A Comparative Assessment of Nutritional Values of Jaggery and Sugar

Project Report

Submitted by
Dr. Sourabh Jain
Assistant Professor
Shri Ram College
Muzaffarnagar

funded by

Cosmos Ferrous Pvt. Ltd.
Muzaffarnagar

Shri Ram College Muzaffarnagar

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IQAC, Shri Ram College,
Muzaffarnagar

Principal
Shri Ram College
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37/1

Cosmos Ferrous (P) Ltd

Ref: COS/Grants/02/2019

Date: 09.06.2019

To,

Dr S C Kulshreshtha
Chairman,
Shri Ram Charitable Trust,
Parikrama Marg,
Muzaffarnagar

Dear Sir,

I am pleased to inform you that on occasion of GudMahotsava the management has approved an amount of Rs: 1,01,000/- for carrying out the project on 'A Comparative Assessment of Nutritional Values of Jaggery and Sugar'.
You are requested to submit us one copy of Project Report on its completion.
We are hereby sending you an amount of ₹ 1,01,000/- for the project.

Payment Details:
Cheque number-020159
Date-07/06/2019
Amount- ₹ 1,01,000/-
Bank Name- Allahabad Bank, Muzaffarnagar City Branch

With regards,
Yours truly
For Cosmos Ferrous Pvt. Ltd.

Usman
(Md Usman)
Director

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37/2

SHRI RAM COLLEGE

(Affiliated To CCS University, Meerut & Approved By NCTE) CIRCULAR ROAD, MUZAFFARNAGAR

'A' Grade Accredited by NAAC

Date: 09.06.2019

Dr. Sourabh Jain,
Department of Biosciences
Shri Ram College,
Muzaffarnagar

We are pleased to inform you that the Project Proposal entitled "**A Comparative Assessment of Nutritional Values of Jaggery and Sugar** " submitted by you to the Management Committee, which is related to Cosmos Ferrous Pvt. Ltd has been approved and an amount of Rs. 101,000 has been sanctioned for the Project in your department.

Please start working on the above said project and take necessary action for timely completion of the project.

Principal

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3713

Utilization Certificate

S.N.	Detail of sanction of Fund with Project name and Duration	Amount
1.	60-Day project on A Comparative Assessment of Nutritional Values of Jaggery and Sugar , Date of Sanction of Fund- 09-06-2019 as per Sanction Letter	101000.00
	TOTAL	101000.00

It is Certified that out of Rs. 101000.00 (Rs. One Lakh One Thousand Only) of grants sanctioned by **M/s Cosmos Ferrous Pvt Ltd** during the year 2019-20 in favor of **Shri Ram College, Muzaffarnagar,** a sum of Rs. 101000.00 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 expenses bills.

