International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
IJABR 2024; SP-8(1): 384-384
www.biochemjournal.com
Received: 14-11-2023
Accepted: 22-12-2023

Trishla Sahu
Ph.D. Scholar, Department of Agricultural Processing and Food Engineering, SV CAET & RS, FAE, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Dilip Kumar
Principal Scientist, Division of Agricultural Engineering, ICAR- Indian Institute of Sugarcane Research, Lucknow, Uttar Pradesh, India

Shadanan Patel
Professor, Department of Agricultural Processing and Food Engineering, SV CAET & RS, FAE, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Suman Sahu
Ph.D. Scholar, Department of Agricultural Processing and Food Engineering, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Amit Kumar Painkra
Ph.D. Scholar Department of Agricultural Economics, College of Agriculture, IGKV, Raipur, Chhattisgarh, India

Corresponding Author:
Trishla Sahu
Ph.D. Scholar, Department of Agricultural Processing and Food Engineering, SV CAET & RS, FAE, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Physico-chemical properties of solid and molten Jaggery from CoLk94184

Trishla Sahu, Dilip Kumar, Shadanan Patel, Suman Sahu and Amit Kumar Painkra

DOI: https://doi.org/10.33545/26174693.2024.v8.i1Sf.340

Abstract
Jaggery is the sugarcane based traditional Indian sweetener. Jaggery is nutritious and easily available to the rural people. The Physico-chemical properties of Jaggery is the one of the most important key parameters. Jaggery (Variety: CoLk 94184) was used in the entire experimental tests. In the present study, five samples were collected and evaluated of Physico-chemical characteristics of fresh jaggery (molten and solid). The investigation were carried out for determination of Physico-chemical evaluation such as total soluble solids, colour, true density, moisture content, pH, reducing sugar, hardness and viscosity according to standard procedures. The mean value of density, moisture content, reducing sugar and texture of solid jaggery were measured to be 1.36 g/cc, 6.97% (db), 6.86% and 346 N respectively. The mean value of total soluble solids (⁰brix), colour (L*, a* and b* values), moisture content, pH and viscosity of molten jaggery were measured to be 79.80⁰, 35.52 (L*), 7.34 (a*), -5.02 (b*), 25.57% (db), 5.87 and 2519.79 mPa.s., respectively.

Keywords: Sugarcane, jaggery, liquid jaggery, physico-chemical

Introduction

Jaggery (also known as gur) is a natural, traditional sweetener made by the concentration of sugarcane juice. The word *'gur'* is found in the Sanskrit language, indicating that it has been produced in India since the beginning of time, is a traditional sweetening substance that is still used in many nations' rural diets (Mandal, 2006) [9]. It contains all the minerals and vitamins present in sugarcane juice and that is why it is known as healthiest sugar in the world. Jaggery is consumed all over the world and is recognized by a various name; in most Asian and African countries it is known as jaggery. "Goda" in (Sanskrit),"Gud/Gur" in (India and Pakistan), "Bellam" in (Telugu), "Bella" in (Karnataka), "Vellam" in (Tamil and Malayalam),: Hong Tang" in (China), "Chancaca" in (Chile, Peru and Bolivia), "Panela" in (Columbia, Ecuador, Guatemala and other Central American countries), "Black sugar (Kurosato)/Kokuto" in (Japan), "Papelon/Panela" in (Venezuela), "Dulce/Tapa dulce" in (Costa Rica and Nicaragua), "Gula Java/Gula Merah" in (Indonesia), "Gula Melka" in (Malaysia), "Raspadura" in (Panama), "Raw sugar" in (Europe, North America and United States) and "Unrefined muscovado" in (United Kingdom) (Guerra and Mujica, 2009; Kouhestani and Honarwar, 2021; Kumar *et al*., 2022) [4, 5, 6].

