

Investigation physico-chemical characterization of jaggery from different sugarcane varieties

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Author contributions

Alok Sharma designed the concept of the research, whereas Amrat Pal Singh performed the some of the experiment part. Alok Sharma and Amrat Pal Singh wrote the manuscript. Both the authors provided feedback and complied the experimental data of the manuscript.

Competing interests

The authors declare no conflicts of interest.

Acknowledgments

The authors are thankful to the Department of Pharmacognosy, ISF College of Pharmacy for providing all the facilities.

Citation

Singh AP, Sharma A. Investigation physico-chemical characterization of jaggery from different sugarcane varieties. *Food Health* 2022;4(4):22. doi: 10.53388/FH20221101022.

Executive editor: Na Liu.

Received: 15 September 2022; Accepted: 26 October 2022;

Available online: 31 October 2022.

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Abstract

Objective: Jaggery is a natural sweetener prepared by hand in limited facilities from concentrated sugar cane juice. Jaggery is regarded as a therapeutic sugar in Indian Ayurvedic medicine for the treatment of lung and throat diseases. Studies conducted in vivo revealed that a jaggery-based dietary supplement has positive health effects. The awareness among the general public regarding the functional food products has been catching up fast. Consumers are opting more for functional food products due to higher health consciousness. Higher the demand, higher the supply of new varieties of functional food. Thus giving scope to develop new products with highly nutritive value. **Method:** The goal of the current study was to examine the physical and chemical characteristics of jaggery made from the sugarcane varieties Co 86032, Co 419, and Co 62175. With varied traits including yield, sucrose content, disease resistance, and salt tolerance, these sugarcane varieties have dominated the peninsular India. The physical and chemical characteristics of jaggery prepared experimentally from three distinct sugarcane varieties (Co 86032, Co 419, and Co 62175) were determined in the study. Moisture, water activity (a_w), ash, minerals, reducing sugars, sucrose, pH, colour, insoluble solids (IS), transmittance at 720 nm, and filterability were the variables that were assessed. Additionally, measurements of the flavonoid and total phenolic contents were performed. Water activity (a_w), reducing sugars, pH, colour, moisture, and water activity (a_w) were the variables with the most variability. **Result:** Sample Co 62175 had the highest observed total sugar, whereas sample Co 419 had the lowest. In accordance with the findings of the current experiment, sugarcane variety Co 62175 produced the best jaggery when compared to sugarcane variants Co 419 and Co 86032. **Conclusion:** There is higher potential to develop functional food which can enhance the qualitative and quantitative factors. Hence the study was undertaken with the objective of development, nutritional characteristics and consumer acceptability of jaggery.

Keywords: sugarcane; jaggery; nutraceuticals; properties; functional food; Ayurveda

Introduction

Jaggery, a sugar-rich plant food that is consumed globally, is typically made by concentrating sugarcane juice (*Saccharum officinarum*). Jaggery provides a lot of nutritional and therapeutic benefits. Jaggery is regarded as a therapeutic sugar in Indian Ayurvedic medicine for the treatment of lung and throat diseases. Studies conducted in vivo revealed that a jaggery-based dietary supplement has positive health effects. Dietary jaggery has protective effects against lung damage brought on by coal, silica dust, and other particulate matter, as well as against the development of atherosclerosis [1], chromosomal abnormality owing to arsenic poisoning, and lung cancer [2, 3]. According to research, jaggery, which is the least processed sugar, preserves phenolics and other phytochemicals with strong biological properties including antioxidant, cytoprotective, and anthelmintic action [4, 5].

Asava, Arishta, Guda, and other Ayurvedic medicines' standards and quality are just some of industry's issues. These issues directly relate to the caliber of the jaggery. The society also has to be made aware of the many kinds of jaggery available on the market, its various sources, preparation techniques, quality, and any accepted standards for gauging its purity, among other things.