For Shri Ram College

Secretary

Place: Muzaffarnagar
Date: 02-09-2019

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Muzaffarnagar

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Muzaffarnagar

For Goel Rakesh & Co.
Chartered Accountants

Muzaffar-Nagar

Rakesh Kumar Goel
Proprietor
M. No. 071858
FRN : 003374C

A Comparative Assessment of Nutritional Values of Jaggery and Sugar

INTRODUCTION

The reference of sugar which was supposed to be invented in India can be found from ancient Indian text like "Atharva Veda." The sugar was introduced to world after the invasion of Alexander the Great in 327 BCE, when they found an alterna- tive to honey to sweeten food and described it as a "reed that gives honey without bees". Jaggery is noncentrifugal sugar (NCS) obtained by evaporation of water in sugarcane and is known by different name such as panela (Latin Amerika), jaggery (South Asia) and kokuto (Japan), Hakura (Srilanka), rapadura (Brazil), and Gur/Desi (Pakistan). Jaggery, a product of sugarcane, is rich in important minerals (calcium: 40–100 mg, magnesium: 70–90 mg, potassium: 1056 mg, phosphorus: 20–90 mg, sodium: 19–30 mg, iron: 10–13 mg, manganese: 0.2–0.5 mg, zinc: 0.2–0.4 mg, cop- per: 0.1–0.9 mg, and chloride: 5.3 mg per 100 g of jaggery), vitamins (vitamin A: 3.8 mg, vitamin B1: 0.01 mg, vitamin B2: 0.06 mg, vitamin B5: 0.01 mg, vitamin B6: 0.01 mg, vitamin C: 7.00 mg, vitamin D2: 6.50 mg, vitamin E: 111.30 mg, and vitamin PP: 7.00 mg), and protein: 280 mg per 100 g of jaggery, which can be made available to the masses to mitigate the problems of mal nutrition and under nutrition. Sugarcane (Saccharum officinarum Linn.) is well-known crop of the family Poaceae. India is the second largest producer of sugarcane, after Brazil. Saccharum is derived from the Greek word Sakcharon, which means sugar especially sucrose. S. officinarum Linn, is a perennial grass, indigenous to tropical South Asia and South- east Asia. It has a thick longitudinal stalk, which is generally three to five meters in height, approximately 5 cm in diameter, and is characterized by its sweet taste due to its high sucrose content. It is also known as chewing and noble cane. The sugar- cane crop grows well in tropical and subtropical regions. It will require well-drained soil of pH 7.5–8.5 and high organic matter, along with a hot and humid environment.

Sugarcane crop is cultivated for the production of sugar, but the processing of sug- arcane yields various valuable products such as bagasse, brown sugar, molasses, syrup, and jaggery, along with sugar (table sugar). However, other sugarcane prod- ucts such as jaggery, brown sugar, and molasses are obtained in an unrefined form. On account of the unrefined form of these products, there must be a presence of some phenolic compounds, which enhance their nutritional and medicinal value. Sugar is of considerable cultural and hedonic relevance in India; nutritionally it pro- vides only "empty" calories (1 g of sugar gives 4 kcal). It lacks the natural minerals which are present in the beet root or sugarcane.

COMPOSITION OF JAGGERY

The color of jaggery varies from golden brown to dark brown and its constitute of 50% sucrose, 20% invert sugar, 20% moisture, and remainder is insoluble matter such as ash, protein, and bagasse fines. It contains all the vitamins. It is rich in important minerals (namely, calcium: 40–100 mg, magnesium: 70–90 mg, potassium: 1056 mg, phosphorus: 20–90 mg, sodium: 19–30 mg, iron: 10–13 mg, manganese:0.2–0.5 mg, zinc: 0.2–0.4 mg, copper: 0.1–0.9 mg, and chloride: 5.3 mg per 100 g of jaggery), vitamins (namely, vitamin A: 3.8 mg, vitamin B1: 0.01 mg, vitamin B2:0.06g, vitamin B5:

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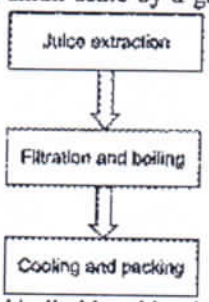
0.01 mg, vitamin B6: 0.01 mg, vitamin C: 7.00 mg, vitamin D2: 6.50 mg, vitamin E1: 11.30 mg, and vitamin PP: 7.00 mg), and protein: 280 mg per 100 g of jaggery. The other form of jaggery is also called as Gur which is high calorie sweetener and contains minerals, protein, glucose, and fructose and is health- ier in intake when compared with white sugar. The good quality Gur contain more than 70% sucrose, less than 10% of glucose and fructose and 5% minerals, 3% moisture, and accumulate large amount of ferrous (iron) during its preparation in iron vessel

