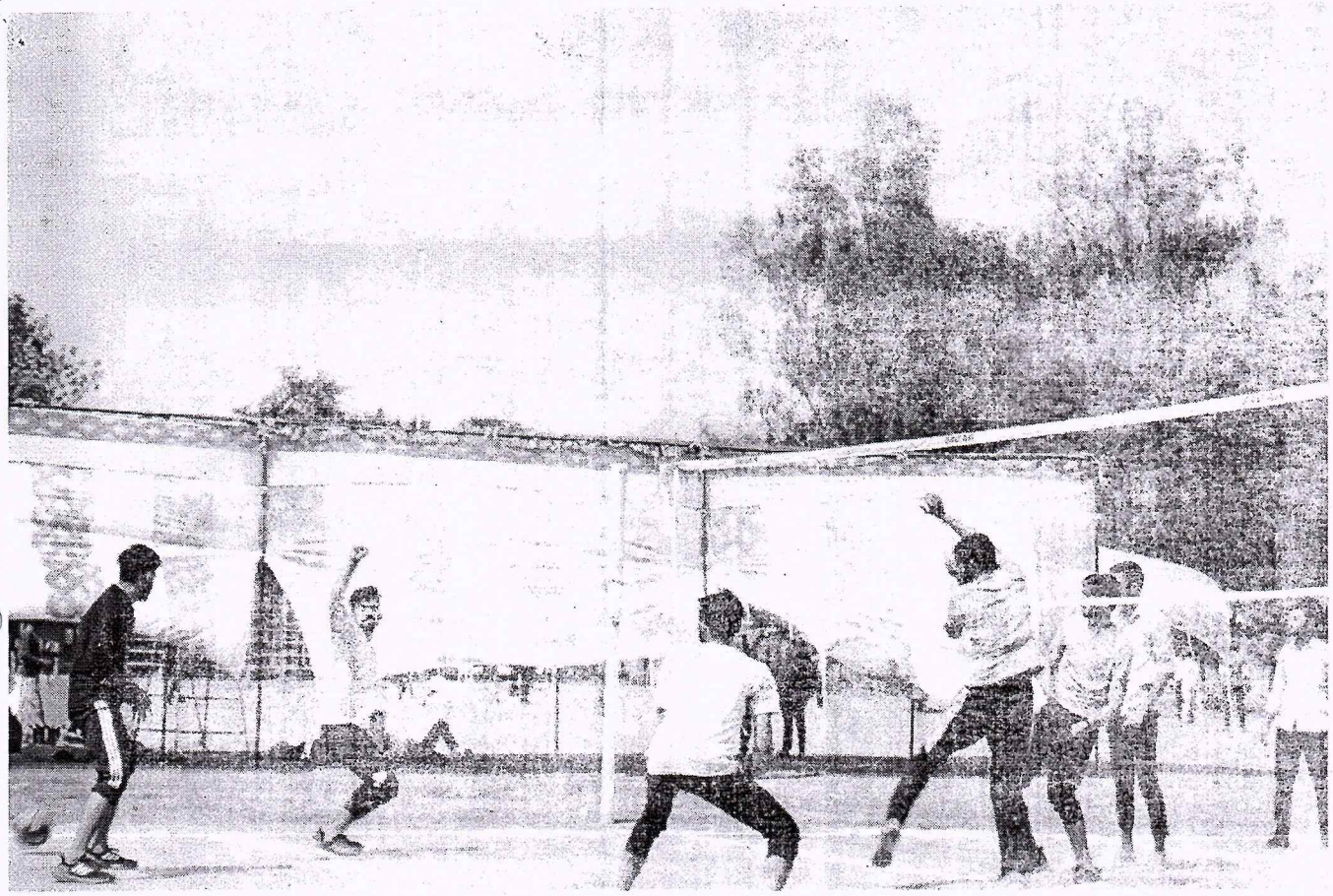
Chairman
IQAC, Shri Ram College,
Muzaffarnagar

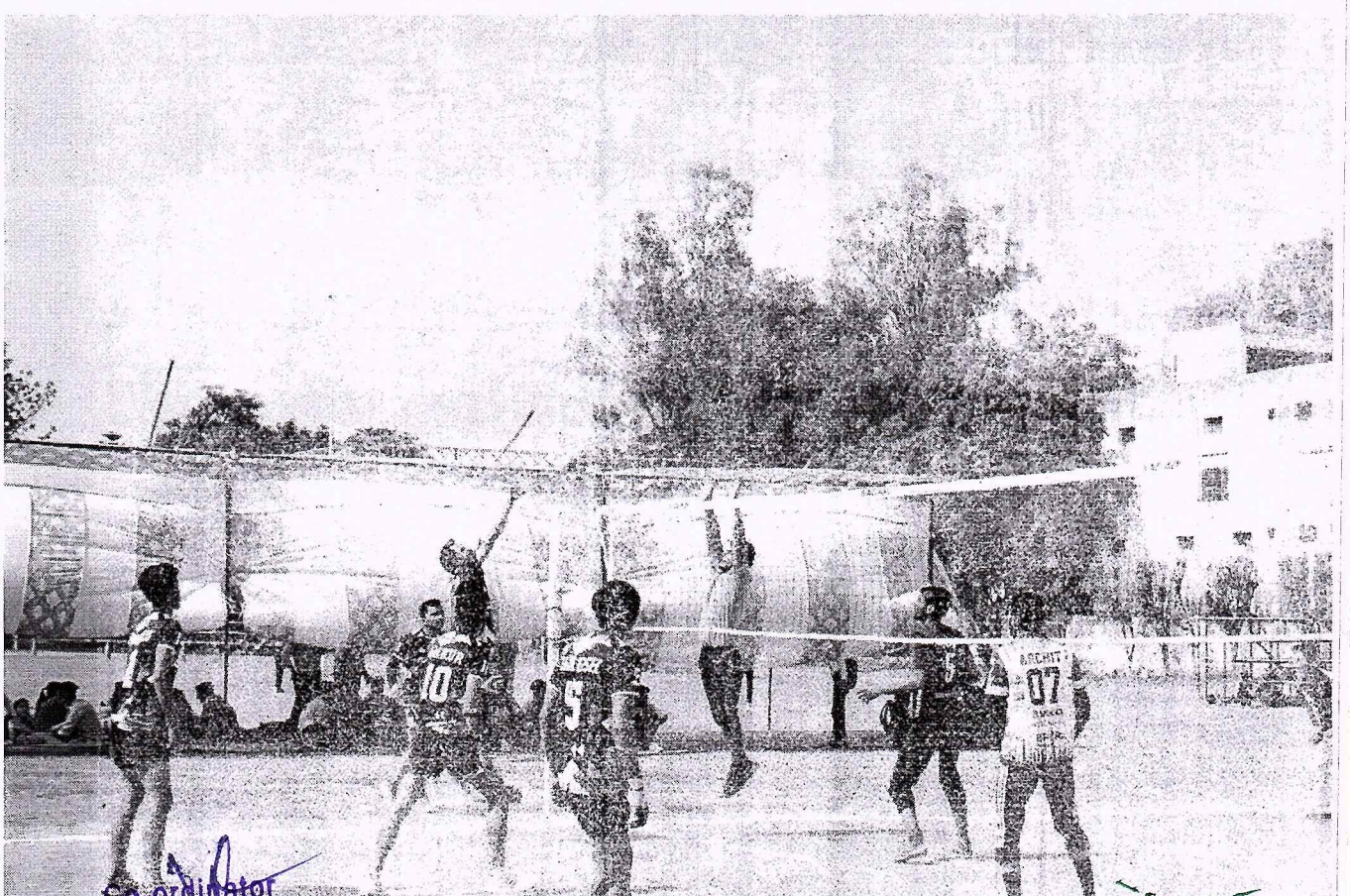




Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar



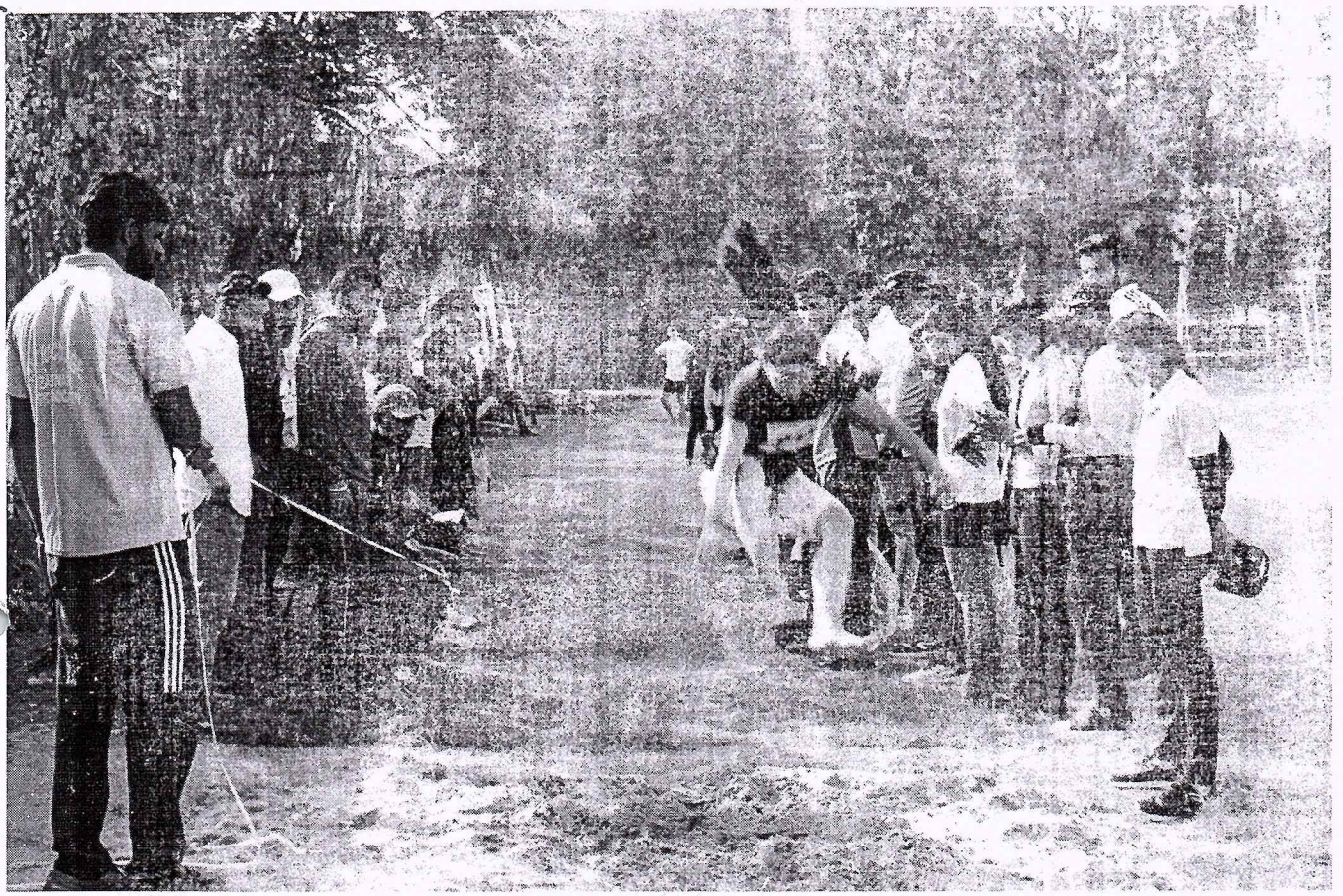


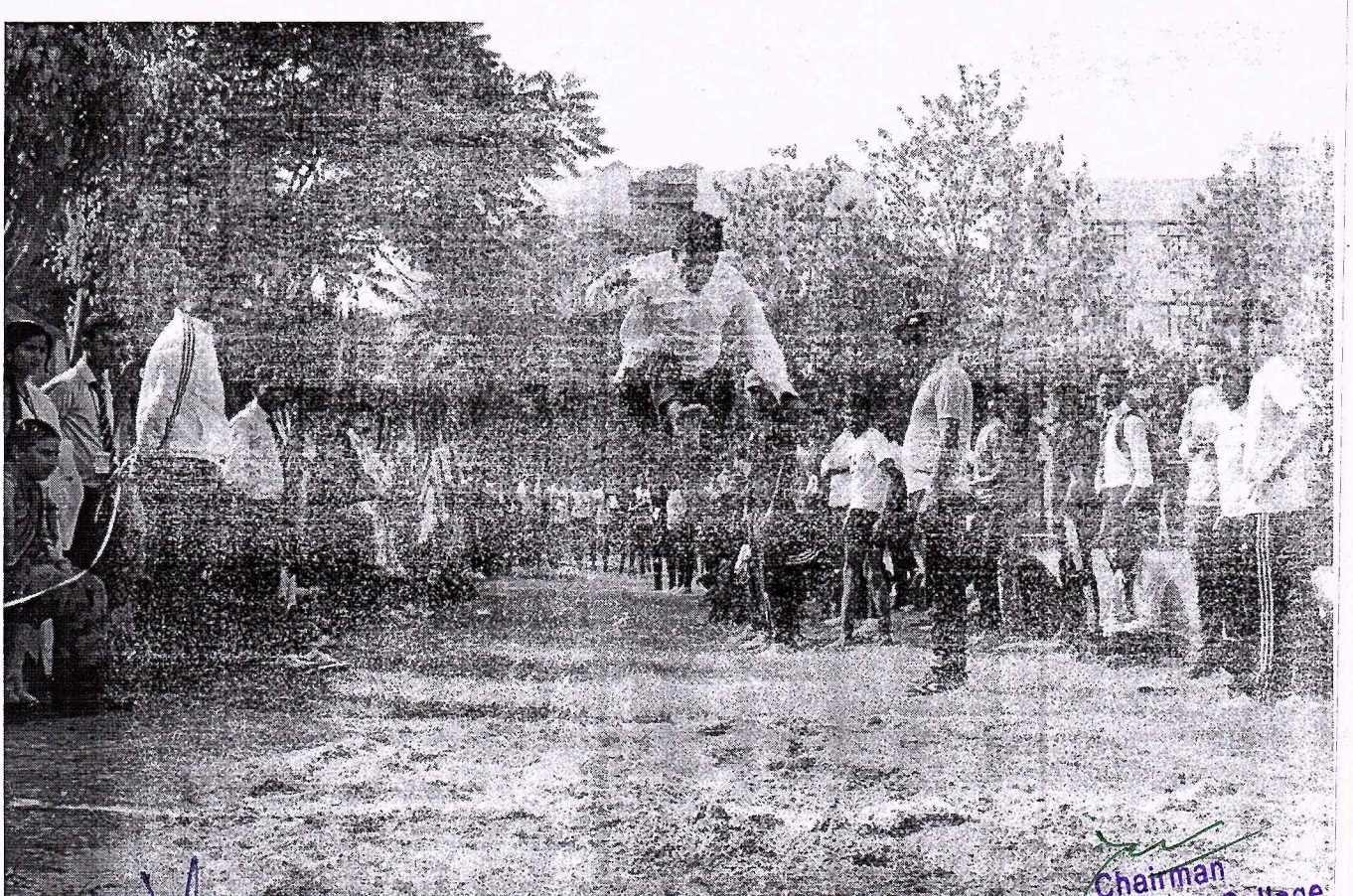
Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar





Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Project Report on Khelo India Programme

Date: 29-06-2024

Shri Ram College, Muzaffarnagar successfully completed an externally funded a one year research project on "khelo India Progrmame" during the session 2023-24. This project was fully funded by Sports: A Way of Life, an NGO with the mission of sports literacy. Mr. Bhupendra Kumar worked as project investigator. In this project Shri Ram College organized mainly three events such as Athletics, Kho-Kho and Volleyball where at least 150 players and 10 coaches participated. The events were scheduled as that throughout the year players remain engaged in the sports activity, which is very beneficial for continuous development of the players as well as the coaches.

First Activity: Athletics

This project started with Athletics which remain the first activity of this project. It is organised during the month September 2023, where 50 players and 04 officials participated for the future of the nation of the sports. This activity was organized under the Head Coach of athletics Dr. Abdul Azeej Khan, Assistant Professor, Shri Ram College, Muzaffarnagar.

Second Activity: Kho-Kho

Next activity of this project was Kho-Kho. It is organised during the month Decemberr 2023, where 50 players and 03 officials participated for the future of the nation of the sports. This activity was organized under the Head Coach of athletics Mr. Bhupendra Kumar, Assistant Professor, Shri Ram College, Muzaffarnagar.

Third Activity: Volleyball

Last activity of this project was Volleyball. It is organised during the month March 2024, where 50 players and 03 officials participated for the future of the nation of the sports. This activity was organized under the Head Coach of athletics Mr. Sandeep Deshwal, Assistant Professor, Shri Ram College, Muzaffarnagar.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

At the end of the project Dr. S C Kulshreshtha, Founder and Charman of Shri Ram Group of the College motivated all students by their experience and praised the Project Investigator Mr. Bhupendra Kumar and all officials for successfully completion of the project.

Following Staff given their valuable time for this project-

- Dr. Pramod Kumar, HOD Physical Education
- Dr. Abdul Azeej Khan, Assistant Professor
- Mr.Bhupendra Kumar, Assistant Professor
- Mr. Prashant Kumar, Assistant Professor
- Mr. Tarun Kumar, Assistant Professor
- Mr. Sandeep Deshwal, Assistant Professor
- Mr. Amardeep Sharma, Assistant Professor
- Mr. Vishwadeep Kaushik, Assistant Professor

Mr. Bhupendra Kumar
Project Investigator

Dr. Prerna Mittal
Principal, Shri Ram College

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Shri Ram College

Approved by UGC, NCTE and Affiliated to MS University, Saharanpur
Muzaffarnagar - 251001, NCR (U.P.)

A++ Grade Accredited by NAAC

To,

Dated:20/7/2023

The Managing Director,
Gulshan Polyols Ltd.,
Muzaffarnagar

Subject: Regarding Seed money grant

Dear Sir,

We are submitting the proposal of the project entitled "**Study of heavy metal concentrations in vegetables obtained from local markets of Muzaffarnagar city** " for seed money grant. The expected total expenditure of the project is Rs.150,000. So, you are requested to grant some seed money amount for the project and the rest of the financial burden will be bear by the institute itself. Proposed work is based on an awareness among the peoples for the heavy metal toxicity present in vegetables due to the polluted water.

Kindly accept our proposal for seed money.

Thanking you

With regards

Dr. Suchitra Tyagi,
(Principal Investigator)
Associate Professor
Chemistry Department,
Shri Ram College, Muzaffarnagar

Attachment: Proposal of the project

Co-ordinator
Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Contact @ 9927028908, 9927011422
Website : www.srgcmzn.com E-Mail : src_mzn@rediffmail.com

"STUDY OF HEAVY METAL CONCENTRATIONS IN VEGETABLES OBTAINED FROM LOCAL MARKETS OF MUZAFFARNAGAR CITY"

A RESEARCH PROJECT PROPOSAL

BY

Dr. Suchitra Tyagi
Shri Ram College, Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Project title- Study of heavy metal concentrations in vegetables obtained from local markets of Muzaffarnagar city

Introduction

Industrialization and population growth has led to an increase in demand for food especially in urban areas. Farmers are under pressure to produce more crops to cater to an ever-increasing population in cities. The vegetable vendors prefer vegetables and especially greens, to be fresh and try to source them from farms located close to the cities and peripheries and usually in polluted areas. Owing to scarcity of water resources, farmers are resorting to irrigate their crops with untreated sewage and effluent. This unethical practice has increased the threat of toxic metal entry into the human bodies through a process called bioaccumulation in crops as well as humans leading to biomagnification.