Jaggery has a sweet, winy fragrance, as well as a delicious flavor and texture. A good grade jaggery has a golden yellow colour, a firm texture, a crystalline structure, a sweeter taste and contains less moisture. It is a concentrated product of cane juice without separation of the molasses and crystals, and can vary from golden brown to dark brown in colour. For liquid, solid and powdered/granular jaggery, the temperatures are 105-108 ⁰C, 114-117 ⁰C and 118-120 ⁰C, respectively.

Jaggery is a type of sugar that is utilized in pharmaceutical formulations and is known as "medicinal sugar". Since jaggery is enriched with highest medicinal and nutritional qualities, an intrinsic flavour and fragrance with less sucrose (75.85%) and reducing sugar (5-10%) compared to regular sugar (90-95%), it is referred to as the "Healthiest Sugar" or the "Especially Medicinal Sugar" (Rao *et al*., 2009) [13]. Jaggery is available in the market mainly in the three forms namely; solid jaggery, liquid jaggery and granular/powdered jaggery. In India, 20 percent of jaggery is produced in liquid and granular form, while the remaining 80 percent is manufactured in solid form (Shukla, 2012) [15].

Jaggery is a kind of unrefined sugar that's popular in Asia, Africa, Latin America, Caribbean, China, UK, Germany, France, Canada, Mexico and Russia, where the levels of consumption demand are increasing day by day (Kumbhar, 2016) [8]. It is consumed in almost all sections of the society as a sweetener and as a source of energy.

Table 1: Composition of different forms of jaggery (per 100 g)

Composition	Types of jaggery		
	Solid	Liquid	Granular
Water (g)	3-10	30-35	1-2
Sucrose (g)	65-85	40-60	80-90
Reducing sugar (g)	9-15	15-25	5-9
Protein (g)	0.4	0.5	0.4
Fat (g)	0.1	0.1	0.1
Total minerals (g)	0.6-1.0	0.75	0.6-1.0
Calcium (mg)	8.0	300	9.0
Phosphorous (mg)	4.0	3.0	4.0
Iron (mg)	11.4	8.5-11	12
Calorific value (Kcal)	383	300	383

(***Source***: Said and Pradhan, 2013; Jaswant Singh, 1996 & 1997; Rao *et al.*, 2007) [14, 16, 12].

Due to its nutritional and health benefits, it can be made available to community to help alleviate malnutrition and under nutrition problems. Jaggery is frequently utilized because of its high nutritional value, reported health benefits, and accessibility to rural populations (Pathak and Dwivedi, 2019) [10].

Keeping in view all the considerations, the present study has been taken to analyzed the Physico-chemical characteristics of fresh jaggery.

Materials and Methods

Experimental Site

The present study was conducted at Jaggery Unit, Division of Agricultural Engineering, ICAR-Indian Institute of Sugarcane Research, Lucknow (U.P.) India.

Raw Materials

Jaggery (Variety: CoLk94184) were used to determine the physico-chemical characteristics. Five samples were kept in separate sterile glass container were evaluated by using standard method for: -

Determination of total soluble solids (ºBrix)

The hand held refractometer with 0 - 90° Brix scale (LC = 0.1% °Brix) was used for the determination of total soluble solids (TSS) of the jaggery. In order to determine the TSS, the refractometer was initially set to zero followed by placing 1 to 2 drops of liquid jaggery on its screen and start pressed button. It directly gives the reading in percent or °Brix (Patil and Anekar, 2014) [11].

Determination of colour (L*, a* and b* values)

Jaggery colour is one of the most important qualities which indicate the freshness of the jaggery, and plays a significant role in determining its market value. The L*, a*and b* values of jaggery were measured using Colour reader (Konica Minolta Sensing Inc., CR-10). The colour brightness coordinate L* is used to assess the whiteness value of a colour, ranges from black at 0 to white at 100. The chromaticity coordinate a* gives green when negative and red when positive. The coordinate b* gives yellow when positive and blue when negative (Arslan *et al*., 2010) [1]. A clean and dry petri-plate with a closed cover was used to collect juice samples. The device was placed over the petri-plate and the start button was pressed. The colour reading was shown on the screen and noted the values of L*, a* and b*.