Jaggery may be found in the market primarily in three different forms: solid, liquid, and granular. About 80% of the jaggery produced in India is made in solid form, with the remaining 20% prepared in liquid and granular forms. In much of Maharashtra and West Bengal, liquid jaggery is consumed as part of the diet and is becoming more and more significant commercially. Granular jaggery is also well-liked, especially among rural populations. Depending on the color of the cane, sugarcane juice can range in color from dark grey to bright yellow and is an opaque liquid [6].

The goal of the current study was to examine the physical and chemical characteristics of jaggery made from the sugarcane varieties Co 86032, Co 419, and Co 62175. With varied traits including yield, sucrose content, disease resistance, and salt tolerance, these sugarcane varieties have dominated the peninsular India.

Materials and Methods

Sugarcane Varieties

Three different sugarcane types, Co 86032, Co 419, and Co 62175, were purchased from a local farmer in Moga, Punjab (Chahal farm). The same piece of land was used to grow every kind of sugarcane using comparable management practices.

Jaggery preparation

The process outlined by Jagannadha Rao et al. was used to make jaggery (2007). Milk of Lime [$\text{Ca}(\text{OH})_2$] was used to bring the pH of sugarcane juice, which was extracted from several sugarcane varieties, to 6.6. The juice was originally boiled for 10 minutes, and all of the scum that had developed during the boiling process was fully removed using muslin cloth as a filter. After reaching a final temperature of 118 °C, the juice was boiled and condensed into a thick syrup. Subsequent boiling totally eliminated the scum that had accumulated. To get the correct forms, the syrup was put into chocolate moulds after cooling. For subsequent examination, all of the samples were kept at 4 °C in a sealed container.

Physical characterization

pH. A pH meter (Systronics India Pvt. Ltd., India) was used to measure the pH of a 5% W/V jaggery solution at room temperature [7].

Color. Using a visible spectrophotometer (Systronics India Ltd. Gujarat, India) with a small modification, the color of jaggery in a 5% W/V solution was measured at 540 nm [8].

Turbidity and filterability. Jaggery's turbidity and filterability were assessed using the previously stated methodology [7]. A 5% (W/V) jaggery solution was separated into two halves and tested for turbidity. The second component was measured for the percentage of transmittance at 720 nm using a visible spectrophotometer, whereas

the first piece was filtered with Whatman No. 1 filter paper and referred to as blank. Under the same circumstances, the filtration rate of the jaggery solution was compared to that of the pure sucrose solution. After filtering a pure sucrose (28 °Brix) solution using Whatman No. 1 filter paper, the filtered volume was measured after 3 minutes. The steps were repeated using a 5% jaggery solution, and the filterability percentage was computed.

Insoluble solids. Jaggery's insoluble solids were measured using a modified technique described in the literature [7]. After being dissolved in distilled water and run through Whatman No. 1 filter paper, one gramme of jaggery was used. The filter paper residue was dried and weighed. The proportion of insoluble solids on a dry weight basis.

Water activity (a_w). A water activity meter (Novasina, Switzerland) with resistive electrolytic measurement-based technology was used to calculate the water activity.

Moisture and ash content. Jaggery's moisture and ash content were calculated using the official AOAC's standard procedures [9]. In a hot air oven, 10 g of jaggery was dried for 6 hours at 70 °C. The drying process was continued until a steady weight was reached. Weight loss reveals the jaggery's moisture content. The dried jaggery was heated to 600 °C in a muffle furnace for 4 hours after being burned in a silica crucible above a burner. This process removed all carbon. The furnace's silica basin was taken out, cooled, and weighed. Results were presented as percentages based on dry weight.

Chemical characterization

Reducing sugars. Jaggery's reducing sugar content was calculated using Fehling's technique [10]. In a nutshell, N/2 jaggery solution (13 g in 100 mL) was titrated against Fehling's solution and taken in a conical flask while being heated using 1% methylene blue as an internal indicator. The titrant's blue tint turning colorless was used to identify the endpoint. The titrates volume was noted. As a benchmark, dextrose (0.5%) was employed.

$$\text{Reducing sugar (\%)} = 100 \left(\frac{\text{mL}}{\text{Sample weight (g)}} \right) \times 0.12 \times 100 / \text{Sample titer (mL)} \times$$