The present study was conceptualized to estimate the concentration of heavy metals in vegetables obtained from various markets in Muzaffarnagar city. The permissible limits of heavy metals (mg/kg) in vegetables as prescribed by FAO/WHO are; Cadmium - 0.2, Lead - 0.3, Nickel - 67.9, Iron - 425.5, Copper - 73.3, Zinc - 99.4, Chromium - 2.30, Manganese - 500.

Further, to understand the source of vegetables and its contamination in different stores/markets, a detailed study may be proposed. This would help us to reduce the exposure of vegetables to heavy metal contamination at the source and thereby reduce the health risk to humans.

Project Details

Geographical Area to be Studied:

Local market of Muzaffarnagar City

Project Duration: Approx 12 months

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Planned Submission: 12 months		Expected time to complete the project: 12 months											
Project component	Time (e.g. month)	1	2	3	4	5	6	7	8	9	10	11	12
Literature Review													
Data Collection													
Data analysis/ Model development													
Policy Recommendation													
Write up													

Project Objectives:

- To estimate the concentration of heavy metals in vegetables obtained from retail hypermarkets, local markets and organic stores
- To compare the concentration of heavy metals among the vegetable samples from different types of stores.

Expected Expense:

S.No.	Budget Head	Expected Amount
1.	Travel & Meetings	Rs. 10,000
2.	Chemicals and glass wares	Rs. 60,000
3.	Equipments	Rs. 40,000
4.	Miscellaneous expenses	Rs. 20,000
3.	Contingency	Rs. 20,000
Grand Total for the whole project		**Rs.150,000**

Commercial Viability

The proposed work doesn't have any direct role in commercial sector. This is a research and developmental project which will help to improve our knowledge and in future the extension of

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

this work will help in vegetable quality improvement for good health. But some of the viabilities of the project are

- Identification of possible sources of contamination in the vegetables.
- To aware peoples about the disease-causing heavy metals in vegetables.
- Provide suggestions to improve the quality of vegetables

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Registered Office:
9th Km, Jansath Road,
Muzaffarnagar - 251001
Ph.: 0131-3201231
Fax: 0131-2661378

GULSHAN
POLYOLS LIMITED

Ref:

Date: 2/8/23

To,

Dr. Suchitra Tyagi,
Associate Professor
Chemistry Department,
Shri Ram College, Muzaffarnagar.

Subject: Regarding Seed money grant for the project entitled, **"Study of heavy metal concentrations in vegetables obtained from local markets of Muzaffarnagar city "**

Dear Mam,

With reference to your letter dated 20/7/23, we are pleased to inform you that we have accepted your proposal and sanctioning an amount of 1,20,000/- for the project entitled, **"Study of heavy metal concentrations in vegetables obtained from local markets of Muzaffarnagar city "**

Wishing you a good research journey ahead

Thanking you,

Yours faithfully,

C.K. Jain

(The Managing Director),
Gulshan Polyols Ltd.,
Muzaffarnagar

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Shri Ram College
Approved by UGC, NCTE and Affiliated to MS University, Saharanpur
Muzaffarnagar - 251001, NCR (U.P.)
A++ Grade Accredited by NAAC

Dated:10/5/2024

Project Fund Details

1. **Title of Project:**Study of heavy metal concentrations in vegetables obtained from local markets of Muzaffarnagar city.
2. **Principal Investigator**: Dr.Suchitra Tyagi,Associate Professor, Chemistry Department,Shri Ram College, Muzaffarnagar.
3. **Sponsored Body:**Gulshan Polyols Ltd.,Muzaffarnagar.
4. **Sanctioned project amount:**Rs.1,20,000/-
5. **Project Duration:** 10 months
6. **Project Completion date:** 10/5/2024

Statement of Expenditure

Amount Received: Rs. 1,20,000/-

Details of the Expenditure:

1. Local Journey: 10,000/-
2. Equipments:40,000/-
3. Books and Journals:2,500/-
4. Chemicals:36,000/-
5. Glassware: 15,000/-
6. Refreshment: 6,500/-
7. Miscellaneous amount: 10,000/-

Total: Rs. 1,20,000/-

(Dr. Suchitra Tyagi)
Project Investigator

(Dr. Prerna Mittal)
Principal, Shri Ram College

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Contact @ 9927028908, 9927011422
Website : www.srgcmzn.com E-Mail : src_mzn@rediffmail.com

Utilization Certificate

S.N.	Detail of sanction of Fund with Project name and Duration	Amount
1.	10 months project on Study of Heavy Metal Concentrations in In vegetables obtained From local markets Of muzaffarnagar city Date of Sanction of Fund- 02-08-2023 as per Sanction Letter	120000.00 /-
	TOTAL	120000.00/-

It is Certified that out of Rs. 120000.00/- (One Lacs Twenty Thousands only) of grants sanctioned by **Gulshan Polyols Limited** during the year 2023-2024 in favor of **Shri Ram College, Muzaffarnagar,** a sum of Rs. 120000.00 has been utilized for the purpose of the project for which it was sanctioned and that the balance of Rs. **Nil** remaining unutilized at the end of the year has been surrendered. The Extra amount (If any) is met out by Shri Ram College.

2. Certified that we have satisfied our self that the conditions on which the grant was sanctioned have been duly fulfilled/are being fulfilled and that we have exercised the following checks to see that the money was actually utilized for the purpose for which it was sanctioned.

Kinds of checks exercise-

1 Checking of cash book
2 Checking of payment vouchers.
3 Checking of salary register.
4 Checking of expense bill.

For Shri Ram College

Secretary
Date: 17-05-2024
Place: Muzaffarnagar

For Goel Rakesh & Co.
Chartered Accountants

Rakesh Kumar Goel
Proprietor

GOEL RAKESH & CO. CHARTERED ACCOUNTANTS Muzaffar-Nagar (U.P.)

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

"STUDY OF HEAVY METAL CONCENTRATIONS IN VEGETABLES OBTAINED FROM LOCAL MARKETS OF MUZAFFARNAGAR CITY"

A RESEARCH PROJECT

BY

Dr. Suchitra Tyagi
Shri Ram College, Muzaffarnagar

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

SUMMARY

Industrialization and population growth has led to an increase in demand for food especially in urban areas. Farmers are under pressure to produce more crops to cater to an ever-increasing population in cities. The vegetable vendors prefer vegetables and especially greens, to be fresh and try to source them from farms located close to the cities and peripheries and usually in polluted areas. Owing to scarcity of water resources, farmers are resorting to irrigate their crops with untreated sewage and effluent. This unethical practice has increased the threat of toxic metal entry into the human bodies through a process called bioaccumulation in crops as well as humans leading to biomagnification.

The present study was conceptualized to estimate the concentration of heavy metals in vegetables obtained from various markets in Muzaffarnagar city. Samples of vegetables were collected randomly in duplicates from five different Retail A total of ten vegetables namely Brinjal, Tomato, Capsicum, Bean, Carrot, Green Chilly, Onion, Potato, Spinach and Coriander were collected in pairs from each of these markets. Hundred samples were analyzed from each type of store/market (10 vegetables in duplicates = 20 x 5 stores/markets = 100 samples). A total of 400 vegetable samples were collected, processed and digested using pre-automated program in NuWav-Ultra Microwave Digestion Extraction System and analysed for heavy metals content (Cd, CO, Cr, Cu, Fe, Mn, Ni, Pb, and Zn) using Shimadzu Atomic Absorption Spectrophotometer 6300 model. The results are represented as mg/kg dry weight.

The permissible limits of heavy metals (mg/kg) in vegetables as prescribed by FAO/WHO are; Cadmium - 0.2, Lead - 0.3, Nickel - 67.9, Iron - 425.5, Copper - 73.3, Zinc - 99.4, Chromium - 2.30, Manganese - 500. The concentration of heavy metals in vegetables varied in different stores.

Further, to understand the source of vegetables and its contamination in different stores/markets, a detailed study may be proposed. This would help us to reduce the exposure of vegetables to heavy metal contamination at the source and thereby reduce the health risk to humans.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

It is very clear from the present study that the edible portion of the vegetables are hyperaccumulators of heavy metals. So, taking into consideration the health risks associated with consumption of these vegetables, it is suggested that vegetable cultivation should not use waste water as a source. The farmers should be made aware of toxic metal accumulations in greens and vegetables and their imminent threat to consumers. For the farmers who grow food crops, testing of soils and water should be mandated by the concerned regional agricultural department or pollution control board. More particularly, farmers, who grow these crops on either side of highways, must go for soil testing. Farmers should not resort to unethical farming practices such as irrigating the crops with drainage and effluent waters. It is advised to avoid eating spinach bought from the vegetable markets of the Muzaffarnagar. Instead, these greens can be grown organically at home in rooftop gardens, window gardens and balcony gardens. Farmers of the suburban areas should not be allowed by law to grow the greens and vegetables utilizing the drainage and effluent waters. A continuous monitoring is recommended to rule out toxic metal contamination in these greens and vegetables.

INTRODUCTION

Background

Metals are found all over the earth, including the atmosphere, earth crust, and water bodies, and can also accumulate in biological organisms, including plants and animals. Heavy metals have a high specific density and an atomic weight greater than 40.04. They are distributed in the environment by natural processes such as volcanic eruptions, spring waters, erosion, and bacterial activity, as well as by anthropogenic activities such as fossil fuel combustion, industrial processes, agricultural activities, and feeding (Florea et al., 2004). Rapid urbanisation and industrialization have raised heavy metal levels in the environment and, as a result, in the food chain.

Vegetables are a major portion of the human diet, providing micro and macronutrients, fibers, vitamins etc., In addition, a wide range of antioxidants such as ascorbic acid, carotenoids, tocopherols, glutathione, phenolic acids, and flavonoids are found in vegetables (Sara et al, 2005) that are known to have positive effects on human health as they play a crucial role in preventing a number of chronic diseases (Agarwal et al., 2007). Vegetables can grow on all types of land, which is commonly contaminated with heavy metals. Depending on the

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

vegetables, some of them have a greater potential to accumulate higher concentrations of heavy metals than others. That may have an impact on human health by consuming contaminated food. Differential plant tolerance to heavy metals is the cause of the leafy vegetables' varying metal uptake rates (Itanna, 2002). Leafy greens have a higher accumulator of metal ions than root vegetables and legumes (Alexander et al., 2006). Some heavy metals, such as cobalt, chromium, copper, magnesium, iron, molybdenum, manganese, selenium, nickel, and zinc, are essential nutrients that are required for various physiological and biochemical functions in the body and may result in deficiency diseases or syndromes if inadequate amounts but then in large doses they can cause acute or chronic toxicities. Long term accumulation of heavy metals in the body may result in slowing the progression of physical, muscular and neurological degenerative processes that mimic certain diseases such as Parkinson's disease and Alzheimer's disease (Jaishankar et .al, 2014).

Heavy metal contamination is a matter of serious concern in different countries of the world (Khalid et.al. 2021). Linked with environmental pollution, water pollution is also a problem of worldwide concern and ground water is extremely polluted due to unplanned disposal of untreated domestic sewage and industrial effluents into watercourses (Mashiatullah et al., 2005). Long-term irrigation with waste water could result in heavy metal toxicity in agricultural plants and soils. Potential difficulties with food safety are among the most serious issues due to the health dangers in the environment (Cui et al. 2004). A heavy metal is any metallic element that has a relatively high density and is toxic or poisonous even at low concentrations.

The uptake and bioaccumulation of heavy metals in vegetables are influenced by a number of factors such as climate, atmospheric depositions, the concentrations of heavy metals in soil, the nature of soil on which the vegetables are grown and the degree of maturity of the plants at the time of harvest (Lake et al.,

1984; Scott et al., 1996; Voutsa et al., 1996). Air pollution may pose a threat to post-harvest vegetables during transportation and marketing, causing elevated levels of heavy metals in vegetables are reported from the areas having long-term uses of treated or untreated wastewater (Sinha et al., 2005; Sharma et al., 2006, 2007). Other anthropogenic sources of heavy metals include the addition of manures, sewage sludge, fertilizers and pesticides, which may affect the uptake of heavy metals by modifying the physico- chemical properties of the soil such as pH, organic matter and bioavailability of heavy metals in the soil. Whatmuff (2002) and McBride

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

(2003) found that increasing concentrations of heavy metals in soil increased the crop uptake.

Heavy metals are significant environment pollutants and their toxic response is a problem of increasing implication meant for ecological, evolution, nutritional and environmental reasons concern Enhancement of heavy metals concentration in soil can be characteristic to contribution of effluent from waste water treatment structure, mining, industries, power or energy stations and farming of crops (Jaishankar M, et.al 2014). Heavy metals are extremely persistent environmental contaminants. Mostly they are non-thermo degradable as well as non-biodegradable in features therefore readily accumulate to toxic levels (Hazrat Ali, et.al 2019).

Increasing industrialization has been accompanied throughout the world by the extraction and distribution of minera like substances from their normal deposits. Different other pollutants also associated with the environments, due to non-biodegradable nature of metals and they can undertake bio magnifications in living beings (Alengebawy, A et.al 2021). Uptake and accumulation of heavy metals by plants is either via the roots and foliar surfaces. Some other factors which also affect the uptake of metals include soil pH, solubility of metal, soil nature of conductivity, different phases of plant growth and types of plant species. (Alengebawy, A et.al 2021).

Industrial wastewater contains high range of heavy metals that may pollute the environment once it is discharged to the nature. Metals are mostly including like As, Cr, Co, Zn, Al, Cd, Pb, Fe, Ni, Hg and Ag. (Kinuthia et. Al 2020) They are some of the most toxic types of water pollutants" at least 20 metals are considered to be toxic, in addition to approximately half of these metals are emitted to the environment in quantities that are hazardous to the environment, additionally to the health of mankind. Many people could be at hazard of adverse health effects from consuming vegetables developed in contaminated soil areas.

Many investigators have exposed that several vegetables are capable of accumulating rich ranges of metals from the soil or water". Heavy metals are one of a range of significant category of contaminants that can be established on the surface along with in tissues of fresh vegetables. Heavy metals, such as Cd, Cr, Pb. Co and Hg are environmental pollutants, particularly in areas under imitation with wastewater. Contamination of heavy metal in agricultural soils may

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

lead to the disorder of soil functionality and retardation of plant growth and influence the human health from side to side a contaminated food chain"(Kinuthia et. Al 2020). Soils may become contaminated by accumulation of metalloids and heavy metals through emissions from the speedily expanding areas of industries, mine tailings, high metal wastes disposal, leaded gasoline, paints, and application of fertilizers on land, sewage sludge pesticides, wastewater irrigation and residues of coal combustion, petrochemicals spillage, and atmospheric deposition"(Alengebawy, A et.al 2021). Biochemical progressions can assemble to heavy metals so they polluted the water supplies and in directly showed the impact on food chains. Potential soil and water pollutants concern heavy metals are Cu. Cr. Cd. Ni and Pb"..

Toxic impacts of heavy metals

According to scientific evidence, heavy metals are toxic. At a lower range, it plays a vital role in the metabolism of a cellular system, whereas at a higher range, it becomes toxic, and thus these elements are called trace elements. After interacting with water, soil, and air, heavy metals can become highly poisonous, and humans and other living organisms can be exposed to them through the food chain (Jaishankar, M. et.al 2014).

Cadmium (Cd)

Cd is a byproduct of the formation of Zn, and it is a dangerous element because it can be absorbed through the digestive tract, easily cross the placenta during pregnancy, and damage DNA. Cd accumulation at higher concentrations is also subject to the bio remediation phenomena associated with Cd and soil. "Chronic Cd exposure can lead to acute liver and lung toxicity, induce renal toxicity and impair immune system function."

Lead (Pb)

Lead (Pb) is one of a limited class of elements that can be described as purely toxic. Pb spreading has caused extensive environmental pollution in addition to health problems. Pb is a collective toxicant that affects multiple body systems and is found at low levels in the earth's crust. Pb has a number of known levels which have shown significant responses in the body. Studies on animals investigate the mechanism of toxicity of Pb and it is found that there is no evidence shown threshold to exposure". Lead (Pb) can enter your body through breathing Pb-contaminated air. “The toxicity of Pb is monitored in the body system by encephalopathies in

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

the central nervous system (CNS), impacts of Pb on children's behavior, abortion and preterm delivery in women, and alterations in sperm and declination of fertility in men.

Zinc (Zn)

Zinc is an important and necessary element for human nutrition, working as a co-factor for more than 300 enzymes and their activities. Zn is found in all tissues and various functioning enzymes. Zn participates in catalytic functions of enzymes, the maintenance of structural stability and regulatory functions. Zn is also involved in DNA and RNA synthesis and cell proliferation anhydrase activity. The body contains 1.5-2.5g of Zn. Deficiency of Zn affects the reproduction process in both males and females due to the alteration in hormones status and a range of enzymes which involved in reproduction. Large amount of Zn intake reduces Cu and Fe utilization and vitamin A. Zn also accumulated along with Cd with more interaction in plant and in rhizoid bacterial species on the process of metal uptake.

Chromium (Cr)

Chromium (Cr) is mostly found in rocks, soil layers, animals and plants. Cr can be solid, liquid and in the form of gas. Cr compounds are very much persistent in water sediments. They can occur in many different forms such as divalent Cr, tetra valent Cr, penta valent Cr and hexavalent state. Cr (VI) and Cr
(III) are the most stable forms and only their relation to human exposure is of high interest. The Cr supplementation could result in potentiating of insulin sensitivity in the redistribution of body fat, protein and water. Exposure of higher amounts of Cr compounds in humans can lead to the inhibition of erythrocyte glutathione reductase activity directly which in turn lowers the capacity to reduce methemoglobin to hemoglobin. Cd sorption and transport process is easily possible in varieties of soils with different metal contents.

Copper (Cu)

Copper is critical for energy production in the cells. It is also involved in conduction of nerve, connective tissue, the cardiovascular system and the immune system. Cu is closely related to estrogen metabolism, and is required for women's fertility and to maintain pregnancy. The deficiency of Cu effect upon thyroid function, anticipated vascular lesions, central nervous system disorder and convulsion, hair abnormalities. Higher concentration of Cu decreased the

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

hemoglobin and erythrocyte levels, death and cancer". The Cu micronutrient activates the normal plant growth. Cu is strongly bound to soils it is very immobile in nature therefore plant roots are frequently higher in Cu content than other plant tissues. Duration of time and moisture content directly affect to the bioavailability of Cu in the soil.