NUTRITIONAL CONTENT OF JAGGERY

Jaggery is far complex than sugar, as it is made up of longer chains of sucrose. Hence, it is digested slower than sugar and releases energy slowly and not spon- taneously. This provides energy for a longer time and is not harmful for the body. Jaggery also gathers a considerable amount of ferrous salts (iron) during its prepa- ration, as it is prepared in iron vessels. This iron is also good for health, particu- larly for those who are anemic or lack iron. Jaggery also contains traces of min- eral salts which are very beneficial for the body. Mineral salts present in jaggery leaves a hint of salt on tongue. These salts come from the sugarcane juice where it is absorbed from the soil. Furthermore, jaggery is very good as a cleansing agent. It cleans lungs, stomach, intestines, esophagus, and respiratory tracts. Those who face dust in their day-to-day life are highly recommended to take a daily dose of jaggery. This can keep them safe from asthma, cough and cold, congestion in chest, etc. Gur is known to produce heat and give instant energy to a human body. Gur is sup- plied to the workers for in order to protect them from dust allergies.

PRODUCTION OF JAGGERY

Jaggery manufacturing is done on a small scale by a group of farmers. The juice is extracted from



fresh sugarcane. Then it is filtered and boiled in wide, shallow iron pans with continuous stirring and, simultaneously soda or bhindi juice is added in required quantity. While boiling, brownish foams come at the top which are continuously removed to get golden yellow color of jaggery. The consistency of the juice becomes thick and then it is poured into the small to medium sized iron or aluminum cans where blocks of jaggery are formed after cooling. Size of the blocks can vary from 1 to 12 kg. Finally these blocks are packed in gunny bags. From 100 kg of sugarcane, 10 kg of jaggery is made. The process flowchart is as follows:

TYPES OF JAGGERY

The jaggery is produced in three forms: liquid, solid, and granular, which are described subsequently in detail.

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LIQUID JAGGERY

It is that product which is obtained during concentration of purified sugarcane juice during jaggery making, and is semi liquid syrup like product. The quality of liquid jaggery largely depends upon quality and composition of cane juice, type of clarificants used, and striking temperature at which concentrating juice is collected. For quality liquid jaggery, the juice concentrate is removed from boiling pan, when it reaches striking point temperature of 103°C–106°C, depending upon the variety and agroclimatic zone. To avoid crystallization and to make liquid jaggery attrac- tive in color, citric acid is added at 0.04% (400 mg/kg of liquid jaggery), whereas to improve shelf life of liquid jaggery without deterioration in quality, potassium metabisulphite at 0.1% (1 g/kg of liquid jaggery), or benzoic acid at 0.5% (5 g/kg of liquid jaggery), is added. Liquid jaggery is then allowed to settle for period of 8–10 days at ambient conditions. Later after filtration, it is properly packaged in sterilized bottles. Chemical composition of typical liquid jaggery could be: water 30%–36%, sucrose 40%–60%, invert sugar 15%–25%, calcium 0.30%, iron 8.5–10 mg/100 mg, phosphorus 05/100 mg, protein 0.10/100 mg, and vitamin B 14/100 mg.

GRANULAR OR POWDER JAGGERY

The process of making granular jaggery is similar up to concentration. The concen- trating slurry is rubbed with wooden scrapper, for formation of grains. The gran- ular jaggery is then cooled and sieved. It is yellow to golden brown in color and 3 mm sized crystals are found to be better for quality granular jaggery. Raising of pH of cane juice with lime, up to 6.0–6.2, and striking point temperature of 120°C was found to yield quality granular jaggery with high sucrose content of 88.6%, low moisture of 1.65%, with good color, friability and crystallinity. Jaggery in the form of granules (sieved to about 3 mm), sun dried and moisture content reduced to less than 2%, and packed in polyethylene polyester bags or polyethylene bottles, can be stored for longer time (more than 2 years), even during monsoon period with little changes in quality. The caloric value of jaggery is same when compared with solid jaggery. The composition per 100 g of granular jaggery is 80–90 g sucrose, 5–9 g reducing sugar, 0.4 g protein, 0.1 g fat, 9 mg calcium,4 mg phosphorous, and 12 mg iron.