Determination of true density (g/cc)

The true density was determined by toluene displacement method. Jaggery (solid) being insoluble in toluene this method was used comfortably. In a measuring cylinder, 25 mL of toluene was taken precisely and 5 g of jaggery was added to it. The volume of toluene and jaggery was increased by putting the jaggery into the measuring cylinder. The difference between the initial and the final volumes of the toluene was recorded and the true density was calculated by the following expression (Eqn. 3.1).

$$\text{Density (g/cc)} = \frac{\text{Mass}}{\text{Volume (final volume} - \text{initial volume)}} \quad (3.1)$$

Determination of moisture content (%)

Hot air oven method for solid jaggery (70 ºC) and vacuum oven method for liquid jaggery (70 ºC) were used to determine the moisture content of jaggery. 10 g samples each of solid and liquid were weighed accurately and placed in a pre-weighed crucible and placed in the pre-set (at 70 °C) ovens (hot air and vacuum) and then dried until successive weighing did not change by more than 0.5 mg (Kumar *et al.* 2013; Patil and Anekar, 2014) [7, 11]. The dishes containing the dried jaggery samples were drawn out from the ovens and placed in desiccators and allowed to cool before being weighed. The following expression (Eqn. 3.2) was used to calculate the moisture contents.

$$\text{Moisture content (\%)} = \frac{100\,(M_1 - M_2)}{M_1 - M} \quad (3.2)$$

Where,

M_1 = initial weight of the sample and crucible before drying (g)

M_2 = final weight of the dried sample with crucible (g)

M = weight of empty crucible (g)

Determination of pH

pH of the samples was determined by digital pH meter (Hanna Pvt. Ltd., India). The electrode of the digital pH metre was dipped inside the beaker containing the sample (jaggery) and recorded the pH value. Prior to measurement the pH meter was calibrated using pH 7 and pH 4 standard solutions (Patil and Anekar, 2014) [11].

Determination of reducing sugar (%)

Reducing sugar was determined following the method described by Nelson Somogyi Madan *et al.* (1997) [16] and Kumar *et al.*, (2013) [7] using alkaline copper reagent and Arseno Molybdate reagent (1 mL each) with the absorbance measured at 510 nm by UV-visible spectrophotometer (Thermo Scientific Evolution-201). Reducing sugars having a free aldehyde/ ketone group, when reacts with alkaline copper reagent reduces its Cu^{3+} ion to Cu^{2+} ion. The amount of copper reduced is proportional to the quantity of sugar present. An aliquot containing about 1 g jaggery sample was taken in 100 mL volumetric flask and added distilled water (1 mL). To this distilled water was added to make up the volume to 10 mL. Alkaline copper reagent (1 mL) was introduced to blood sugar tubes containing 1 mL sample, tubes were then placed in a boiling water bath for 10 minutes. In blood sugar tubes, simply copper reagent and distilled water were used as the control sample. Arseno molybdate reagent (1 mL) was added when the reduction was finished, mixed thoroughly, this complex forms a blue colour and the absorbance at 540 nm was measured in comparison to the reagent and a blank that contained no sugars. A standard curve with various sugar concentrations was used to calculate the amount of sugars. While measuring it should be kept in mind that the absorbance reading should fall between 0.1 and 0.3.

Determination of hardness (N)

A Perten Texture Analyzer (Model: Tvt-300 XP Software program) was used for single/double compression testing to determine the hardness of jaggery. The probe P/36 (cylindrical probe) was used to determine the hardness test as suggested by the manufacturer for similar products. Prior to testing, the machine was calibrated using 50 kg load cell and with the attachment of probe. The sample was properly placed on the mounting platform and experiment started. The plot between the force and time was generated by software. Fracture appeared as a peak or sequence of peaks as compression progressed. The highest peak value represented the ultimate hardness of the sample (Kumar *et al.*, 2013) [7].