Iron (Fe)

Iron (Fe) is a trace mineral because body requires in very small amounts. Every tissue in the body and numerous cellular mechanisms need Fe. The metal is a part of hemoglobin in red blood cells that help in the oxygen transport and storage. Fe content is responsible for neurotransmitters functions, hormone synthesis and process of detoxification. Fe causes anemia, shortness of breath, overweight in children and adolescents. High doses of Fe can decrease the absorption of Zn and caused liver cancer and heart disease. Fe is essential for chlorophyll and protein formation, photosynthesis mechanism, electron transfer process, oxidation and reduction of nitrates and sulphate along with the activities of enzymes. Fe is one of the potential nutrients for plant growth and development.

Manganese (Mn)

Manganese is naturally occurring element found in rock, soil, water and food. In humans, manganese is an essential nutrient that plays a role in bone mineralization, protein and energy metabolism, metabolic regulation, cellular protection from damaging free radical species and formation of glycosaminoglycans. Mild or unnoticeable effects may be caused by low but physiologically excessive amounts of manganese and these effects appear to increase in severity as the exposure level or duration of exposure increases. Chronic exposure leads to permanent neurological damage, inability to perform rapid hand movements and some loss of co-ordination and balance. Symptoms of forgetfulness, anxiety or insomnia are also noticed. (www.ncbi.nlm.nih.gov).

Nickel (Ni):

Nickel fumes can irritate the lungs and lead to pneumonitis. In people who are sensitive to nickel and its compounds, exposure to these substances can cause the development of "nickel itch," dermatitis. Itching is typically the initial sign, and it can last for up to 7 days before a skin eruption starts. Erythematous or follicular skin eruption is the initial skin eruption, and

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

skin ulceration may follow. Once developed, nickel sensitivity seems to last forever. Power plants and waste incinerators emit nickel into the air. Once it settles or falls to the ground, raindrop reactions cause it to do so. The removal of nickel from the air typically takes a long period.

LITERATURE REVIEW

Sources of Heavy Metals in Vegetables

Heavy metal contamination of an ecosystem is one of the major and most widely discussed ecotoxicological problems. Some heavy metals (Cu, Fe, Ni, Zn, Mn, etc.) are essential for the growth and development of plants when present in trace amounts, but at excessive concentrations these become toxic. Both natural and anthropogenic sources are responsible for increasing the levels of heavy metals in the environment. Natural sources include parent geologic rock material, volcanic outcropping, spontaneous contributions or forest fires, whereas anthropogenic sources include sew- age sludge, pesticides, organic matter, composts, fertilizer supplements (Lopez-Alonso *et al.* 2000; Singh and Agrawal 2007), industrial waste, mining, smelting and metallurgical industries (Singh 2001) and use of treated or untreated industrial and municipal effluents for irrigation purposes (Barman *et al.* 2000; Singh *et al.* 2004; Mapanda *et al.* 2005; Singh and Kumar 2006; Sharma *et al.* 2006, 2007). In Mexico, mining activities have caused considerable in- crease in concentrations of As, Ni, Co and Cu in the soil (Razo *et al.* 2004). Mining and smelting processes have also contaminated wide areas of Japan, Indonesia and China with Cd, Cu and Zn (Herawati *et al.* 2000). Agricultural practices like the use of pesticides, fungicides and organic and inorganic fertilizers have increased the concentrations of heavy metals (Cd, Ni, Mn, Co and Cu) in the top layer of the soil and consequently in crops via their uptake (McBride 2003).

Aerosols also cause heavy metal contamination of Cd, Pb, Zn, Cr and Ni in soil through atmospheric deposition, which are consequently absorbed and accumulated by plants or get adsorbed on aerial surfaces of the plants (Tem- merman and Hoenig 2004). Energy supplying power stations such as coal burning power plants, petroleum combustion, nuclear power stations and high-tension electric lines also contribute heavy metals (Se, B, Cd, Cu, Zn, Cs and Ni) to the environment (Verkleij 1993). Electricity supply like power lines/cables contributed to 31% of the total antimony, 42% of the total cadmium, 38% of the total cobalt and 43% of

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

the total Hg in ambient air in Australia. Metal ore miningalso contributed substantially to the reported emission of metallic ions such as beryllium (93%), chromium VI (26%), copper (60%), manganese (~100%), and nickel (74%). Sew- age and drainage services in Australian states and territoriescontributed about 32% and hospitals about 36% of the total heavy metal contamination. Petroleum refining was a major contributor of chromium III compound emission (about 85%; NPI 2001). Vegetable-growing areas, mostly situated in or near the smelters such as Boolaroo and Port Kembla, have an elevated risk of potential contamination. These smelters are an important source of Pb pollution which can affect human health (Kachenko and Singh 2006).

Accumulation of Heavy Metals inVegetables

Literature on contamination and accumulation of heavy metals in leafy and non-leafy vegetables from different sources has been widely reported in the past studies by researchers. Concentrations of heavy metals in vegetables varied from below the detection limit to above the safe limits depending upon the sources of heavy metal contamination. Vegetable samples were collected from two different agricultural lands of Greece irrigated by municipal, domestic and some industrial discharges (Stalikas *et al.* 1997). Among all the metals (As, Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb, Se, V and Zn), higher concentrations of Cd, Cu, and Pb (0.043, 2.45, and 0.134 mg kg^{-1}, respectively) were found in Spinach plants than in other leafy and non-leafy vegetables.

Dogheim *et al.* (2004) assessed the heavy metal concentrations in leafy vegetables and some aromatic medicinal plants from local markets of Egypt. Leafy vegetables were found to be contaminated by heavy metals more frequently than other vegetables. Among the total samples about 97% of the leafy vegetables were contaminated with heavy metals and 39% of leafy vegetables exceeded the maximum limits established for Cd, Cu and Pb. Cu was accumulated more frequently in leafy vegetables, being recorded in 97% of the samples. A greater accumulation of heavy metals in the leaves of leafy vegetables may be due to their higher biomass accumulation as compared to other parts such as stem, root and fruits. The higher uptake of heavy metals in leafy vegetables is due to higher transpiration rate of plant to maintain the growth and moisture content of plant (Tani and Barrington 2005).

Atmospheric deposition also contributes to elevating the levels of heavy metals in vegetables.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

In a study done by Jassir *et al.* (2005) the vegetable samples were randomly divided into two fractions. The first fraction was soaked in tap water for 15 minutes to remove the soil impurities, and then washed twice. The second fraction was subjected to digestion without washing and hence labeled as unwashed samples then analyzed the heavy metal concentrations in the edible portions of commonly consumed green leafy vegetables *Coriandrum sativum* (coriander), watercress, parsley, *Portulaca oleracea* (purslane) and lettuce collected from different selling points at Riyadh city in Saudi Arabia before and after washing with tap water. Collectively in all the leafy vegetables the reductions due to washing of the samples were about 41% for Pb, 26% for Cd, 42% for Cu and 24% for Zn. The order of levels for Pb concentration in washed samples from highest to lowest was coriander > lettuce > purslane > watercress > parsley > garden rocket. The concentrations of Cu (20.18 mg kg^{-1}) and Zn (41.93 mg kg^{-1}) were highest in purslane and Cd (0.384 mg kg^{-1}) in garden rocket. Cd accumulation was more in leafy vegetables than in other vegetables.

Singh and Kumar (2006) assessed heavy metal concentrations in vegetables spinach and *Abelmoschus esculentus* L. (lady's finger) grown in peri urban areas of Delhi (India), contaminated with heavy metals through industrial effluents, sewage sludge and vehicular emission. Results showed that the concentrations of heavy metals (mg kg^{-1}) varied from 7 to 50 for Cu, 51 to 282 for Zn, 1.4 to 9.0 for Cd and 1.7 to 9.2 for Pb in spinach and in lady's finger it varied from 12 to 29 for Cu, 39 to 156 for Zn,
0.4 to 6.0 for Cd and 0.8 to 7.3 for Pb. It was further observed that the accumulation of all the heavy metals was higher in *S. oleracea* compared to *A. esculentus*. This difference is due to the physiology and morphology of plants like variation in root interception of metal ions, variation in entry of the metal ions through mass flow and diffusion and translocation of metal ions from the root to shoot, their accumulation tendency and retention capacity (Carlton-Smith and Davis 1983).

The study conducted by Sharma *et al.* (2006) in suburban areas of Varanasi, India, where the use of treated and untreated wastewater is one of the most common agronomic practices, showed that the concentration of heavy metals (mg kg^{-1}) in the edible portion of vegetables including *Spinacia oleracea* (palak), lady's finger, *Solanum melongena* (brinjal), amaranthus, *Lycopersicon esculentus* (tomato) and cabbage collected in late autumn ranged between 0.55 and 10.30 for Cu, 29.35 and 469.45 for Zn, 1.55 and 6.90 for Cd, 9.00 and 28.0 for Pb, 4.05

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

and 15.0 for Ni, and 2.75 and 51.15 for Cr. Palak accumulated more Cu, Cr, Pb, Ni and C d than amaranthus and cabbage. Among different metals, Cu and Cr concentrations were found to be higher in leafy vegetables (Palak, Amaranthus and Cabbage) than in non- leafy vegetables (brinjal, lady's finger and tomato). In the edible portion of palak, the concentrations of heavy metals (mg kg^{-1}) varied from 10.95 to 28.58 for Cu, 2.22 to 41.51 for Zn, 0.5 to 4.36 for Cd, 3.09 to 15.74 for Pb, 1.81 to 7.57 for Ni and 5.37 to 27.83 for Cr. The study showed that Zn, Cr and Mn concentration in plants are influenced by seasonal variations. At the Dinapur site of Varanasi the concentration of Cd (4.2 mg kg^{-1}), Zn (29 mg kg^{-1}) Cr (18 mg kg^{-1}) and Mn (125 mg kg^{-1}) were found to be higher during summer and Cu (16.5 mg kg^{-1}), Pb (16.0 mg kg^{-1}), and Ni (7.5 mg kg^{-1}) during winter (Sharma *et al.* 2007). Due to high decomposition rate of organic matter during the summer season there is more release of heavy metals in soil solution for uptake by plants (McGrath *et al.* 1994).

Intawongse and Dean (2006) analyzed heavy metal concentrations in lettuce, spinach, *Raphanus sativus* (radish) and *Daucus carota* (carrot) grown in compost containing soil through batch culture. The study showed that the accumulation of Cd, Zn, Mn was higher in the leafyportion than in the root portion of the plants. The concentrations of heavy metals (mg kg^{-1}) ranged, respectively for Cu, Pb and Zn from 12.8 to 274.9, 1.2 to 4.9 and 73.9 to 2611, respectively in lettuce and from 25.8 to 182.4, 0.9
to 16.3 and 137.4 to 1351, respectively in spinach.

Liu *et al.* (2006) analyzed the concentrations of metals in 23 vegetable species from agricultural soil of four sampling sites located in the suburb of Zhengzhou city, Henan Province, China. Maximum concentration of Cd (0.20 mg kg^{-1}) was recorded in radish leaves and in *Brassica compestris* L. spp. Pekinensis (Lour) Olsson (Chinese cabbage) (0.2 mg kg^{-1}) followed by radish leaves (0.18 mg kg^{-1}). Mohamed *et al.* (2003) collected 15 different species of vegetables including cucumber, *Cucurbita pepo* (vegetable marrow), tomato, *Solanum tuberosum* (potato), green pepper, *Solanum melon- gena* (eggplant), carrot, *Petroselinum crispum* (parsley), lettuce, spinach, *Allium cepa* (onion), *Allium porrum* (leek), *Nasturtium officinales* (watercress) and cabbage from Al-Taif district of Saudi Arabia. Results showed that concentra tions (ppm) of Cd (1.22), Ni (42.62) and Zn (105.2) were highest in the watercress and of Cu and Pb were highest in vegetable marrow (5.71 ppm) respectively. Among different vegetables watercress showed higher element concentrations than other vegetables. The

Co-Ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

variations in concentrations of heavy metals between test vegetables were d u e to the differences in the metal selectivity and their accumula- tion tendency in vegetables from soil solution.

Demirezen and Aksoy (2006) found that the levels of heavy metals such as Cd, Pb, Cu and Ni in vegetables like cucumber, tomato, green pepper, lettuce, parsley, onion, bean, eggplant, peppermint, pumpkin and okra obtained from urban areas affected from municipal, domestic, traffic and some industrial discharges were higher than those of the rural areas affected by traffic and industrial activities except Zn having higher concentration in rural areas of Turkey. Concentrations of heavy metals (mg kg^{-1}) in vegetables like cucumber, tomato, green pepper, lettuce, parsley, onion, bean, eggplant, peppermint, pumpkin and okra collected from urban areas of Kayseri ranged from 0.34 to 0.97 for Cd, 5.3 to 10.7 for Pb, 32.6 to 76.5 for Cu, 1.8 to 13.45 for Ni and 3.56 to 39.5 for Zn, whereas in rural areas the concentrations ranged from 0.24 to 0.63 for Cd, 3.00 to 8.00 for Pb, 22.19 to 60.40 for Cu, 0.44 to 4.10 for Ni and 47.13 to 259.20 for Zn (Demirezen and Aksoy,2006). The results showed that peppermint had the ability to accumulate more concentration of Cd, Cu, Pb, and Ni than other vegetables. Enhanced levels of heavy metals observed in vegetables showed a direct correlation with the concentrations of metals in the soil.

A market-based study was conducted by Radwan and Salama (2006) to assess the atmospheric deposition of heavy metals in fruits and vegetables sold in Egyptian markets. The average concentrations of metals ranged from0.01 to 0.87, 0.01 to 0.15, 0.83 to 18.3 and 1.36 to 20.9 mg kg^{-1} for Pb, Cd, Cu and Zn, respectively. Among all the vegetables, leafy vegetables, lettuce and spinach accumulated highest concentrations of Pb and Cd.

Varalakshmi et al., (2010) assessed the concentration of heavy metals of vegetables grown in wastewaters from four water bodies viz, Bellandur, Varthur, Byramangala and Nagavara. Analysis revealed high concentrations of Cd and Cr in waters of all the tanks, exceeding the recommended levels. Concentration of Cd was highest in waters of Bellandur and concentration of Cr was highest in waters of Byramangala tank. Among the different tanks, Bellandur and Varthur were found to be highly contaminated with Cd, Pb and Ni. The Cd and Pb contents were highest in the vegetables near Varthur and Bellandur tanks, while Cr was highest in vegetables near Byramangala. Among all the vegetables, Amaranthus and palak, accumulated higher concentrations of heavy metals followed by carrot and radish. The Cd

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

concentration of all the vegetables grown near Varthur and Bellandur tanks exceeded the PFA safe limit. Pb and Ni concentrations exceeded the safe limits in all the vegetables.

Eight agriculture and vegetable samples each used for commercial consumption, which were irrigated by waste-water and tube-well water in the Lahore district were considered for analysis of metals such as, i.e., Fe, Na, K, Mg and Ca. The metal concentration in vegetables and soil irrigated with tube-well water was less than the soil and vegetables grown using waste-water. The concentration in leafy vegetables was higher as compared to non-leafy vegetables. Heavy metal concentration in vegetables irrigated by wastewater was observed as K > Na > Ca > Mg > Fe, while in vegetables irrigated by tube-well water, a trend was observed as K > Ca > Na > Mg > Fe (Ghosh et al.,2011).

Seid-mohammadi et al. (2013) estimated the concentration of heavy metals in vegetables that are irrigated by using contaminated water compared with those irrigated with fresh water in Hamadan, west of Iran in 2012. The mean concentration of Pb, Cr, and Cd, regardless of the kind of vegetables irrigated with contaminated water, was 6.24, 1.57, and 0.15 mg/kg, respectively. Because of tolerability, the uptake of metal concentration by the vegetables differed from one another. The higher concentration of the heavy metals in vegetables is due to the use of untreated sanitary and industrial wastewater by the farmers for the irrigation of vegetables.

Green leafy vegetables such as Spinach, Fenugreek, Amaranthus collected from agricultural fields across Vrishabhavathi river at five different stations were analysed for heavy metals Fe, Zn, Cd, Cr, Cu, Mn, and Pb. The results show higher concentration of iron content in plants followed by manganese. Chromium content is lower in leafy vegetable species. Spinach has higher transfer factor for the heavy metals among the three leafy vegetables followed by Fenugreek and Amaranthus. Highest transfer factor is recorded for zinc followed by manganese. Lowest transfer factor is recorded for chromium and lead. The average transfer factor observed in the selected green leafy vegetables is in the order of Zn>Mn>Fe>Cu>Ni>Pb>Cr Jayadev et al (2013).

Swapna Priya et al. (2014) estimated the heavy metals in leafy vegetables from surroundings of Musi River (Hyderabad, Andhra Pradesh) which is polluted with sewage, domestic effluents and industrial wastes flows. The leaf samples were analyzed for the heavy metals namely Cu,

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Zn, Pb, Fe, Cd and Mn. The extent of heavy metal contaminations was investigated in three leafy vegetables viz., Palak (*Beta vulgaris*), Thotakura (*Amaranthus*) and Chukkakura (*Rumex* sp.), soil and water of Musi River. Results showed that, leafy vegetable Chukkakura had the highest metal load followed by Palak and Thotakura.

A study focused on the concentration of heavy metals (Cr, Co, Cd and Pb) in vegetables (Cabbage, potato, and khat) of eastern Ethiopia cultivated through wastewater irrigation. The findings revealed that, apart from Co, all metal concentrations in the vegetables were found to be above the safe limits that various international organizations for consumption, causing a significant health risk to humans. As a result, frequent monitoring of effluents, soils, and vegetables is essential for preventing toxic heavy metal build up in food (Deribachew et al., 2015).

A comparative analysis of heavy metals in *Brassica campestris* and *Raphanus sativus* irrigated with municipal waste water of Sargodha city was carried out. Vegetable samples collected from three experimental sites i.e, Bhalwal Road, Ajnala Road and Faisalabad Road were selected for analysis of heavy metals such as Cu, Cr, Pb, Cd, Ni, Zn, Co, Ar, Mn, Fe, Mg and Mo. The leaves of *Brassica campestis* accumulated higher concentration of heavy metals at three different growth stages while the roots of *Raphanus sativus* have least significant lower concentration of heavy metals. The field experimental data showed that due to sewage application, Zn content was much higher in leaves of *Brassica campestris*. Cadmium accumulation in the vegetables irrigated with sewage water was also much higher. Nickel showed the similar trend for its accumulation in the vegetables (Imran Khan et al.,2016).

A study assessed the heavy metal concentration in vegetables (swiss chard, lettuce, cabbage, collard green, tomato, green pepper, and carrot) irrigated with wastewater in Gamo, Ethiopia. The study revealed that the mean levels of Cd in most vegetables and Cr and Pb in some vegetables were higher than the maximum recommended limits set by the World Health Organization/Food and Agriculture Organization, 2001. Among the vegetables, cabbage had the highest heavy metal content followed by Swiss-chard, carrot, tomato, collard green, green pepper, and lettuce. The study recommended regular monitoring of heavy metal content in vegetables to prevent their excessive accumulation in food chains (Feseha et.al., 2021).