SOLID JAGGERY (CUBE SHAPE)

The filtered cane juice was pumped into open pans kept on triple pan furnace, and heated with the bagasse as fuel. The juice was clarified with herbal clarificant (deola extract at 45 g/100 kg juice), to make light colored jaggery by eliminating impurities in suspension, colloidal and coloring compounds by accumulation. The juice was then boiled and concentrated to make jaggery in desired shape and size. Mandal studied the effect of common packing materials on keeping quality of sug- arcane Jaggery during monsoon season. In their studies, it was revealed that the best packing material for storing Gur during monsoon season was heat sealed low-den- sity polyethylene (LDPE) packet of 150 gauge followed by glass jars. LDPE packets prevented moisture ingress, fall in pH and inversion of sucrose in the stored Gur to the maximum extent.

PHYTOCHEMICAL PROFILE OF JAGGERY

The phytochemistry of jaggery (NCS), brown sugar, and molasses, it is necessary to explain the phytochemical profile of sugarcane juice. Before 1971, it was assumed that the color of juice might be due to the presence of plant pigments. In 1971 several color components from sugarcane juice have been identified, with chlorogenic acid , cinnamic acid, and flavones being some of them. Following that, all the colored components from sugarcane juice were classified into four major classes: Plant pigments, polyphenolic compounds, caramels, and degradation products of sugars condensed with amino derivatives. Sugarcane juice was then extensively studied for their flavonoid content. Thereafter, a large num- ber of old and new flavonoids were isolated and identified. High-perfor- mance liquid chromatography with diode-array detection analysis of phenolic com- pounds from sugarcane juice showed the presence of phenolic acids such as hydrox- ycinnamic acid, sinapic acid, and caffeic acid, along with flavones such as apigenin, luteolin, and tricin. Among the flavones, tricin de- rivatives accounted for the highest concentration. Four new minor flavones swertisin , tricin-7-O-neohesperoside-4′-O-rhamnoside, tricin-7-O-methyl- glucuronate-4′-O-rhamnoside, and tricin-7-O-methylglucuronide were isolated and identified from sugarcane juice.

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MEDICINAL BENEFIT OF JAGGERY

Sugarcane contains various phytochemicals including phenolic compounds, plant sterols, and policosanols. Phenols help in the natural defense of plants against pests and diseases, while plant sterols and policosanols are the components of wax and plant oils. The phytochemicals have gained increased interest due to their antioxidant activity, cholesterol-lowering properties, and other potential health benefits. Several workers have reported the different biological activities of sugarcane in various in vivo and in vitro test models.

ANALGESIC ACTIVITY

Ethanol extracts (95%) of both fresh leaves and shoots were administered intragastrically to mice at a dose of 1 g/kg. The leaf extracts were active against benzoyl peroxide-induced writhing and tail-flick response, but ethanol extract of shoots were active only against the tail-flick method.

ANTIHEPATOTOXIC ACTIVITY

The aqueous extract of dried stems administered intraperitoneally to mice, at a dose of 25 mg/kg, was active against chloroform-induced hepatotoxicity.

ANTIHYPERGLYCEMIC ACTIVITY

The ethanol extract of both dried leaves and stems was administered intragastrically to rabbits at a dose of 1 g/kg and 60 mg/animal, respectively. The ethanol extract of leaves produced weak activity against alloxan-induced hyperglycemia. Furthermore, the juice of dried stems also exhibited hypoglycemic activity when adminis- tered intraperitoneally to mice at a dose of 200 mg/kg.

DIURETIC ACTIVITY

The ethanol extract (50%) of fresh leaves administered intragastrically to rats at a dose of 40 mL/kg, was active, while its decoction did not exhibit any diuretic activity.

ACETYLCHOLINE RELEASE

The effect of policosanols on the release of acetylcholine (ACh) at the neuromus- cular junction in mice was examined. Results showed that policosanols enhanced either the spontaneous or the evoked ACh release to a small extent. Furthermore it was also observed that the rate of conformational changes induced at the nicotinic receptor channel complex was also increased, which confirmed the release of Ach.