Non-reducing sugar (sucrose). Jaggery's non-reducing sugar content (sucrose) was measured using the ICUMSA technique and a Double R. Polarimeter [11]. As a result, 0.5 g of lead acetate was used to decolorize 13 g of jaggery that had been dissolved in 100 mL of distilled water. Whatman No. 1 filter paper was used to filter the solution, and the filtrate collected in a 200-mm tube was tested for pol reading. Also noticed were the pol reading and the ambient temperature. The following formula was used to determine the jaggery's % sucrose content:

$$\text{Brix (\%)} = \text{Observed Brix} - \text{Corrected Brix (at room temperature)}$$

$$\text{Sucrose (\%)} = \text{Pol reading} \times 100 / \text{Brix (\%)}$$

Total phenol content. Using the Folin-Ciocalteu technique, the total phenol content of jaggery was measured spectrophotometrically [12]. To 900 µL of water, a sample aliquot of 100 µL jaggery (5%) was added. Sequentially adding 1 mL of Folin-Ciocalteu reagent (1:2, v/v) and 2 mL of 10% sodium carbonate, they were well mixed before being incubated for an hour at room temperature. In a visible spectrophotometer, the absorbance was recorded at 765 nm. The standard was gallic acid. Milligrams of gallic acid equivalent (GAE) per gramme of sample served as the unit of measurement for the total phenolic content.

Total flavonoid content. The aluminium chloride technique was used to calculate the total flavonoid content of jaggery [13]. Distilled water was used to dilute a sample aliquot of 200 µL jaggery (5%) to 2 mL. 100 mL of 1 M potassium acetate and 100 mL of 10% aluminium chloride were added sequentially and incubated for 30 min at room temperature. 415 nm was used to measure the optical density of the reaction mixture. Total flavonoid concentration was reported as micrograms of quercetin equivalent (QE) per gramme of sample, with quercetin serving as the reference.

Results and discussion

Physical characterization of jaggery

The findings of jaggery's physical characteristics, including pH, color, moisture, turbidity, filterability, and insoluble particles, are shown in Table 1.

In terms of ensuring food safety, maintaining quality, and meeting standards, moisture content and water activity are two essential metrics. Water activity evaluates the free/active water present in jaggery that is significant for microbial development, chemical reactions, and enzyme activity. Moisture content describes the overall quantity of water contained in jaggery in terms of percentage. The range of water activity (a_w) values is 0 to 1. Foods with a high water activity and moisture content offer a favorable environment for the development of microorganisms that cause deterioration. 5% – 7% moisture content is what the Bureau of Indian Standards (BIS) mandates for fresh jaggery [14]. The moisture content and water activity of all sugarcane varieties in jaggery did not significantly differ from one another. The moisture content range for the jaggery samples was within the BIS guidelines for all evaluated kinds. The results were comparable to the jaggery tested by Guerra and Mujica and the water activity (a_w) of jaggery ranged between 0.6 and 0.7. Due to the fact that this range of a_w was ideal for xerophilic microbe development [15], care must be taken to limit their growth in jaggery while it is being stored. Slight variations in moisture content and water activity within kinds of jaggery may be the result of undetermined mistakes made during the chilling and moulding processes. Jaggery often discourages the growth and proliferation of germs, moulds, and yeast due to its low initial moisture and high solid components [8]. According to Guerra and Mujica, the pH of jaggery was in the range of

5.58 and 5.87. However, the actual pH of all sugarcane kinds' jaggery was somewhat lower, establishing a panela minimum pH of 5.90. All cane types tested for jaggery exhibited a reduction in pH, which may have been caused by inadequate lime addition during juice clarity.

Based on the optical density of the jaggery solution at 540 nm, the color intensity of the jaggery was calculated. The color of jaggery is a key factor in both customer preference and market value. Jaggery browning, which results in deeper coloring of the jaggery, is caused by the Maillard process, sucrose alkaline breakdown, polyphenol oxidation, or sugar caramelization [16]. All cane kinds of jaggery had considerably more color intensity. Co 62175, Co 86032, and Co 419 jaggery, respectively, showed enhanced color absorbance as the proportion of optical absorbance increased.