Abrham and Gholap (2021) assessed the heavy metal levels in water, soil, and vegetables

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

(swiss chard, lettuce, cabbage, collard green, tomato, green pepper and carrot) irrigated with waste water in Gamo, Ethiopia. The samples of soils, water, and vegetables were randomly collected, processed, and analyzed for heavy metals using atomic absorption spectrophotometry. The results obtained show that the irrigational water is profoundly contaminated with heavy metals Cd, Cr and Ni and Pb, Zn and Cu had the lowest concentration in irrigation water. The levels of Cd in Kulfo river area and Chamo Lake area and Ni in most of the farm soils were also found to be higher than the guideline values. The study also revealed that the mean levels of Cd in most vegetables and Cr and Pb in some vegetables were higher than the maximum recommended limits set by WHO/FAO. Cabbage was maximally contaminated with potential toxic elements followed by Swiss-chard, carrot, tomato, collard green, green pepper and lettuce. Hence, from Kulfo river area frequent consumption of cabbage and Swiss chard may cause serious health risks to consumers.

OBJECTIVE

- To estimate the concentration of heavy metals in vegetables obtained from retail hypermarkets, local markets and organic stores
- To compare the concentration of heavy metals among the vegetable samples from different types of stores.

MATERIALS AND METHODS

Experimental Area

The vegetable samples have been collected from different retail markets, local markets, and organic stores of Muzaffarnagar.

Collection and preservation of vegetable samples

Samples of vegetables were collected randomly in duplicates from different retail markets, local markets and organic stores. A total of ten vegetables namely Brinjal, Tomato, Capsicum, Bean, Carrot, Green Chilly, Onion, Potato, Spinach and Coriander were collected in pairs from each of these markets. Hundred samples were analyzed from each type of store/market (10 vegetables in duplicates = 20 x 5 stores/markets = 100 samples). Therefore, a total of 400 vegetable samples were collected and analyzed for heavy metal content.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Vegetable samples from the aforesaid stores were randomly collected in duplicate and were properly sealed in labelled, fresh and sterile zip - lock bags and brought back to the laboratory in ice chest and kept at 4°C for further processing.

Preparation, digestion and analysis of vegetable samples

Prior to analysis, the vegetable samples are pre-processed. The vegetables are washed in tap and distilled water and are air dried for a period of 24 hours. The dried sample is cut with stainless steel knife into small pieces, followed by drying in hot air over for 48 hours at 80^0C. The dried samples are ground to the powder form and sieved through a 0.2 mm sieve to obtain fine powder and stored in butter paper until further processing.

Table: Scientific names of vegetables along with their family

Vegetable name	Botanical/Scientific name	Family
Carrot	*Daucus carota subsp. sativus*	Apiaceae
Green Chilli	*Capsicum spp.*	Solanaceae
Common bean	*Phaseolus vulgaris*	Fabaceae (Leguminosae)
Coriander	*Coriandrum sativum*	Apiaceae (Umbelliferae)
Brinjal	*Solanum melongena*	Solanaceae
Onion	*Allium cepa*	Amaryllidaceae
Potato	*Solanum tubersum*	Solanaceae
Spinach	*Spinacia oleracea*	Amaranthaceae
Tomato	*Solanum lycopersicum L.*	Solanaceae
Capsicum	*Capsicum frutescens*	Solanaceae

The vegetable samples were digested using a high-performance microwave assisted digestion. About 0.2g of powdered vegetable sample was mixed with 11ml HNO_3, 2.2ml H_2SO_4, and 2.2 ml of $HClO_4$ using a pre-automated program in NuWav-Ultra Microwave Digestion Extraction System. The pre-automated program designed for digestion is as follows:

a.10 minutes at 130°C at 400W power

b. 5 minutes at 150°C at 400W power

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

c.10 minutes at 180°C at 500W power

The digested solution was then left for automatic ventilation for 10 minutes and the temperature was allowed to cool down to 50°C. After cooling, the sample was filtered through Whatman filter paper No. 40. The filtered sample was made up to 100 ml volume with metal-free distilled water and stored in a PPE bottles ready for analysis.

A Shimadzu Atomic Absorption Spectrophotometer 6300 model with air-acetylene flame of an average fuel flow rate between 0.8 and 4.0 L/min, and the support gas flow rate AAS were of Hamamatsu

Photonics Co. Ltd., L2433 was used for the analysis. The standard references for the given metals were procured from Inorganic Ventures Inc. and Sisco Research Laboratories, Mumbai Ltd. between 13.5 and 17.5 L/min was used. The single element hollow cathode lamps used in Calibration curves for various elements obtained from these standards were of first order reaction. The vegetable samples were analyzed for heavy metals namely Cd, Cr, Cu, Fe, Mn, Ni, Pb, and Zn. The results are represented as mg/kg dry weight.

Table: FAO/WHO maximum permissible values for metals in vegetables (mg/kg)

Metals	FAO/WHO maximum permissible limit (mg/kg)
Cd	0.2
Pb	0.3
Ni	67.9
Fe	425.5
Cu	73.3
Zn	99.4
Mn	500
Cr	2.30

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

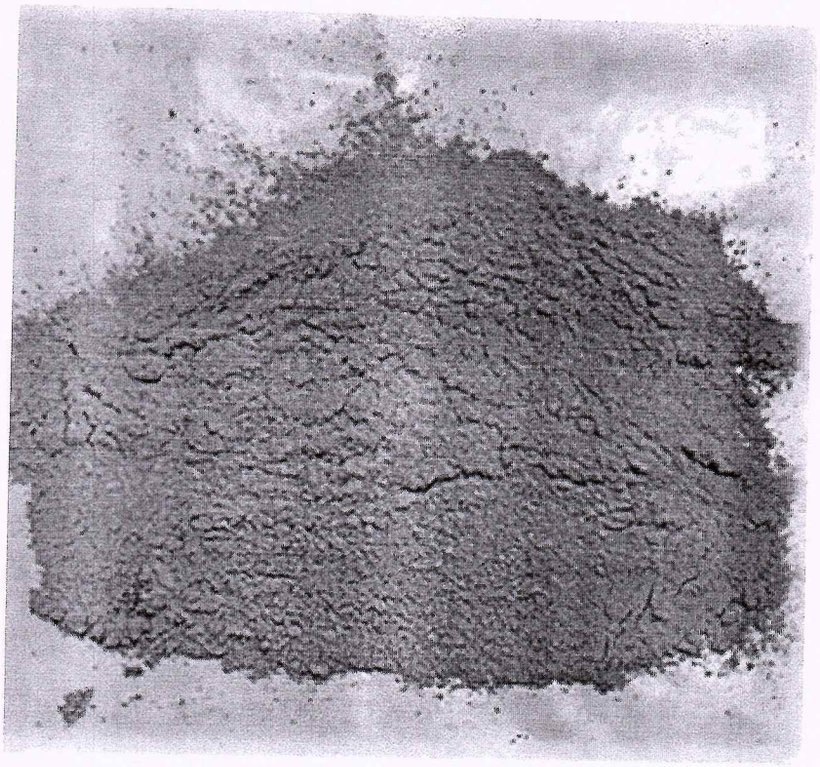
Photographs showing the collection, processing and analysis of vegetable samples

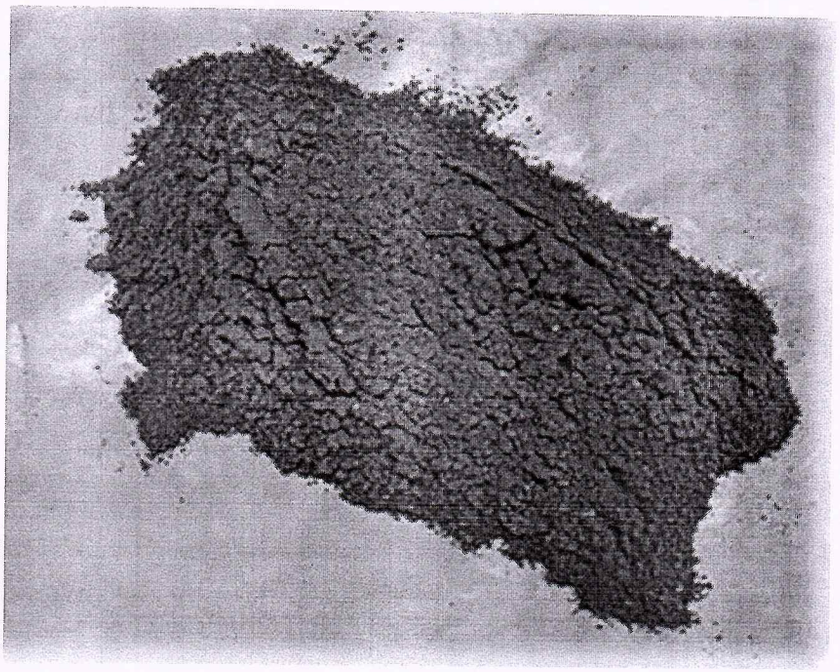
Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College
Muzaffarnagar

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar





Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

RESULTS & DISCUSSION

Samples of vegetables were collected randomly in duplicates from different Retail Markets, Local Markets and Organic Stores. A total of ten vegetables namely Brinjal, Tomato, Capsicum, Bean, Carrot, Green Chilly, Onion, Potato, Spinach and Coriander were collected in pairs from each of these markets. Hundred samples were analyzed from each type of store/market (10 vegetables in duplicates = 20 x 5 stores/markets = 100 samples). Therefore, a total of 400 vegetable samples were collected and analyzed for heavy metal concentration.

Table 1: Concentration of heavy metals in vegetable samples collected from Sabzi Mandi, Bhagat Singh Road of Muzaffarnagar city

Vegetables	Heavy metals(mg/kg)							
	Fe	Zn	Cr	Mn	Pb	Cu	Ni	Cd
Brinjal	38.70	32.20	150.80	181.80	BDL	15.00	77.3*	52.30*
Coriander	144.90	48.80	136.00	499.60		29.50	88.3*	53.30*
Spinach	216.20	49.70	157.50	242.90		8.70	71.8*	53.50*
Capsicum	55.00	53.60	152.30	180.80		6.60	67.60	53.80*
Green Chilly	49.20	44.10	160.40	189.10		8.70	76.6*	53.70*
Onion	185.90	23.40	182.60	159.70		10.10	97*	54.60*
Carrot	210.10	78.60	204.80	171.10		8.20	98.3*	54.60*
Potato	178.50	53.00	203.30	170.00		12.00	95.5*	54.30*
Tomato	174.10	38.90	214.40	161.60		9.20	84.1*	54.30*
Beans	161.20	317.10*	210.00	174.70	12.20	9.90	98.50	52.10*
Maximum	216.20	317.10	214.40	499.60	12.20	29.50	98.50	54.60
Minimum	38.70	23.40	136.00	159.70	-	6.60	67.60	52.10
Average	141.38	73.94	177.21	213.13	-	11.79	83.05	53.65
Standard Deviation	216.20	86.69	214.40	499.60	-	6.63	21.85	54.60
No. of samples above safe limit	0	1	-	0	-	0	8	10

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Table 2: Concentration of heavy metals in vegetable samples collected from Mimlana road of Muzaffarnagar city

Vegetables	Heavy metals(mg/kg)							
	Fe	Zn	Cr	Mn	Pb	Cu	Ni	Cd
Brinjal	151.33	BDL	270.65	143.85	BDL	2.63	53.13	45.97*
Coriander	514.05	16.65	262.53	184.73		9.8	64.38	46.52*
Spinach	401.15	26.28	244.03	248.33		9.98	79.35*	47.82*
Capsicum	237.73	24.80	213.73	148.91		9.45	76.85*	47.32*
Green Chilly	193.65	16.28	186.35	149.13		11.55	78.35*	48.82*
Onion	193.98	21.35	187.08	149.35		6.13	86.32*	48.75*
Carrot	153.13	44.78	189.30	143.48		8.4	96.30*	49.95*
Potato	250.60	35.98	170.83	147.95		7.88	93.30*	49.70*
Tomato	229.35	27.48	174.50	149.25		7.53	74.85*	51.22*
Beans	240.95	53.13	173.78	165.70		7.88	78.85*	51.97*
Maximum	514.05	53.13	270.65	248.33	-	11.55	96.30	51.97
Minimum	151.33	BDL	170.83	143.48	-	2.63	53.13	45.97
Average	269.27	25.88	209.52	168.54	-	7.95	77.59	48.83
Standard Deviation	114.62	16.10	36.27	32.49	-	2.46	12.72	1.96
No. of Samples above safe limit	0	0	-	0	0	0	8	10

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

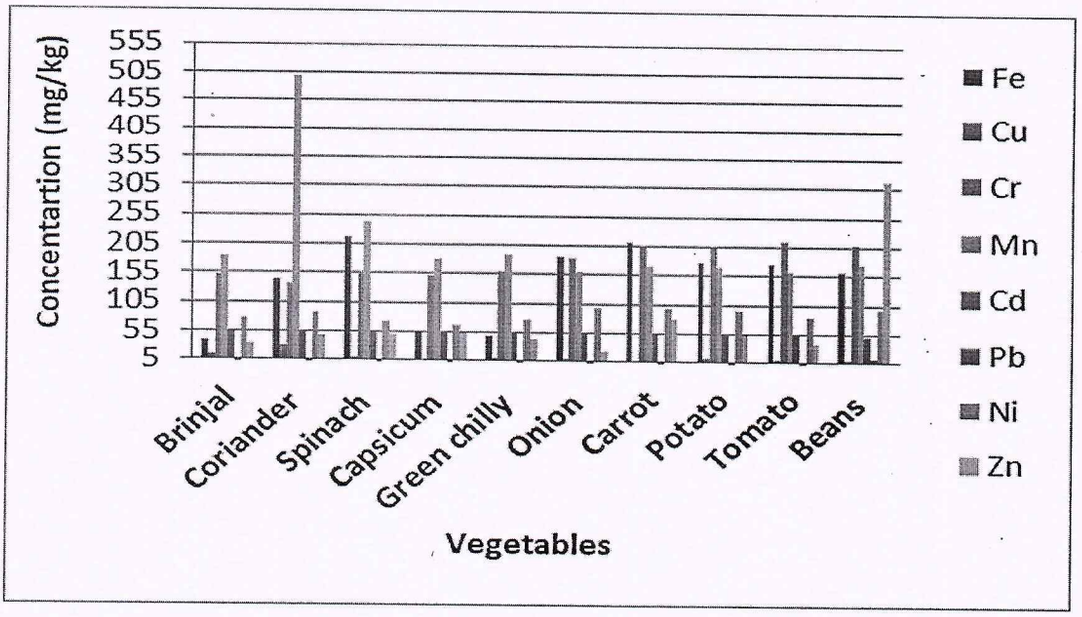


Table 3: Concentration of heavy metals in vegetable samples collected from Kukda Mandi of Muzaffarnagar city

Vegetables	Heavy metals (mg/kg)							
	Fe	Zn	Cr	Mn	Pb	Cu	Ni	Cd
Brinjal	78.50	BDL	422.23	148.30	BDL	BDL	3.00	30.60*
Coriander	194.60		400.05	186.28		BDL	35.43	30.90*
Spinach	257.33		421.53	238.10		4.73	32.93	32.55*
Capsicum	85.23		421.50	152.75		BDL	14.73	32.33*
Green Chilly	83.33		413.38	160.88		4.58	22.95	34.83*
Onion	57.25		371.23	155.13		BDL	46.40	35.83*
Carrot	140.25		380.10	158.90		BDL	36.45	38.95*
Potato	161.15		343.88	159.23		1.23	61.88	38.80*
Tomato	57.90		320.93	158.65		1.23	55.65	41.35*
Beans	90.73		271.40	182.03		1.40	47.65	45.40*
Maximum	257.33	-	422.23	238.10	-	4.73	61.88	45.40
Minimum	57.25	-	271.40	148.30	-	BDL	3.00	30.60
Average	126.74	-	371.65	173.89	-	-	35.16	36.46

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Standard Deviation	66.21	-	50.88	26.85	-	3.34	18.32	4.89
No. of Samples above safe limit	0	0	-	0	0	0	0	10

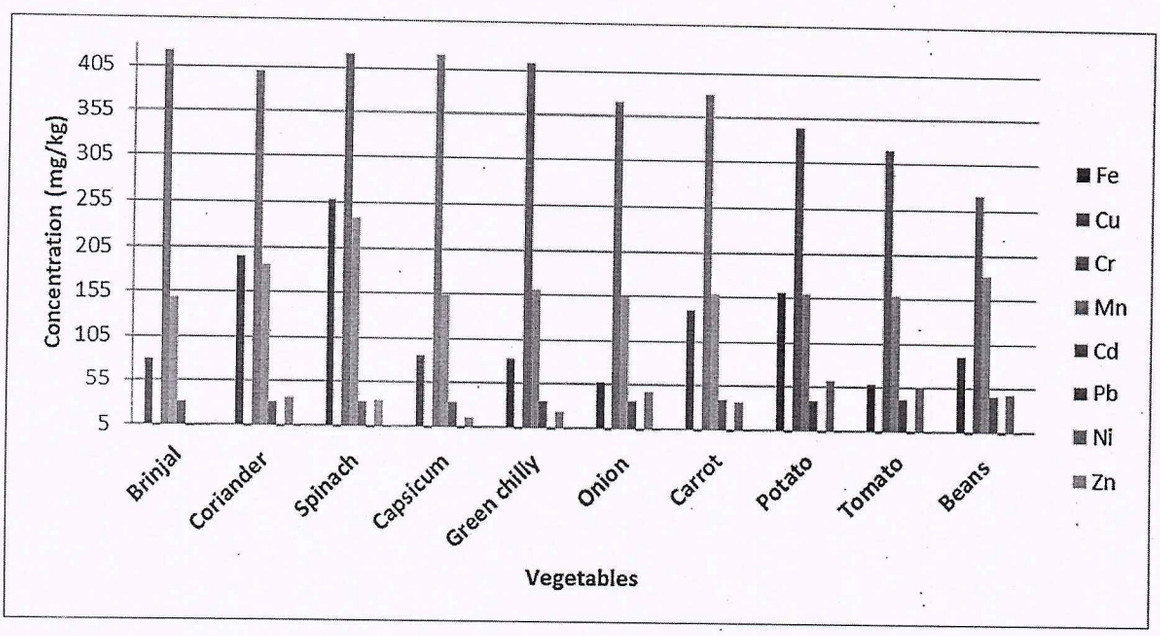


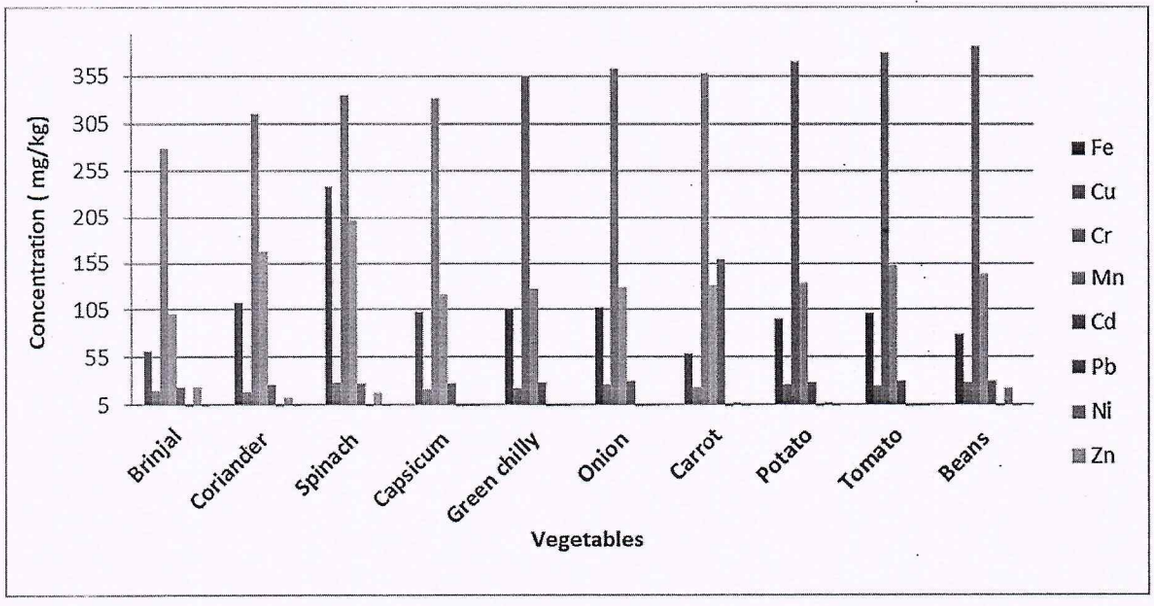
Table 4: Concentration of heavy metals in vegetable samples collected from New Mandi of Muzaffarnagar city