ANTIINFLAMMATORY EFFECT

Mixtures of fatty acids isolated from sugarcane wax were examined for their an- tiinflammatory effect on both rats and mice. Oral administration of this mixture showed antiinflammatory activity in the cotton pellet granuloma assay and in the carrageenan-induced pleurisy test, both in rats, as well as in the peritoneal capillary permeability test in mice.

ANTIHYPERCHOLESTEROLEMIC EFFECT

The antihypercholesterolemic effect of policosanols was examined on normocholesterolemic New Zealand rabbits. Policosanols were administered orally at a dose of 5–200 mg/kg for 4 weeks. Results showed that there was a significant decrease in the level of total cholesterol and low-density lipoprotein cholesterol (LDL-C) in a dose-dependent manner. The serum triglyceride level was also reduced, but the reduction observed was not dose dependent. The high-density lipoprotein level re- mained unchanged. The policosanols were also examined for prevention of ath- erosclerosis in male New Zealand rabbits fed on a cholesterol-rich diet for 60 days at doses of 25 or 200 mg/kg. Policosanol-treated rabbits did not develop marked hypercholesterolemia and the intima thickness was also significantly less compared to the control animals.

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ANTITHROMBOTIC ACTIVITY

Policosanols and D-003 were examined for their platelet aggregation and antithrombotic activity in rats. Oral administration of D-003 at a single dose of 200 mg/kg and policosanols at a concentration of 25 mg/kg in rats significantly increased the plasma level of 6 keto-PGF1-α (a stable metabolite of prostacyclin PGI when compared with the control group. Furthermore, D-003 also significantly reduced the thromboxane, TxB, plasma levels and weight of venous thrombus in collagen-stimulated whole blood of rats. The pharmacokinetic study showed that the effect of D-003 was observed after 0.5 hours of dosing and the maximal ef- fect exhibited after 1- 2 hours of treatment.

SUGAR AND ITS CLASSIFICATION

The most popular sweetener in the world, sugar, was invented in India. There is ref- erence to sugarcane cultivation and the preparation of sugar in an Indian religious text, the Atharva Veda. The word sugar is a derivative of sarkara, meaning gravel in Sanskrit. Sugar became known to the world when the army of Alexander the Great came to India in 327 BCE. Interestingly they were surprised to see another alter- native to honey to sweeten food, and described it as a "reed that gives honey with- out bees". The term "added sugar" is sometimes used interchangeably with "free sugar" but is considered to include sugars and syrups added to foods during processing, food preparation, or at the table, but does not include honey or fruit juices. Sugar-sweetened beverages (SSBs) include the full spectrum of aerated drinks, fruit drinks, and energy and vitamin water drinks containing added sugars. Many of these beverages are sweetened with high fructose corn syrup (HFCS), the most common added sweetener in processed foods and beverages, and some with sucrose or fruit juice concentrates. The HFCS that is commonly used in beverages contains 55% fructose and 45% glucose, while sucrose or table sugar consists of 50% fructose and 50% glucose. In the Indian context, available databases do not define sugars clearly; however, from the data breakdown it appears that "sugar" means white sugar, honey, or brown sugar but not syrups and "traditional sugars" such as jaggery (also called gur in India) and khandsari.

SUGAR CONSUMPTION IN INDIA

India is the next largest producer of sugar after Brazil. The data suggested the consumption of traditional sugar consumption mainly jaggery and khandsari declined in last decade. The per capita sugar intake is defined as raw sugar con- sumption per person of a given country or territory, it is calculated based on the statistical disappearance of sugar in the country or territory after adjustment for trade and exports. The assumption is made that the statistical disappearance of sugar is equal to consumption after adjusting for utilization for nonhuman consumption. Indian sugar production exceeded 27 million tons during 2012–13, a jump from 15 million tons in 2005. Overall sugar intake has not changed from 2008 to 2011; however, a slight decrease in sugar intake from 19.6 kg in 2005 to 18.9 kg in 2011 has been recorded. Interestingly while intake of "traditional sugars" has declined, an increase in the intake of sugar from SSBs has been recorded. It is interesting to note that when consumption from jaggery/khandsari and SSBs are added to that of white sugar, the "total" sugar intake in Indians exceeded the average global per capita consumption.