Determination of viscosity (mPa.s.)

A digital rotational viscometer (Labman LMDV-200, L 6550, Scientific Instruments, Pvt Ltd.) was used to determine the viscosity of jaggery. The speed of rotational viscometer was kept from 0.1 to 200 rpm. It is required to select a spindle with small dimensions (L3, L4) and a moderate rotational speed for a sample with a high degree of viscosity. The spindle with large dimensions (L1, L2) is selected for rapid rotational speed for the sample with low viscosity. Jaggery sample was taken in a glass beaker. Appropriate spindle and rotational speed were selected as per the nature of sample. To measure, the spindle was positioned in the middle of the beaker prior to measurement. The liquid surface and the spindle were marked at the same level to maintain the uniformity in different tests. By selecting the "Run" key, the step motor starts to operate which allows measurement of spindle's torque and viscosity with selected rotational speed. While measuring, the torque range should show 20% to 90% (torque), which is the normal range and required to be maintained. The accurate viscosity measurement falls within this range. If the value is not within this range, the viscosity meter sounds an alarm and prompts to adjust the spinning speed and spindle. On the LCD panel, the value of viscosity (mPa.s) is directly shown.

Fig 1: Determination of true density

Fig 2: Determination of reducing sugar

Fig 3: Digital rotational viscometer

Results and Discussion

Total soluble solids (°Brix)

The total soluble solids (ºBrix) values of all the samples ranged from 78.80 to 82.70°Brix. The average value of total soluble solids (°Brix) of jaggery samples was recorded to be 79.80°Brix with a standard deviation of 1.64. The findings are close to the observation communicated by Patil and Anekar (2014) [11] and Chauhan *et al.* (2015) [3].

Colour (L*, a* and b* values) of solid jaggery

L* values of solid jaggery varied from 42.8 to 49.6. The average L* value was observed to be 46.76 with a standard deviation of 2.60. The L* value shows that the jaggery sample is relatively darker in colour.

a* values of solid jaggery varied between 6.2 to 8.6. The average value of a* was observed to be +7.6 with a standard deviation of 1.03. The a* values of all jaggery samples are positive (+) *i.e.* all the samples represent redness.

b* values of solid jaggery varied between 10.8 to 15.9. The average value of b* was observed to be +13.1 with a standard deviation of 1.82. The b* values of all the jaggery samples were observed to be negative indicating yellowness. The results are close to the values reported earlier by Patil and Anekar (2014) [11], Chauhan *et al.* (2015) [3] and Kumar *et al.* (2013) [7].

Colour (L*, a* and b* values) of jaggery syrup

L* values of jaggery syrup samples varied from 35.0 to 36.2. The average L* value was determined to be 35.52 with a standard deviation of 0.48. The L* value shows that jaggery is slightly darker in colour.

a* values of jaggery syrup varied between 5.9 to 10.0. The average value of a* was observed to be +7.34 with a standard deviation of 1.75. The a* values of all jaggery samples were positive (+) *i.e.* all the samples represent redness.

b* values of jaggery syrup varied between -3.7 to -6.2. The average value of b* was observed to be -5.02 with a standard deviation of 0.97. The b* values of all the jaggery samples are negative *i.e.* all the samples represent blueness. The results are close to the values reported earlier by Patil and Anekar (2014) [11], Chauhan *et al.* (2014) [3] and Kumar *et al.* (2013) [7].

True density
The average true density of solid jaggery was found to be 1.44g/cc with a standard deviation of 0.20. The result closely aligns with the value reported by Patil and Anekar, 2014 [11] (1.34 g/cc) and Chauhan *et al.* (2015) [3] for solid jaggery samples.