Vegetables	Heavy metals(mg/kg)							
	Fe	Zn	Cr	Mn	Pb	Cu	Ni	Cd
Brinjal	59.93	BDL	278.80	98.83	BDL	19.08	22.43	23.25*
Coriander	111.18		315.03	168.30		17.85	11.38	25.10*
Spinach	238.20		334.98	201.63		27.88	16.90	26.90*
Capsicum	102.25		332.03	120.45		20.13	BDL	27.15*
Green Chilly	104.55		355.68	126.35		21.53	BDL	27.63*
Onion	106.85		363.08	127.85		25.6	BDL	28.68*

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Carrot	57.63		357.18	130.58		23.1	5.95	159.1*
Potato	94.75		370.48	132.33		25.95	6.28	28.63*
Tomato	100.25		378.63	152.30		24.35	2.98	29.75*
Beans	77.75		386.03	143.00		27.88	21.83	29.58*
Maximum	238.20	-	386.03	201.63	-	27.88	22.43	159.15
Minimum	57.63	-	278.80	98.83	-	17.85	-	23.25
Average	112.43	-	344.73	141.84	-	23.25	6.37	49.02
Standard Deviation	50.48	-	32.58	28.51	-	3.59	11.88	41.71
No. of Samples above safe limit	0	0	-	0	0	0	0	10



Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College
Muzaffarnagar

Table 5: Concentration of heavy metals in vegetable samples collected from khalapar of Muzaffarnagar city

Vegetables	Heavy metals(mg/kg)							
	Fe	Zn	Cr	Mn	Pb	Cu	Ni	Cd
Brinjal	35.00	BDL	180.40	66.00	BDL	11.20	25.70	9.70*
Coriander	546.20*		162.70	82.10		7.40	17.20	12.10*
Spinach	474.80*		175.30	183.70		13.10	23.30	13.20*
Capsicum	139.00		233.70	74.40		10.00	37.30	17.00*
Green Chilly	120.60		267.00	95.80		7.00	45.80	18.00*
Onion	131.90		217.40	73.10		7.70	19.00	18.00*
Carrot	54.10		222.60	78.00		10.80	46.10	20.70*
Potato	104.50		263.30	80.80		11.70	13.40	22.10*
Tomato	60.40		272.10	87.80		17.00	7.00	22.60*
Beans	84.80		278.00	98.50		19.00	22.20	22.60*
Maximum	546.20	-	278.00	183.70	-	19.00	46.10	22.60
Minimum	35.00	-	162.70	66.00	-	7.00	7.00	9.70
Average	194.38	-	226.10	97.49	-	11.74	25.84	17.36
Standard Deviation	180.81	-	43.06	33.74	-	3.99	13.30	4.63
No. of Samples above safe Limit	2	0	-	0	0	0	0	10

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

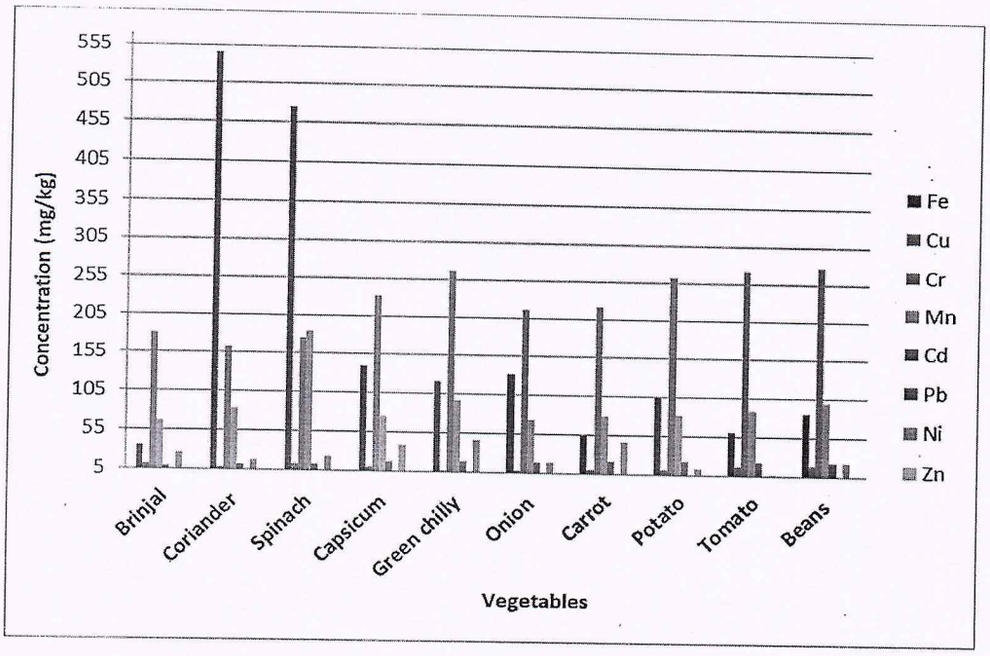


Table 6: Concentration of heavy metals in vegetable samples collected from Malupura of Muzaffarnagar city

Vegetables	Heavy metals (mg/kg)							
	Fe	Zn	Cr	Mn	Pb	Cu	Ni	Cd
Spinach	256.20	11.28	159.20	68.18	BDL	BDL	26.05	3.95*
Coriander	227.88	39.85	142.53	82.83	3.85*	9.70	40.40	6.98*
Brinjal	138.20	16.68	157.20	36.65	24.28*	5.80	6.30	8.53*
Tomato	111.98	11.65	140.55	26.50	23.00*	BDL	23.78	7.05*
Capsicum	119.58	35.95	173.85	44.35	21.73*	5.60	17.75	11.10*
Potato	239.70	29.00	155.20	35.05	19.18*	1.88	21.48	10.30*
Green Chilly	157.85	25.18	195.83	35.68	20.45*	8.18	38.95	6.98*
Onion	179.90	17.85	182.53	33.10	40.90*	3.23	29.80	11.68*
Carrot	140.83	27.95	207.15	34.08	38.35*	6.65	26.93	6.73*
Beans	128.78	33.30	191.15	44.23	35.80*	3.58	17.20	11.93*
Maximum	256.20	39.85	207.15	82.83	40.90	9.70	40.40	11.93
Minimum	111.98	11.28	140.55	26.50	BDL	1.88	6.30	3.95

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College
Muzaffarnagar

Average	172.42	24.98	171.07	45.83	22.37	3.98	24.61	8.42
Standard Deviation	46.25	9.46	23.06	17.70	13.50	3.96	10.20	2.63
No. of samples above safe limit	0	0	-	0	9	0	0	10

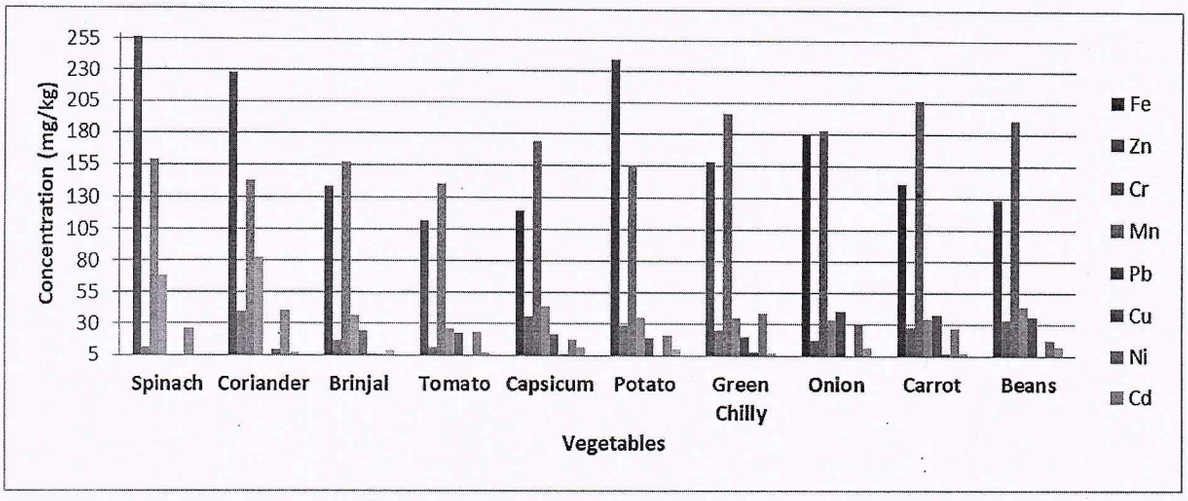


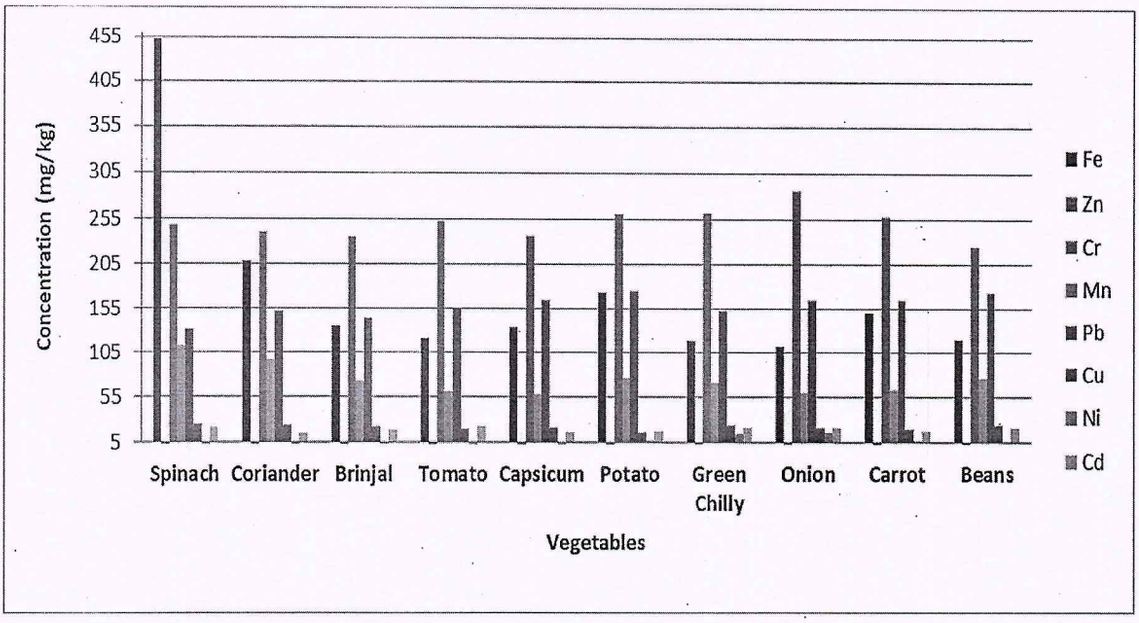
Table 7: Concentration of heavy metals in vegetable samples collected from Bhartiya Colony of Muzaffarnagar city

Vegetables	Heavy metals(mg/kg)							
	Fe	**Zn**	**Cr**	**Mn**	**Pb**	**Cu**	**Ni**	**Cd**
Spinach	452.6*	BDL	247.8	112.37	131.7*	25.025	BDL	21.3*
Coriander	207.675		239.8	97.225	152.15*	23.5	BDL	14.57*
Brinjal	135.325		235.12	73.175	144.47*	22.65	BDL	19.2*
Tomato	120.9		252.5	60.6	155.97*	20.6	BDL	22.17*
Capsicum	133.725		236.47	58.75	165.15*	21.12	BDL	15.9*
Potato	173.85		261.1	76.375	175.15*	16.85	6.875	18.2*
Green Chilly	118.275		261.77	70.85	153.45*	23.32	15.47	21.17*
Onion	112.845		286.42	59.72	164.95*	21.62	16.32	20.97*
Carrot	150.775		258.45	63.4	164.87*	19.575	7.725	17.9*

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Beans	120.1		224.8	76.825	173.875	24.025	5.15	21.5*
Maximum	452.60	-	286.43	112.38	175.15	25.03	16.32	22.18
Minimum	112.85	-	224.80	58.75	131.70	16.85	-	14.58
Average	190.96	-	251.29	76.70	157.38	21.68	-	19.14
Standard Deviation	102.72	-	17.68	17.50	13.44	2.42	-	2.59
No. of samples above safe Limit	1	0	-	0	10	0	0	10



Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Table 8: Concentration of heavy metals in vegetable samples collected from Adarsh Colony of Muzaffarnagar city

Vegetables	Heavy metals(mg/kg)							
	Fe	**Zn**	**Cr**	**Mn**	**Pb**	**Cu**	**Ni**	**Cd**
Spinach	61.68	32.80	103.93	83.63	BDL	BDL	BDL	1.05*
Coriander	37.20	32.30	95.25	48.83		BDL	BDL	2.65*
Brinjal	9.13	12.63	69.28	21.15		1.18	13.75	2.38*
Tomato	25.03	11.65	123.90	11.60		BDL	31.23	2.30*
Capsicum	11.35	24.35	107.23	8.68		BDL	31.50	2.98*
Potato	13.93	6.78	98.50	7.70		BDL	25.50	5.83*
Green Chilly	117.23	20.65	127.23	17.10		BDL	19.18	3.43*
Onion	97.80	12.90	129.90	19.93		BDL	18.03	4.88*
Carrot	146.08	29.50	132.58	31.03		BDL	30.38	7.18*
Beans	122.73	14.58	120.55	32.38		BDL	27.23	7.05*
Maximum	146.08	32.80	132.58	83.63	-	-	31.50	7.18
Minimum	9.13	6.78	69.28	7.70	-	-	BDL	1.05
Average	66.44	19.81	109.18	31.11	-	-	16.14	3.99
Standard Deviation	52.38	9.45	19.87	23.19	-	-	15.99	2.13
No. of Samples above safe Limit	0	0	-	0	-	0	0	10

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

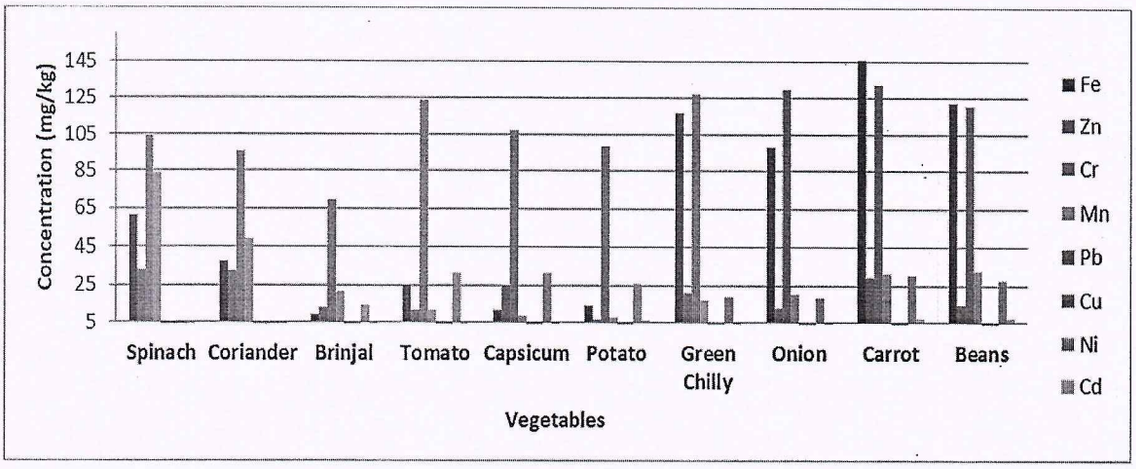


Table 9: Concentration of heavy metals in vegetable samples collected from Gandhi Colony of Muzaffarnagar city

Vegetables	Heavy metals(mg/kg)							
	Fe	Zn	Cr	Mn	Pb	Cu	Ni	Cd
Spinach	363.45	12.83	212.48	100.30	27.83*	11.40	38.10	12.98*
Coriander	305.25	BDL	220.48	59.98	65.20*	10.20	31.53	9.63*
Brinjal	139.65	BDL	206.50	43.85	61.38*	11.93	47.28	13.13*
Tomato	222.13	BDL	243.13	43.35	61.38*	11.58	14.33	15.10*
Capsicum	150.50	BDL	213.80	41.90	57.55*	15.50	22.63	14.58*
Potato	200.35	BDL	213.83	39.10	76.70*	8.18	11.78	10.80*
Green Chilly	140.55	BDL	239.80	53.63	81.83*	13.95	16.63	15.18*
Onion	117.50	BDL	261.10	45.45	92.05*	12.60	12.03	16.03*
Carrot	225.00	BDL	242.45	48.75	80.55*	9.70	BDL	15.30*
Beans	129.80	BDL	245.83	58.88	95.90*	7.48	4.88	16.70*
Maximum	363.45	12.83	261.10	100.30	95.90	15.50	47.28	16.70
Minimum	117.50	-	206.50	39.10	27.83	7.48	BDL	9.63
Average	206.26	-	230.58	56.21	68.67	11.29	20.53	13.81
Standard Deviation	81.83	-	18.60	17.91	19.88	2.47	14.97	2.29