HEALTH EFFECT AND SUGAR CONSUMPTION

The intake of fructose especially at high dose might increase the level of total cholesterol, uric acid, and postprandial triglycerides under caloric matched conditions, based on the metaanalyses of 20 controlled feeding trials in 344 participants. However, its effects on the atherogenic aspects of the lipid profile (LDL-C, ApoB, nonhigh-density lipoprotein cholesterol, and total cholesterol:high-density lipopro- tein cholesterol ratio), insulin, and markers of nonalcoholic fatty liver appear to be no worse than those of glucose. Fructose may also have important advantages for body weight, glycemic control, and blood pressure over glucose. But overall, multiple short-term studies find that sugar intake leads to the following adverse events, mostly through accumulation of body fat and intraabdominal fat hype- ruricemia, hypertriglyceridemia, insulin resistance, metabolic syn- drome, diabetes, fatty liver, and high levels of free fatty acids. High doses of fructose (>50 g/day at least) in humans have been implicated in in- sulin resistance, postprandial hypertriglyceridemia, intraabdominal fat accumula- tion, and elevated blood pressure mediated by high levels of nonesterified fatty

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acid (NEFAs). Increased portal delivery of NEFAs increase hepatic glucose pro- duction, impair β-cell function, and cause hepatic steatosis. Interest- ingly SSBs increase the risk of metabolic syndrome and type 2 diabetes mellitus (T2DM) not only through increasing adiposity but also by increasing the dietary glycemic load, which causes insulin resistance, β-cell dysfunction, and inflamma- tion. Specifically risk of T2DM associated with SSB consumption in humans has been found to be statistically significant after adjustment for total energy con- sumption and body mass index. The above discussion suggests that sugar intake contributes to multiple metabolic disorders due to accrual of body fat, as well as directly through excess NEFAs, which in turn impair critical functioning of the liver, pancreas, and cellular functions. In this context it is important to mention here that Indians already have higher NEFAs, insulin resistance, hepatic steatosis, and dysglycemia than white Caucasians. All these metabolic dysfunctions could be further exacerbated by indirect (through obesity) and direct effects on multiple metabolic organs. Importantly Indians are increasingly consuming traditional Indian sweets along with SSBs, and westernized sugar-loaded food items, which are now easily available due to globalization. Although research data are lacking, it would not be irrational to presume that increasing intake of sugar/sugar-containing prod- ucts may parallel the rapid rise of obesity and T2DM in Indians. In this respect,it is important to note that Weeratunga et al. analyzed data from 165 countries to study the associations between the prevalence of diabetes mellitus and per capita sugar consumption, utilizing data from International Diabetes Federation and from the Sugar Year Book. They showed a stronger association between diabetes preva- lence rates and per capita sugar consumption in Asia ($P<.001$; $\beta=0.707$) and South America ($P=.010$; $\beta=0.550$) $R2=0.568$ when compared with the rest of the world. A strong positive correlation coefficient (0.599; $P<.001$) was observed between the prevalence of T2DM and per capita sugar consumption using data from all 165 coun- tries. Asia had the highest correlation coefficient with a PCC of 0.660 ($P<.001$) and lower correlations were observed for Africa ($PCC=0.381$; $P<.007$). The Eastern European region demonstrated a positive correlation between per capita sugar con- sumption and T2DM prevalence ($PCC=0.608$; $P<.036$.

CONCLUSIONS

The current chapter emphasized that the sugarcane juice used for manufacturing jag- gery/gur has various nutrients and beneficial health effects when compared with the white sugar, although intake of sugar-added products is increasing immensely which is leading to health problems mainly diabetes and obesity. The promotion of per capita intake of jaggery and its related product might increase the beneficial health of individuals and reduce the consumption of dietary sugar.

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