By computing the spectrophotometer's percentage of transmittance at 720 nm, the turbidity of jaggery samples was calculated. Jaggery solution's turbidity decreases with increasing % transmittance. Additionally, the turbidity of jaggery was directly correlated with its insoluble solid concentration. All types of jaggery showed a rise in turbidity, a rise in the amount of insoluble solids, and a fall in filterability. When compared to Co 419 and Co 86032, the turbidity of Co 62175 substantially increased. Co 419 and Co 86032 jaggery samples had greater insoluble solids levels than Co 62175 variety samples. The Co 62175 sugarcane cultivar has more ash in its jaggery. The filterability of jaggery samples, on the other hand, decreased when turbidity and insoluble solids rose. Color, turbidity, filterability, and insoluble solids of jaggery all had recorded trial ratings that differed statistically significantly from one another.

Table 1 Physical characteristics of jaggery from different sugarcane varieties

S. No.	Parameters	Sugarcane varieties		
		Co 62175	Co 419	Co 86032
1.	Moisture (%)	5.14	4.87	4.93
2.	Ash (%)	0.04	0.03	0.03
3.	Insoluble solids (g/100 g)	5.39	7.81	7.12
4.	Filterability (%)	77.17	65.43	71.91
5.	pH	5.98	5.53	5.73
6.	Color (OD at 540 nm)	1.103	0.775	0.941
7.	Turbidity (% transmittance at 700 nm)	33.60	23.13	16.63
8.	Water activity, a_w (%)	0.728	0.739	0.749

Table 2 Chemical characteristics of jaggery from different sugarcane varieties

S. No.	Parameters	Sugarcane varieties		
		Co 62175	Co 419	Co 86032
1.	Reducing sugar (%)	17.91	18.26	17.36
2.	Sucrose (%)	71.16	68.00	70.46
3.	Total phenolic content (mg/g)	3.43	3.16	3.76
4.	Total flavonoid content (mg/g)	0.68	0.58	0.46

Chemical characterization of jaggery

The results of jaggery's chemical characteristics, including its sucrose, reducing sugar, total phenol, and flavonoid content, are listed in Table 2.

The main sugar in jaggery is sucrose, a non-reducing sugar, while the main reducing sugar is glucose. In the current investigation, the values of sucrose for the Co 62175, Co 419, and Co 86032 samples are 71.16, 68.00, and 70.46, respectively. Inversion of sucrose into glucose, fructose, and other hazardous compounds created in jaggery may be the source of the reduced level of sucrose in the market samples, which occurred more than 24 hours after harvest. Therefore, there is a possibility of sucrose depletion. The samples shown above were made during the monsoon season. Juice's sugar content will decrease if suspended contaminants are not properly removed. Flavonoids, the most prevalent type of polyphenols found in plant diets, have a variety of health advantages [17]. In the current samples, sample Co 62175 had the highest total sugar concentration and sample Co 419 had the lowest.

All sugarcane varieties' jaggery had considerable flavonoids and total phenol levels. Jaggery samples from the Co 62175, Co 419, and Co 86032 types had respective phenol content readings of 3.43, 3.16, and 3.76 as well as 0.68, 0.58, and 0.46 flavonoids (quercetin, QE). Jaggery contains phenolic compounds that support biological processes.

Conclusion

Jaggery is frequently used in pharmaceuticals and is freely accessible in the markets. Jaggery comes in a variety of forms and is sold in the market. For jaggery as a whole, Agmark standards are available. Because jaggery is a common food item and is employed as a sweetening ingredient for therapeutic purposes in Ayurvedic medicine, its purity and quality must be guaranteed on grounds of public health. Standards should be established for all types of guda (jaggery) made from sugarcane that are offered for sale in the market in order to achieve the goal of quality.

According to the findings of the current experiment, sugarcane variety Co 62175 produced the best jaggery when compared to sugarcane variants Co 419 and Co 86032. 5.14% moisture, 5.98 pH, and 0.04% total ash were all present. In the current samples, sample Co 62175 had the highest total sugar concentration and sample Co 419 had the lowest.