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

No. of samples above safe Limit	0	0	-	0	10	0	0	10

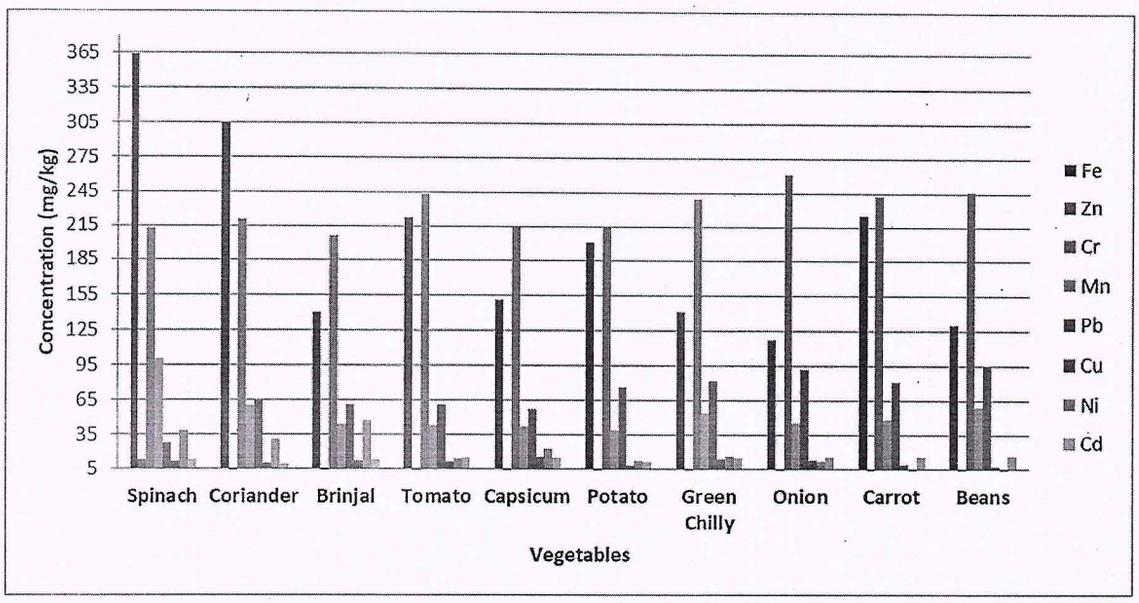


Table 10: Concentration of heavy metals in vegetable samples collected from Gandhi Nagar of Muzaffarnagar city

Vegetables	Fe	Zn	Cr	Mn	Pb	Cu	Ni	Cd
Spinach	546.75*	BDL	267.78	123.65	90.78*	13.10	BDL	16.88*
Coriander	209.80		255.78	110.68	104.85*	17.03	12.03	14.05*
Brinjal	141.35		258.45	68.18	103.58*	15.48	BDL	15.98*
Tomato	125.60		270.45	64.25	126.60*	12.95	BDL	17.55*
Capsicum	158.38		284.43	65.83	138.08*	20.78	BDL	19.28*
Potato	211.35		299.75	66.93	107.40*	16.53	BDL	15.78*
Green Chilly	123.00		282.43	70.25	112.50*	25.53	BDL	17.43*
Onion	96.00		263.78	71.95	121.45*	16.00	BDL	18.73*
Carrot	135.65		273.78	66.08	116.35*	17.03	BDL	17.63*
Beans	131.65		273.78	85.75	120.18*	16.18	5.45	17.35*

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Maximum	546.75	-	299.75	123.65	138.08	25.53	12.03	19.28
Minimum	96.00	-	255.78	64.25	90.78	12.95	BDL	14.05
Average	210.19	-	273.83	81.79	114.22	17.42	-	17.00
Standard Deviation	131.35	-	13.18	21.05	13.39	3.69	-	1.50
No. of samples above safe limit	0	0	-	0	10	0	0	10

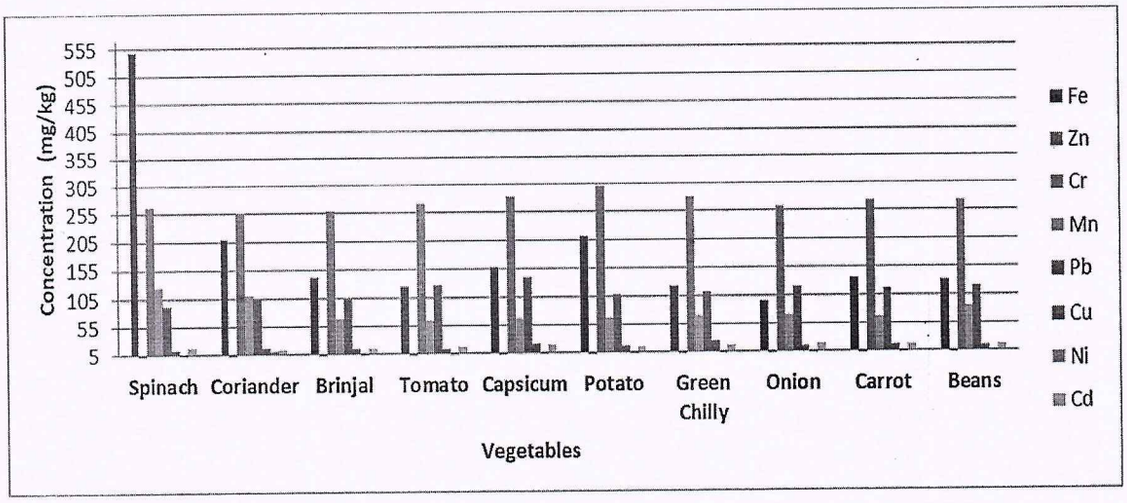


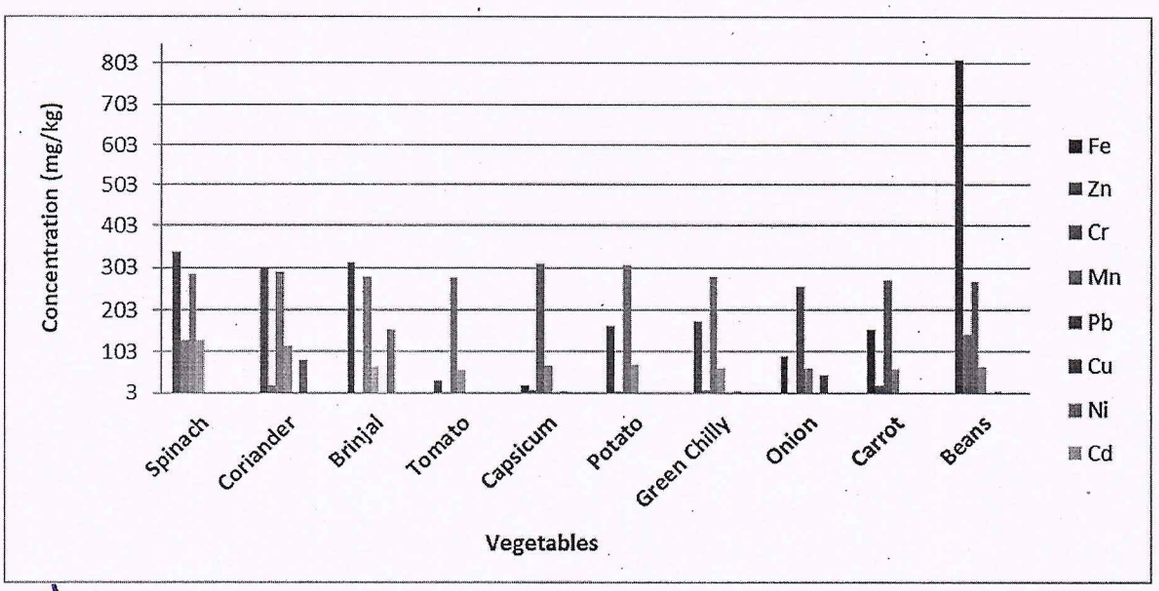
Table 11: Concentration of heavy metals in vegetable samples collected from Vishwkarma Chawk of Muzaffarnagar city

Vegetables	Heavy metals(mg/kg)							
	Fe	Zn	Cr	Mn	Pb	Cu	Ni	Cd
Spinach	340.80	131.45*	286.28	131.63		2.38		
Coriander	304.13	19.15	291.20	116.45		84.13*		
Brinjal	316.00	BDL	281.38	66.33		156.0*		
Tomato	32.45	BDL	278.08	56.93		1.38		

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Capsicum	19.40	9.28	310.88	68.10		3.15		
Potato	165.25	4.20	308.43	70.80		2.78		
Green Chilly	175.55	9.55	279.73	62.23	BDL	4.35	BDL	BDL
Onion	90.98	BDL	257.58	61.98		45.03		
Carrot	157.35	20.93	273.18	61.05		BDL		
Beans	810.20 *	145.08*	269.85	66.13		4.73		
Maximum	810.20	145.08	310.88	131.63	-	156.00	-	-
Minimum	19.40	BDL	257.58	56.93	-	BDL	-	-
Average	270.14	38.73	283.75	79.18	-	37.63	-	-
Standard Deviation	229.90	56.53	16.50	25.79	-	52.22	-	-
No. of samples above safe limit	1	2	-	0	0	2	0	0



Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Table 12: Concentration of heavy metals in vegetable samples collected from Hanuman Chawk of Muzaffarnagar city

Vegetables	Heavy metals(mg/kg)							
	Fe	Zn	Cr	Mn	Pb	Cu	Ni	Cd
Spinach	554.58*	55.55	285.48	228.90	BDL	11.48	BDL	BDL
Coriander	945.70*	27.70	320.73	107.05		17.98		
Brinjal	98.55	5.00	316.63	47.30		165.70*		
Tomato	116.73	1.55	324.00	62.68		46.23		
Capsicum	149.50	BDL	315.00	54.83		62.40		
Potato	219.53	BDL	310.90	65.75		4.73		
Green Chilly	129.78	4.80	303.50	52.10		8.70		
Onion	103.40	BDL	315.80	65.40		8.50		
Carrot	137.05	BDL	310.90	49.53		24.23		
Beans	114.90	BDL	297.75	63.53		101.50*		
Maximum	945.70	55.55	324.00	228.90	-	165.70	-	-
Minimum	98.55	BDL	285.48	47.30	-	4.73	-	-
Average	301.16	10.48	309.18	89.44	-	51.82	-	-
Standard Deviation	277.88	19.49	11.59	55.08	-	52.31	-	-
No. of samples above safe limit	2	0	-	0	0	2	0	0

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

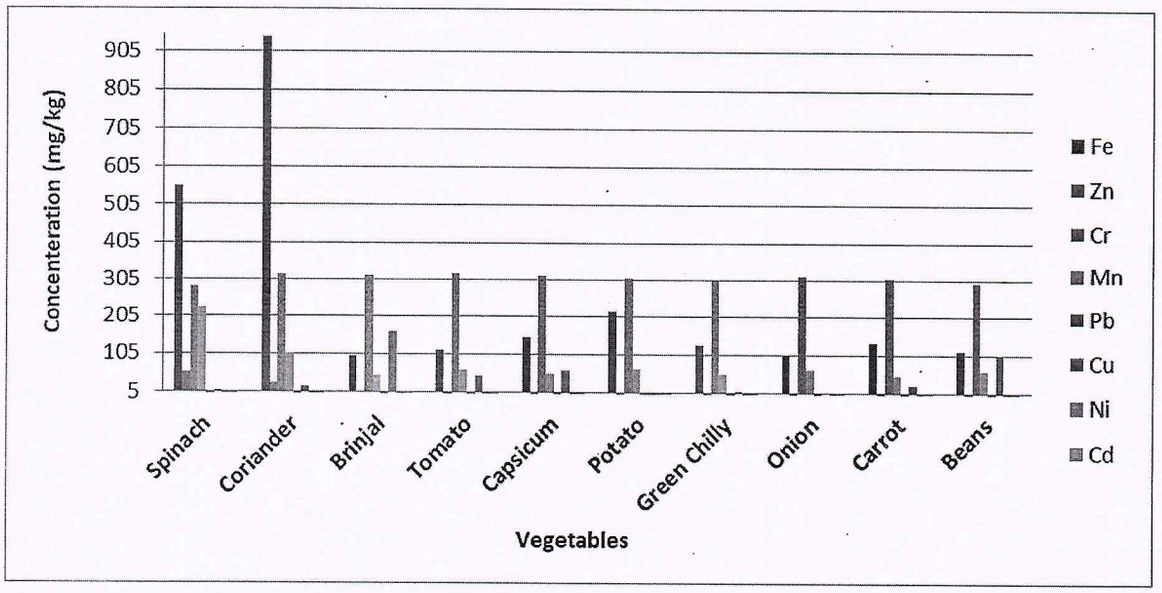


Table 13: Concentration of heavy metals in vegetable samples collected from Shri Ram Chawk of Muzaffarnagar city

Vegetables	Heavy metals(mg/kg)							
	Fe	Zn	Cr	Mn	Pb	Cu	Ni	Cd
Spinach	370.23	35.88	214.80	85.98	BDL	12.43	BDL	BDL
Coriander	361.03	36.03	279.73	137.63		7.50		
Brinjal	96.13	17.08	275.73	73.75		8.10		
Tomato	54.28	19.43	263.20	17.53		6.93		
Capsicum	104.60	3.38	264.15	20.13		4.55		
Potato	200.13	BDL	275.60	21.18		3.75		
Green Chilly	347.33	5.08	276.45	26.35		6.10		
Onion	50.63	BDL	283.83	22.10		7.70		
Carrot	185.58	4.48	297.78	28.93		4.35		
Beans	101.28	20.25	293.65	63.88		6.13		
Maximum	370.23	36.03	297.78	137.63	-	12.43	-	-
Minimum	50.63	-	214.80	17.53	-	3.75	-	-
Average	191.00	13.46	269.79	54.38	-	6.98	-	-

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Standard Deviation	128.39	15.09	23.06	39.84	-	2.49	-	-
No. of samples above safe limit	0	0	-	0	0	0	0	0

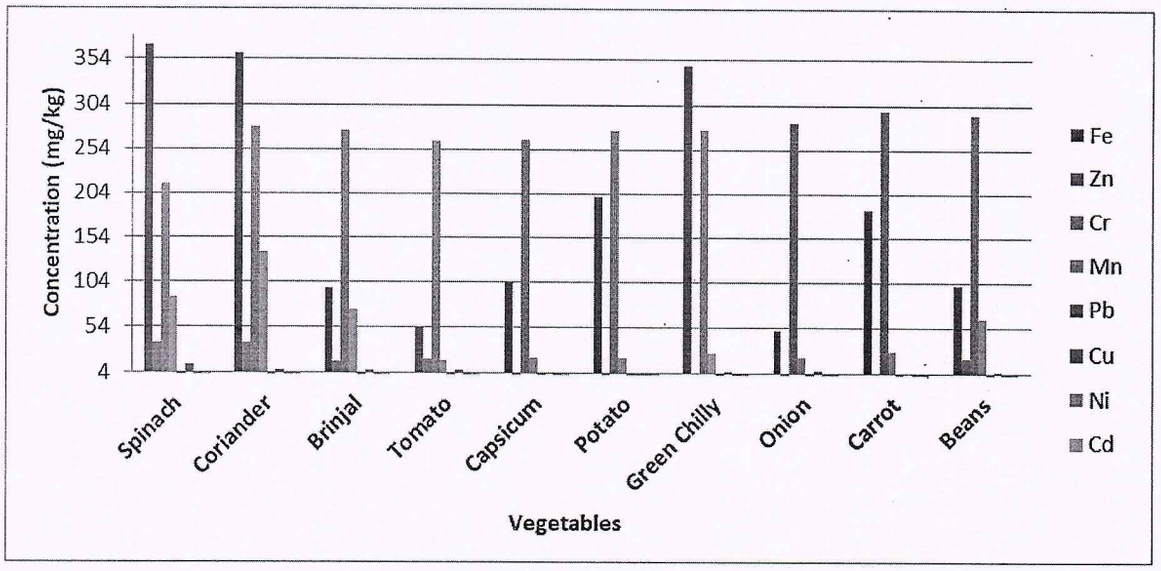


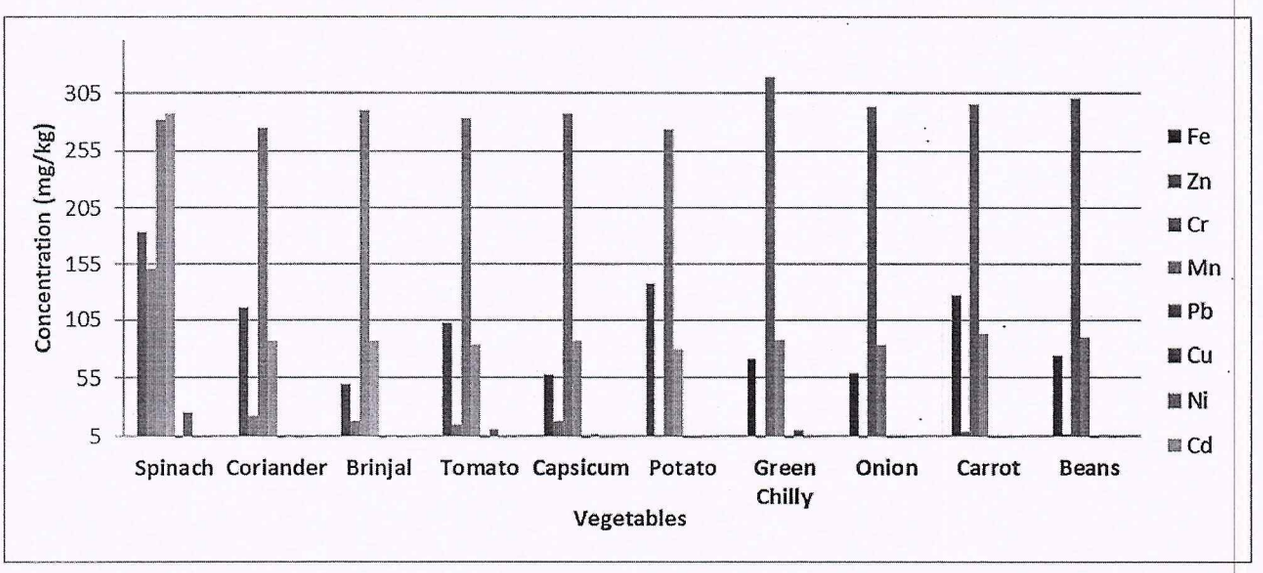
Table 14: Concentration of heavy metals in vegetable samples collected from Saket Colony of Muzaffarnagar city

Vegetables	Heavy metals(mg/kg)							
	Fe	Zn	Cr	Mn	Pb	Cu	Ni	Cd
Spinach	183.15	150.88*	281.35	287.00		25.68		
Coriander	115.85	21.63	274.78	86.70		6.13		
Brinjal	49.43	18.48	290.40	86.33		5.93		
Tomato	101.88	15.03	283.00	83.28		10.48		
Capsicum	58.53	18.35	287.10	86.35		6.50		
Potato	137.05	5.28	273.15	79.73		2.38		
Green Chilly	70.98	0.95	319.08	87.53	BDL	9.68	BDL	BDL

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Onion	59.13	2.75	292.85	83.50		BDL		
Carrot	126.45	8.68	295.30	93.03		BDL		
Beans	74.60	6.83	300.23	90.10		5.35		
Maximum	183.15	150.88	319.08	287.00	-	25.68	-	-
Minimum	49.43	0.95	273.15	79.73	-	BDL	-	-
Average	100.80	33.39	290.79	119.19	-	7.82	-	-
Standard Deviation	42.98	44.85	13.47	63.58	-	7.66	-	-
No. of samples above safe Limit	0	1	-	0	0	0	0	0



Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Table 15: Concentration of heavy metals in vegetable samples collected near Govt. Hospital of Muzaffarnagar city

Vegetables	Heavy metals (mg/kg)							
	Fe	Zn	Cr	Mn	Pb	Cu	Ni	Cd
Spinach	360.50	15.65	290.38	123.85	BDL	5.35	BDL	BDL
Coriander	205.88	46.65	292.83	92.58		0.40		
Brinjal	55.80	27.63	299.40	91.15		BDL		
Tomato	34.58	7.60	273.15	77.30		BDL		
Capsicum	21.83	45.85	316.65	79.63		2.55		
Potato	110.08	8.33	297.75	91.50		2.95		
Green Chilly	30.93	4.53	284.65	84.45		5.93		
Onion	19.40	17.15	290.38	84.93		1.58		
Carrot	158.90	11.65	295.30	125.60		0.38		
Beans	50.95	131.45*	299.40	107.03		BDL		
Maximum	360.50	131.45	316.65	125.60	-	5.93	-	-
Minimum	19.4	4.525	273.15	77.3	-	-	-	-
Average	119.06	37.70	294.14	96.74	-	-	-	-
Standard Deviation	109.76	38.19	11.24	17.33	-	-	-	-
No. of samples above safe limit	0	1	-	0	0	0	0	0

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

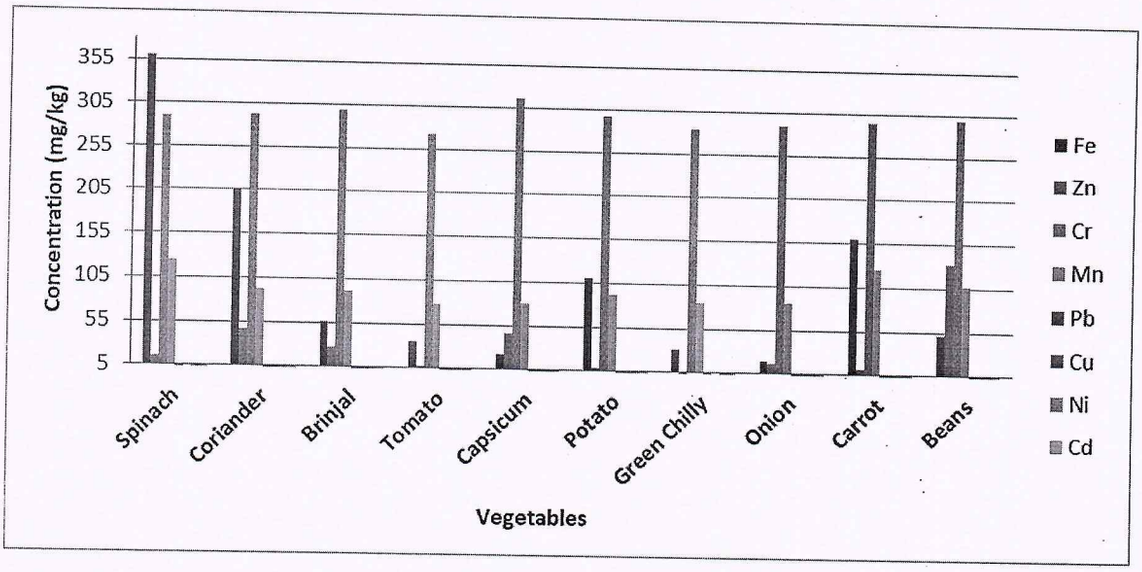


Table 16: Concentration of heavy metals in vegetable samples collected from Rampuri Colony of Muzaffarnagar city

Vegetables	Heavy metals (mg/kg)							
	Fe	Zn	Cr	Mn	Pb	Cu	Ni	Cd
Spinach	370.23	23.30	257.55	85.98	BDL	12.43	BDL	0.93*
Coriander	361.03	23.30	276.45	137.63		7.50		0.93*
Brinjal	96.13	0.68	300.23	73.75		8.10		2.88*
Tomato	54.28	26.90	293.65	17.53		6.93		5.23*
Capsicum	104.60	3.65	292.83	20.13		4.55		BDL
Potato	200.13	BDL	306.80	21.18		3.75		BDL
Green Chilly	347.33	BDL	278.08	26.35		6.10		BDL
Onion	50.63	BDL	270.70	22.10		7.70		BDL
Carrot	185.58	BDL	274.80	28.93		4.35		BDL
Beans	101.28	7.45	269.85	63.88		6.13		BDL
Maximum	370.23	26.90	306.80	137.63	-	12.43	-	5.23
Minimum	50.63	BDL	257.55	17.53	-	3.75	-	-
Average	191.00	8.07	282.11	54.38	-	6.98	-	-

Coordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Standard Deviation	128.39	12.32	15.53	39.84	-	2.49	-	-
No. of samples above safe Limit	0	0	-	0	0	0	0	4

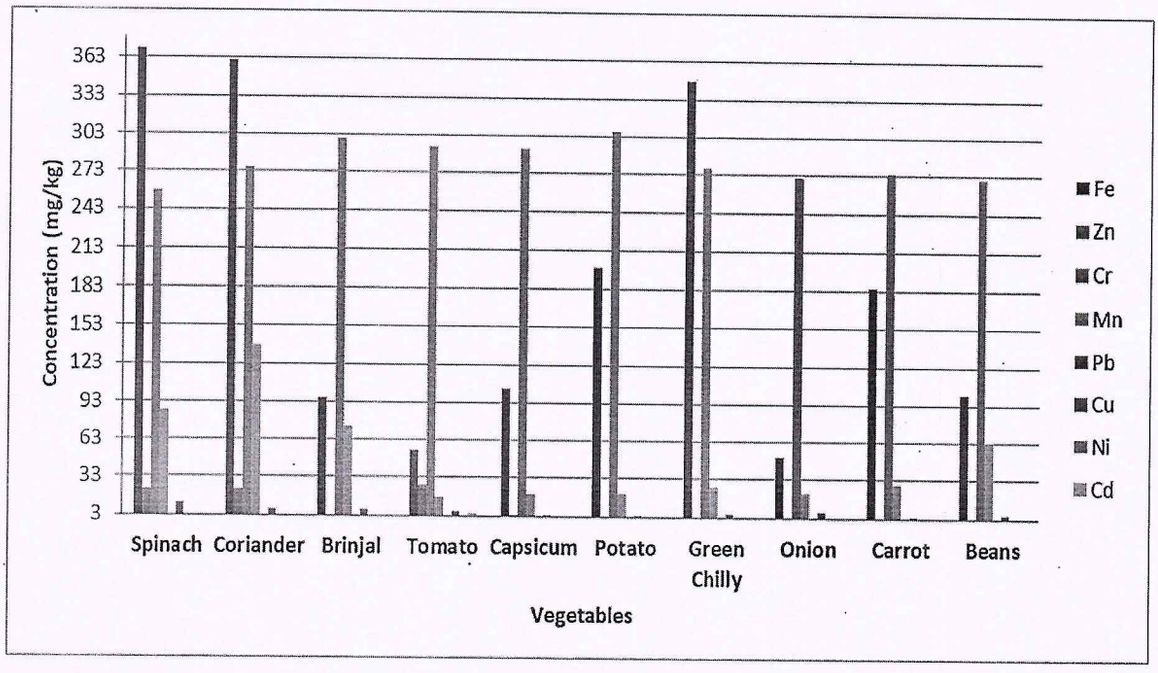


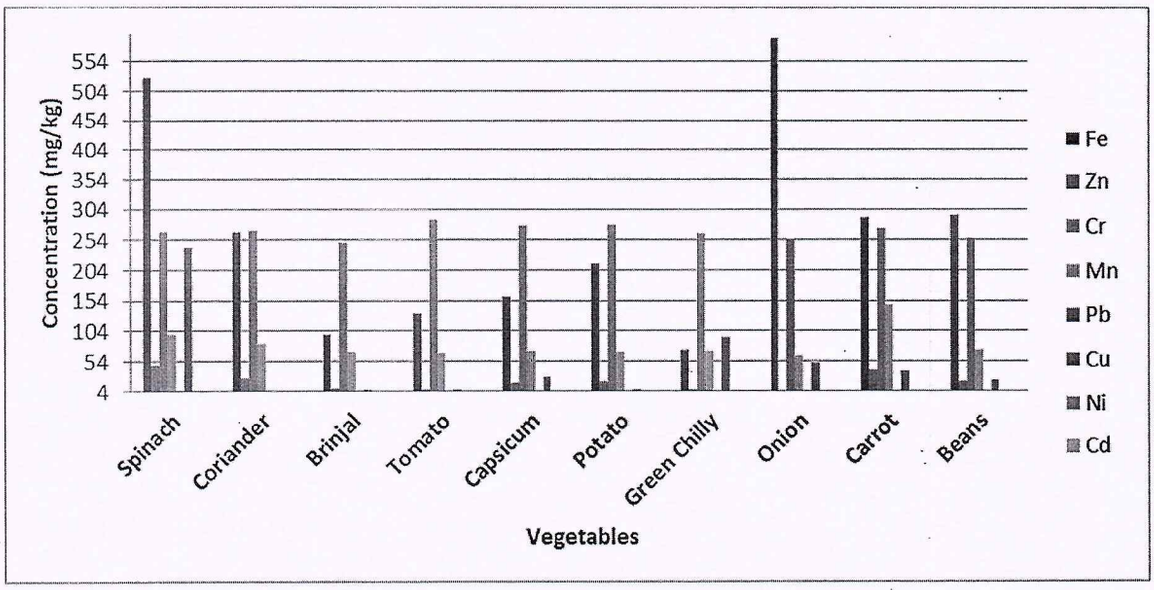
Table 17: Concentration of heavy metals in vegetable samples collected from Indra Colony of Muzaffarnagar city

Vegetables	Heavy metals(mg/kg)							
	Fe	Zn	Cr	Mn	Pb	Cu	Ni	Cd
Spinach	525.78*	48.18	268.23	97.28		241.98*	BDL	
Coriander	266.83	25.48	269.05	82.70		1.78	BDL	
Brinjal	98.53	8.73	249.38	68.10		5.93	BDL	
Tomato	133.10	6.85	287.08	67.50		4.83	BDL	
Capsicum	161.30	18.90	276.43	71.75		28.05	BDL	

Coordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Potato	214.68	21.20	278.88	68.83	BDL	6.53	BDL	BDL
Green Chilly	72.18	4.83	265.75	70.35		94.60*	BDL	
Onion	592.18*	0.40	255.10	62.93		51.35	6.43	
Carrot	290.18	39.35	273.98	146.68		38.50	BDL	
Beans	294.13	19.85	257.55	73.53		21.60	BDL	
Maximum	592.18	48.18	287.08	146.68	-	241.98	6.43	-
Minimum	72.18	0.40	249.38	62.93	-	1.78	-	-
Average	276.10	20.19	268.15	84.94	-	61.57	-	-
Standard Deviation	173.88	15.32	11.63	25.08	-	73.38	-	-
No. of samples above safe limit	2	0	-	0	0	2	0	0



Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College
Muzaffarnagar

Table 18: Concentration of heavy metals in vegetable samples collected from Lohia Bazar of Muzaffarnagar city

Vegetables	Heavy metals(mg/kg)							
	Fe	Zn	Cr	Mn	Pb	Cu	Ni	Cd
Spinach	448.45*	135.53*	246.10	308.40	BDL	19.55	25.00	BDL
Coriander	393.88	112.90*	279.73	157.50		20.13	BDL	2.60*
Brinjal	211.03	39.95	257.58	77.15		3.55	BDL	0.48*
Tomato	109.78	28.65	279.73	116.33		BDL	BDL	3.68*
Capsicum	300.48	10.70	264.13	108.93		BDL	BDL	3.38*
Potato	378.13	17.60	279.73	73.15		5.93	BDL	0.95*
Green Chilly	179.20	17.93	291.20	92.33		2.75	BDL	1.85*
Onion	117.65	3.53	280.55	120.43		2.58	BDL	BDL
Carrot	290.18	10.83	289.58	78.35		BDL	26.45	2.00*
Beans	52.75	12.73	295.30	138.10		BDL	BDL	0.15*
Maximum	448.45	135.53	295.30	308.40	-	20.13	26.45	3.68
Minimum	52.75	3.53	246.10	73.15	-	-	-	-
Average	248.56	44.11	275.42	137.68	-	-	-	-
Standard Deviation	134.68	46.35	15.72	69.44	-	-	-	-
No. of Samples above safe Limit	1	2	-	0	0	0	0	8

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College
Muzaffarnagar

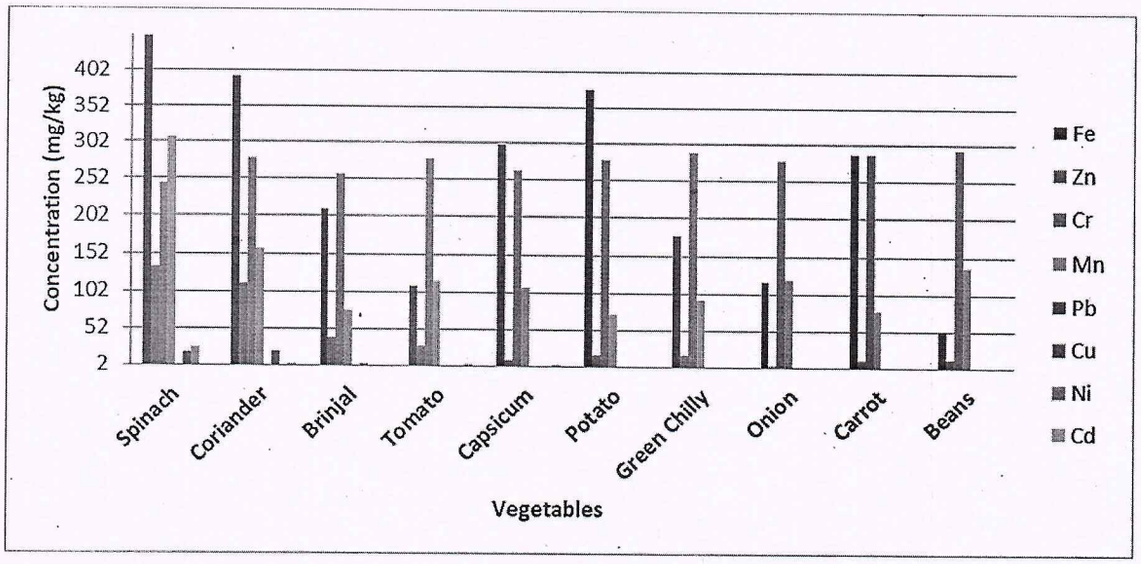


Table 19: Concentration of heavy metals in vegetable samples collected from Shiv Chawk of Muzaffarnagar city

Vegetables	Heavy metals (mg/kg)							
	Fe	Zn	Cr	Mn	Pb	Cu	Ni	Cd
Spinach	122.50	32.50	285.48	119.60	49.45*	BDL	BDL	2.65*
Coriander	121.58	11.80	272.35	158.20	47.80*	11.25		1.28*
Brinjal	112.80	5.48	292.85	104.80	24.73*	8.88		2.93*
Tomato	20.63	12.00	281.35	105.85	74.20*	6.50		BDL
Capsicum	3.63	2.70	273.15	92.10	69.23*	6.90		BDL
Potato	212.78	BDL	264.95	92.45	64.28*	BDL		3.80*
Green Chilly	43.35	9.35	284.65	101.15	72.53*	14.20		2.50*
Onion	127.33	30.60	281.35	100.93	51.10*	53.10		0.88*
Carrot	30.00	6.23	269.05	93.15	56.05*	8.13		3.00*
Beans	60.05	9.28	263.30	116.20	74.18*	64.00		1.80*
Maximum	212.78	32.50	292.85	158.20	74.20	64.00	-	3.80
Minimum	3.625	BDL	263.3	92.1	24.725	BDL	-	BDL
Average	89.25	12.30	277.05	111.23	56.87	18.76	-	1.24

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Standard Deviation	64.79	11.31	9.73	19.85	15.76	23.06	-	2.20
No. of samples above safe limit	0	0	0	0	10	0	0	8

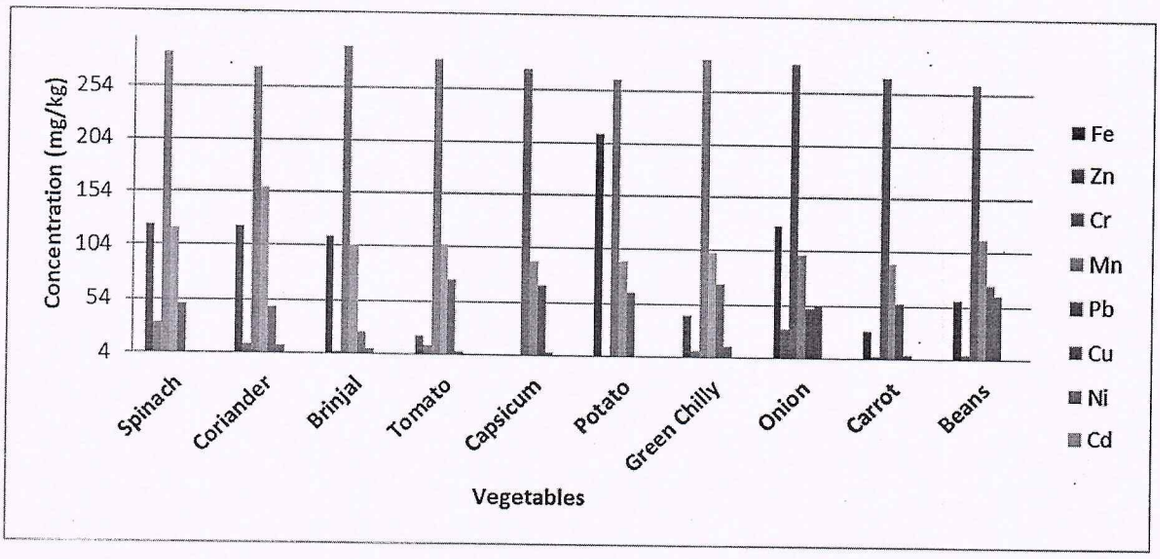


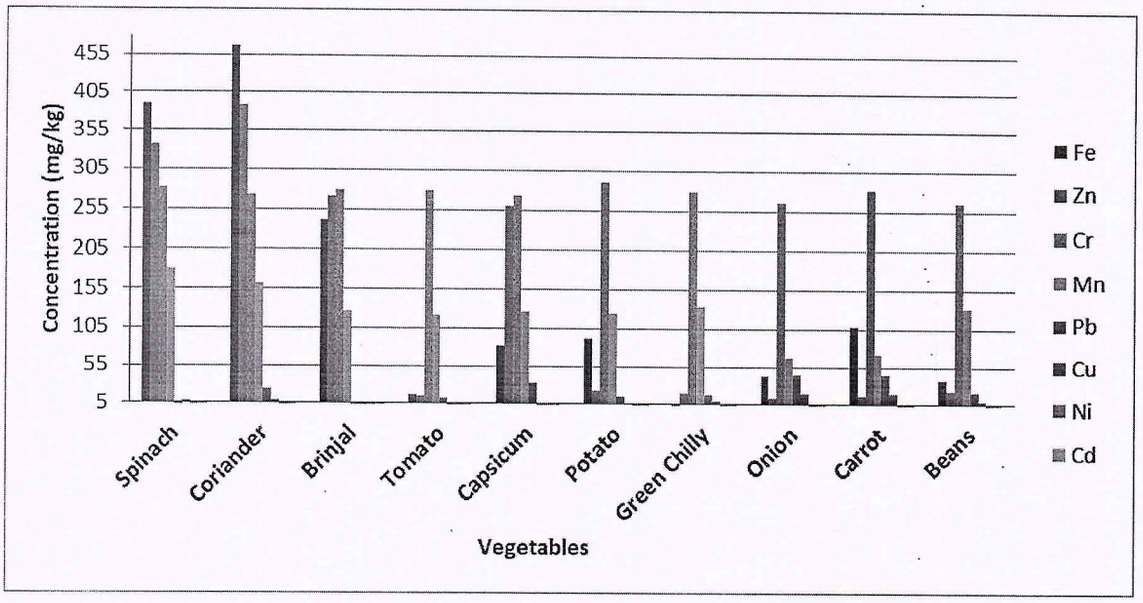
Table 20: Concentration of heavy metals in vegetable samples collected from Meenakshi Chawk of Muzaffarnagar city