References

- Okabe T, Toda T, Inafuku M, et al. Antiatherosclerotic Function of Kokuto, Okinawan Noncentrifugal Cane Sugar. *J Agric Food Chem* 2008;57:69–75. <http://dx.doi.org/10.1021/jf802796m>
- Singh N, Kumar D, Raisuddin S, et al. Genotoxic effects of arsenic: Prevention by functional food-jaggery. *Cancer Letters* 2008;268:325–330. <http://dx.doi.org/10.1016/j.canlet.2008.04.011>
- Sahu AP, Saxena AK. Enhanced translocation of particles from lungs by jaggery. *Environmental Health Perspectives* 1994;102:211–214. <http://dx.doi.org/10.1289/ehp.94102s5211>
- Harish Nayaka MA, Sathisha UV, Manohar MP, et al. Cytoprotective and antioxidant activity studies of jaggery sugar. *Food Chem* 2009;115:113–118. <http://dx.doi.org/10.1016/j.foodchem.2008.11.067>
- Prasad P, Kumar PP, K. Satyavathi K, Prabhakar MC. Comparatives studies on anthelmintic activity of natural sweeteners. *Res J Pharm Biol Chem Sci* 2010;1(3):510-514. [http://rjpbcs.com/pdf/2010_1\(3\)/59.pdf](http://rjpbcs.com/pdf/2010_1(3)/59.pdf)
- Rao PVK, Das M, Das SK. Jaggery-A Traditional Indian Sweetener. *Indian J Tradit Knowl* 2007;6(1):95-102. <http://nopr.niscpr.res.in/handle/123456789/854>
- Guerra MJ, Mujica MV. Physical and chemical properties of granulated cane sugar “panelas.” *Food Sci Technol* 2010;30:250–257. <http://dx.doi.org/10.1590/S0101-20612010005000012>
- Mandal D, Tudu S, Mitra SR, et al. Effect of common packing materials on keeping quality of sugarcane jaggery during monsoon season. *Sugar Tech* 2006;8:137–142. <http://dx.doi.org/10.1007/BF02943648>
- Helrich K. *Official methods of analysis of the Association of Official Analytical Chemists*. 15th eds, Washington DC, 1990.
- Chandrakanth V, Mysore Annaiah HN, Shivalingaiah S, Chikkappaiah L. Cardamom [Elettaria cardamomum (L.) Maton]-fortified jaggery: its physicochemical characterization and In Vitro antioxidant capacity. *Sugar Tech* 2019;21(3):388-97. <https://doi.org/10.1007/s12355-018-0678-z>
- Anon. 1999. ICUMSA METHODS, 2002 Updates.
- Singleton VL, Orthofer R, Lamuela-Raventós RM. Analysis of total phenols and other oxidation substrates and antioxidants by means of folin-ciocalteu reagent. *Oxidants and Antioxidants Part A* 1999:152–178. [http://dx.doi.org/10.1016/S0076-6879\(99\)99017-1](http://dx.doi.org/10.1016/S0076-6879(99)99017-1)
- Chang CC, Yang MH, Wen HM, et al. Estimation of total flavonoid content in propolis by two complementary colometric methods. *J Food Drug Anal* 2020;10. <http://dx.doi.org/10.38212/2224-6614.2748>
- Anonymous. 1990. Bureau of Indian Standards, IS 12923, 1990: (Clause 4.3 and 6.1), New Delhi, India.
- Beuchat LR. Microbial stability as affected by water activity. *Cereal Foods World* 1981;26:345-349. <https://agris.fao.org/agris-search/search.do?recordID=US8116821>
- Damodaran S. Damodaran S. Aminoácidos, péptidos y proteína. *Química de los alimentos*, 2000.
- Hagerman AE, Riedl KM, Jones GA, et al. High Molecular Weight Plant Polyphenolics (Tannins) as Biological Antioxidants. *J Agric Food Chem* 1998;46:1887–1892. <http://dx.doi.org/10.1021/jf970975b>