Vegetables	Heavy metals(mg/kg)							
	Fe	Zn	Cr	Mn	Pb	Cu	Ni	Cd
Spinach	389.33	336.20*	282.20	179.85	BDL	7.50	BDL	1.50*
Coriander	466.35*	388.70*	273.40	161.63	24.73*	9.10		BDL
Brinjal	241.05	271.80*	278.08	126.20	BDL	BDL		BDL
Tomato	17.30	15.10	278.08	121.50	12.38*	BDL		BDL
Capsicum	81.25	259.40*	273.15	125.50	32.98*	4.73		BDL
Potato	92.48	22.03	290.38	124.78	14.85*	5.73		BDL
Green Chilly	3.33	20.25	278.08	134.20	18.13*	9.30		BDL
Onion	43.05	14.30	265.78	67.63	44.50*	18.95		BDL

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College
Muzaffarnagar

Carrot	108.85	16.33	281.35	70.80	44.50*	18.95		BDL
Beans	37.90	22.00	265.78	132.10	21.43*	9.68		BDL
Maximum	466.35	388.70	290.38	179.85	44.50	18.95	-	1.50
Minimum	3.33	14.30	265.78	67.63	BDL	BDL	-	-
Average	162.55	147.43	276.87	124.30	13.81	7.75	-	-
Standard Deviation	162.78	156.61	7.50	34.52	25.79	7.46	-	-
No. of Samples above safe Limit	1	4	0	0	8	0	0	1



Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

CONCLUSION

It is very clear from the present study that the edible vegetables are hyperaccumulators of heavy metals. So, taking into consideration the health risks associated with consumption of these vegetables, it is suggested that vegetable cultivation should not use waste water as a source.

- Farmers growing vegetables should use clean surface water for cultivation of the crops
- In case of non-availability of clean water, at least treated water should be used for the purpose of cultivation
- Few vegetables studied had higher amounts of heavy metals than the prescribed limits standardized by various health associations.
- In terms of the eight metals analyzed, the concentrations in vegetables were not very different in the four categories of markets
- Cultivation of root and leafy vegetables which are hyper-accumulators, should be restricted in such polluted areas such as peripherals of the city
- Waste water reuse is the need of the hour because it will help to conserve and replenish the depleting potable water resources. Hence, it should be properly treated to remove the harmful pollutants before its reuse for irrigational purposes
- Awareness campaigns about the cause and effect of such toxic pollutants is the need of the hour
- Combined efforts should be done by the government, industrialists, farmers, soil and water scientists and social organizations to tackle such problems
- Reuse and reduction of materialistic things can be the first step to reduce the number of pollutants in the environment.

RECOMMENDATIONS

- ✓ Farmers should be made aware of toxic metal accumulations in greens and vegetables and their imminent threat to consumers
- ✓ For the farmers those who grow food crops, testing of soils and water should be mandated by the concerned regional agricultural department or pollution control board. More particularly, farmers, who grow these crops on either side of highways, must go for soil testing
- ✓ Farmers should not resort to unethical farming practices such as irrigating the crops with drainage and effluent waters
- ✓ It is advised to avoid eating spinach bought from the vegetable markets of the Bangalore. Instead, these greens can be grown organically at home in rooftop gardens, window gardens and balcony gardens
- ✓ Farmers of the suburban areas should not be allowed by law to grow the greens and

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

vegetables utilizing the drainage and effluent waters

- ✓ A continuous monitoring is recommended to rule out toxic metal contamination in these greens and vegetables

References

Abrham, F., & Gholap., A. (2021). Analysis of heavy metal concentration in some vegetables using atomic absorption spectroscopy. *Pollution*, *7*(1), 205-216.

Agrawal, M., (2003). Enhancing Food Chain Integrity: Quality Assurance Mechanism for Air Pollution Impacts on Food and Vegetable System. Final Technical Report (R7530). Submitted to Department for International Development, United Kingdom.

Agrawal., S.B. Anita Singh., R.K Sharma., M.Agrawal (2007). Bioaccumulation of Heavy Metals in Vegetables:AThreat to Human Health, *Terrestrial and Aquatic Environmental Toxicology,* 1(2); 13-23.

Ahmed Alengebawy., Sara Taha Abdelkhalek., Sundas Rana Qureshi., and Man Qun Wang(2021). Heavy Metals and Pesticides Toxicity in Agricultural Soil and Plants: Ecological Risks and Human Health Implications, *Toxics*, 9(3), 42.

Alexander, P.D., Alloway BJ., Dourado AM. Genotypic variations in the accumulation of Cd, Cu, Pb and Zn exhibited by six commonly grown vegetables. *Environmental Pollution.* 2006, 144(3),736-45.

Ames, B.N., Shigenaga, M.K. and Hagen, T.M. (1993). Oxidants, Antioxidants, and the Degenerative Diseases of Aging. Proceedings of the National Academy of Sciences of the United States of America, 90.

Barman,S.C., Sahu RK., Bhargava SK., Chaterjee (2000). Distribution of heavy metals in wheat, mustard and weed grown in field irrigated with industrial effluents. *Bulletin of Environmental Contamination and Toxicology,* 64, 489-496.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Carlton-Smith CH., Davis RD (1983). Comparative uptake of heavy metals by forage crops grown on sludge-treated soils. Proceeding of International Conference on Heavy metals in the Environment. *CEP Consultants Ltd. Edinburg, U.K,* 3933-3940.

Cui,Y.J., Zhu YG., Zhai RH., Chen DY., Huang YZ., Qiu Y., Liang JZ., (2004). Transfer of metals from soil to vegetables in an area near a smelter in Nanning, *China Environ Int.* 30(6), 785-91.

Demirezen,D., Aksoy **A.,** (2006). Heavy metal levels in vegetation in Turkey are within safe limits for Cu, Zn, Ni and exceeded for Cd and Pb. *Journal of Food Quality* 29, 252-265.

Deribachew, B., Amde, M., Nigussie-Dechassa, R., & Taddese, A. M. (2015). Selected heavy metals in some vegetables produced through wastewater irrigation and their toxicological implications in Eastern Ethiopia. *African Journal of Food, Agriculture, Nutrition and Development*, *15*(3), 10013-10032.

Dogheim, S.M., El-Ashraf MM., Gad Alla SA., Khorshid MA., Fahmy SM (2004). Pesticides and heavy metal levels in Egyptian vegetables and some aromatic medicinal plants. *Food Additives and Contaminants* 21, 323-330.

Florea, A.M., E.Dopp., G Obe., A.W.Rettenmeier., Genetoxiciy of organometallic species, 206-215.

Ghosh, R., Xalxo, R., Gope, M.C., Mishra, S., Kumari, B., Ghosh, M., Estimation of Heavy Metals in locally available vegetables collected from road side market sites (1-4) of different areas of Ranchi City. PHARMBIT XXIII and XXIV: 68-73 (2011).

Gurukiran.N., Kumara B.N., Mohammed Rafi, Prashanth Gowda, T., Sripathy, L (2017). Determination of heavy metal analysis in vegetable samples of Bengaluru and Tumukur market places, Karnataka, India, *International Journal of Current Engineering and Scientific Research*, 4(7), 13-18.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Hazrat Ali., Ezzat Khan., Ikram Ilahi., "Environmental Chemistry and Ecotoxicology of Hazardous Heavy Metals: Environmental Persistence, Toxicity, and Bioaccumulation", *Journal of Chemistry*, vol. 2019.

Herawati,N., Susuki S., Hayashi K., Rivai IE., Koyama H (2000). Cadmium copper and zinc levels in rice and soil of Japan, Indonesia and China by soil type. *Bulletin of Environmental Contamination and Toxicology* 64, 33-39.

Intawongse,M., Dean JR (2006). Uptake of heavy metals by vegetables plants grown on contaminated soil and their bioavailability in the human gastroin- testinal tract. *Food Additives and Contaminants* 23, 36-48.

Itanna,F., (2002). Metals in Leafy Vegetables Grown in Addis Ababa and Toxicological Implications. *Ethiopian Journal of Health Development,* 16, 295-302.

Jabeen, F., Aslam, A., & Salman, M., (2018). Heavy metals toxicity and associated health risks in vegetables grown under soil irrigated with sewage water. *Univers. J. Agric. Res, 6*, 173-180.

Jan, F. A., Ishaq, M., Khan, S., Ihsanullah, I., Ahmad, I., & Shakirullah, M. (2010). A comparative study of human health risks via consumption of food crops grown on wastewater irrigated soil (Peshawar) and relatively clean water irrigated soil (lower Dir). *Journal of hazardous materials*, *179*(1-3), 612-621.

Jayadev., E T Puttaih., Heavy Metal Contamination in soil under the application of polluted Sewage water across Vrishabhavathi River (2012). *Journal of Environmental Science,* 2(6).

Jassir, M.S., Shaker A., Khaliq, M.A. (2005). Deposition of heavy metals on green leafy vegetables sold on roadsides of Riyadh city, Saudi Arabia. *Bulletin of Environmental Contamination and Toxicology* 75, 1020-1027.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College
Muzaffarnagar

Jaishankar,M., Tseten,T., AnbalaganN., Mathew BB., Beeregowda KN (2014). Toxicity, mechanism and health effects of some heavy metals. *Interdiscip Toxicol.* 7(2), 60-72.

Kachenko,G.A., Singh B (2006). Heavy metal contamination in vegetables grown in urban and metal smelter contaminated sites in Australia. *Water, Air and Soil Pollution.* 169, 101-123.

Khalid Mohammed Ghasera., Shaik A., Rashid and Khyati Gupta., (2021). Heavy metals abundance and distribution in soil, groundwater and vegetables in parts of Aligarh, Uttar Pradesh, India: Implication for human health risk assessment. *CURRENT SCIENCE*, 121(8),1056-1063.

Kinuthia., G.K., Ngure, V., Beti, D (2020). Levels of heavy metals in wastewater and soil samples from open drainage channels in Nairobi, Kenya: Community health implication. *Sci Rep* 10, 8434.

Lake, D.L., Kirk, P.W.W., Lester, J.N (1984). The fractionation, characterization and speciation of heavy metals in sewage sludge and sewage sludge amended soils: a review. Journal of Environmental Quality 13.

Liu,W.X., Li HH., Li SR., Wang YW (2006). Heavy metal accumulation of edible vegetable cultivated by people's Republic of China. *Bulletin of Environmental Contamination and Toxicology* 76, 163-170.

Lokeshappa, B., Shivpuri, K., Tripath, V., Dikshit, A.K. (2012). Assessment of toxic metals in agricultural product. *Food Pub Heat*, 2(1):24-29.

Lopez-Alonso M., Benedito JL., Miranda M., Castello C., Hernandez J., Shore RF (2000). Toxic and trace elements in liver, kidney and meat from cattle slaughtered in Galicia (NW Spain), *Food Additives and Contaminants* 17, 447-457.

Mapanda F., Mangwayana EN., Nyamangara JK., Giller E (2005). The effect of long term irrigation using waste water on heavy metal content of soil under vegetables in Harare,

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College
Muzaffarnagar

Zimbabwe. *Agriculture Ecosystem and Environment,* 107, 151-165.

Mashiatullah., A. Riffat., M. Qureshi., A. Niaz., T. Javed and A. Nisar (2005). Biological quality of ground water in Rawalpindi/Islamabad. *The Environ. Monitor*, 13-18.

McBride, M.B., 2003. Toxic metals in sewage sludge-amended soils: has proportion of beneficial use discounted the risks? *Advances in Environment Research* 8.

McGrath, S.P., Chang AC., Page AL., Wilter E (1994), Land application of sewage sludge: scientific perspectives of heavy metal loading limits in Europe and the United States. *Environmental Reviews* 2, 108-118.

McBride, M.B., (2003). Toxic metals in sewage sludge-amended soils: has proportion of beneficial use discounted the risks? *Advances in Environmental Research* 8, 5-19.

Mohamed, H., El-Saeid (2003). Pesticide residues in canned foods, fruits, and vegetables: the application of Supercritical Fluid Extraction and chromatographic techniques in the analysis. *Scientific World Journal,* 11(3), 1314-26.

Radwan, M.A, Salama,A.K (2006) Market based survey for some heavy metals in Egyptian fruits and vegetables. *Food and Chemical Toxicology,* 44, 1273- 1278.

Razo I., Carrizales L., Castro J., Diazbarrigs F., Monroy M (2004). Arsenic andheavy metal pollution of soil, water and sediments in a semi-arid climate mining area in Mexico. *Water, Air and Soil Pollution,* 152, 129-152.

Sara AM., Bergquist Ulla EG., Gertsson PK., & Olsson ME., (2005). Flavonoids in baby spinach (spinacea oleracea L.):Changes during plant growth and storage, *Journal of agriculture and food chemistry*,53,9459-9464.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College
Muzaffarnagar

Scott, D., Keoghan, J.M., Allen, B.E., 1996. Native and low input grasses in New Zealand high country perspective. *New Zealand Journal of Agricultural Research*, 39, 499-512.

Seid-Mohammadi, A., Roshanaei, G., & Asgari, G. (2014). Heavy metals concentration in vegetables irrigated with contaminated and fresh water and estimation of their daily intakes in suburb areas of Hamadan, Iran. *Journal of research in health sciences*, *14*(1), 69-74.

Sharma, R.K., Agrawal, M., Marshall, F.M., 2006. Heavy metals contamination in vegetables grown in wastewater irrigated areas of Varanasi, India. *Bulletin of Environmental Contamination and Toxicology* 77, 311-318.

Sharma, R.K., Agrawal, M., Marshall, F.M., 2007. Heavy metals contamination of soil and vegetables in suburban areas of Varanasi, India. *Ecotoxicology and Environmental Safety,* 66, 258-266.

Sharma, A., Katnoria, J. K., & Nagpal, A. K. (2016). Heavy metals in vegetables: screening health risks involved in cultivation along wastewater drain and irrigating with wastewater. *SpringerPlus*, *5*(1), 1-16.

Sharma RK., Agrawal M., Marshall FM (2006). Heavy metals contamination in vegetables grown in wastewater irrigated areas of Varanasi, India. *Bulletin of Environmental Contamination and Toxicology* 77, 311-318.

Sharma,R.K., Agrawal,M., Marshall,F.M (2007). Heavy metals contamination of soil and vegetables in suburban areas of Varanasi, India. *Ecotoxicologyand Environmental Safety* 66, 258-266.

Sinha,S., Pandey,K., Gupta,A.K., Bhatt, K.,(2005). Accumulation of metals in vegetables and crops grown in the area irrigated with river water. *Bulletin of Environmental Contamination and Toxicology* 74, 210-218.

Singh,R.P., Agrawal M (2007). Effect of sewage sludge amendment on heavy metal accumulation and consequent responses of *Beta vulgaris* plant. *Chemo-sphere* 67, 2229-2240.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College
Muzaffarnagar

Singh.B (2001). Heavy metals in soils: sources, chemical reactions and forms. In: Smith D, Fityus S, Allman M (Eds) *Geotechniques*, Proceedings of the 2nd Australia and New Zealand conference on Environmental geotechniques, Newcastle, NSW, Australia, 77-93.

Singh S and Kumar M (2006). Heavy metal load of soil, water and vegetables in periurban Delhi.*Environmental Monitoring and Assessment* 120, 79-91.

Singh K.P., Mohon D., Sinha S., Dalwani R (2004). Impact assessment of treated/untreated wastewater toxicants discharge by sewage treatment plants on health, agricultural, and environmental quality in wastewater disposal area. *Chemosphere* 55, 227-255.

Stalikas CD., Mantalovas AC., Pilidis GA (1997). Multi-element concentrations in vegetable species grown in two typical agricultural areas of Greece. *Science of the Total Environment,* 206, 17-24.

Swapna Priya. E., G. Sunil., K. Shivaiah., Anil Gaddameedi and Ashish Kumar (2014). Extent of heavy metal contamination in leafy vegetables, soil and water from surrounding of musi river, hyderabad, India. *Journal of industrial pollution control,* 30(2), 267-271.

Tani FH., Barrington S (2005). Zinc and copper uptake by plants under two transpiration ratios Part I. Wheat. (Triticum aestivum L). *Environmental Pollution* 138,538-547.

Temmerman L., Hoenig M (2004). Vegetables crops for biomonitoring lead and cadmium deposition.

Journal of Atmospheric Chemistry, 49, 121-135

Varalakshmi, L. R., and Ganeshamurthy, A. N (2010). Heavy metal contamination of water bodies, soils and vegetables in peri urban areas of Bangalore city of India. *19th World Congress of Soil Science, Soil Solutions for a Changing World* 1-6.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College,
Muzaffarnagar

Verkleij JAC (1993). The effects of heavy metals stress on higher plants and their use as biomonitors In: Markert B (Ed). *Plants as Bioindicators: Indicators of Heavy Metals in the Terrestrial Environment*, 415-424.

Voutsa, D., Grimanis, A., Samara, C., (1996). Trace elements in vegetables grown in industrial areas in relation to soil and air particulate matter. Environmental Pollution 94, 325-335.

Whatmuff, M.S., (2002). Applying biosolids to acid soil in New South Wales: Are guideline soil metal limits from other countries appropriate? *Australian Journal of Soil Research* 40, 1041-1056.

Co-ordinator
IQAC, Shri Ram College
Muzaffarnagar

Chairman
IQAC, Shri Ram College
Muzaffarnagar