Moisture content
Solid jaggery had an average moisture content of 6.69% on wet basis or 6.97% on dry basis with the standard deviation of 0.63. Molten jaggery had an average moisture content of 20.36% on wet basis and 25.57% on dry basis with the standard deviation of 0.95. This outcome closely aligns with the results reported by Pathak and Dwivedi (2019) [10], Chand *et al.* (2011), Patil and Anekar (2014) [11] and Kumar *et al.* (2013) [7].

pH
The pH values of jaggery syrup was recorded in the range of 5.847 to 5.924 with a standard deviation of 0.03. The average pH of molten jaggery was observed to be 5.87, whereas pH of plain jaggery was 5.09. This result is at par with the values reported by Pathak and Dwivedi (2019) [10], Mandal *et al.* (2006) [9] and Patil and Anekar (2014) [11].

Reducing sugar
Reducing sugar of jaggery samples was determined using the Nelson Somogyi method. The values of reducing sugar of solid Jaggery ranged between 5.34% to 8.49%. The average reducing sugar of jaggery was observed to be 6.86% with a standard deviation of 1.44. This result is close to the values reported by Said and Pradhan (2013) [14], Patil and Anekar (2014) [11] and Kumar *et al.* (2013) [7].

Texture (Hardness)
The values of hardness of jaggery samples ranged between 290 N to 400 N. The average texture (hardness) of jaggery was observed to be 346 N with a standard deviation of 39.74. These findings are closely in the line reported by Chauhan *et al.* (2015) [3] and Kumar *et al.* (2013) [7].

Viscosity
The viscosity values of molten jaggery samples varied from 1878.7 mPa.s to 3055.9 mPa.s with the variation in spindle rotation from 50 to 190 rpm and 25.5% to 85% torque range. Average value of viscosity in the above measuring range was calculated to be 2519.79 mPa.s with a standard deviation of 367.81.

Conclusion: The physio-chemical properties of jaggery is the one of the most important key parameters. The key characteristics such as total soluble solids (ºbrix), colour (L*, a* and b* values), density, moisture content, pH, reducing sugar, texture and viscosity were determined.

1. The mean value of density, moisture content, reducing sugar and texture of solid jaggery were 1.36 g/cc, 6.97% (db), 6.86% and 346 N, respectively.
2. The mean value of total soluble solids (°Brix), colour (L*, a* and b* values), moisture content, pH and viscosity of molten jaggery were measured to be 79.80°, 35.52 (L*), 7.34 (a*), -5.02 (b*), 25.57% (db), 5.87 and 2519.79 mPa.s., respectively.

References

1. Arslan D, Ozcan MM, Mengeş HO. Evaluation of drying methods with respect to drying parameters, some nutritional and colour characteristics of peppermint (*Mentha x piperita* L.). Energy Convers Manag. 2010;51:2769-2775.
2. Chand K, Singh A, Verma AK, Lohani UC. Quality evaluation of jaggery chocolate under various storage conditions. Sugar Tech. 2011;13(2):150-155.
3. Chauhan L, Prakash KS, Srivastav PP, Bashir K. Physicochemical and thermal properties of candy crystals prepared from palmyra-palm jaggery. J Food Eng; c2015. p. 1-6.
4. Guerra MJ, Mujica MV. Physical and chemical properties of granulated cane sugar "panelas". Ciênc Tecnol Aliment; c2009.
5. Kouhestani S, Honarvar M. An overview on panela. J Food Biosci Technol. 2021;11(1):35-42.
6. Kumar D, Pathak AD, Mishra C, Mishra SK. Technical bulletin on jaggery. ICAR-IISR, Indian Institute of Sugarcane Research, Lucknow (Uttar Pradesh), ABI Lucknow/PUB. No. 2022/01; c2022.
7. Kumar D, Singh J, Rai DR, Kumar M, Bhatia S. Effect of modified atmosphere packaging on keeping quality of jaggery. Sugar Tech. 2013;15(2):203-208. DOI: 10.1007/s12355-012-0197-2.
8. Kumbhar YS. Study on gur (jaggery) industry in Kolhapur. Int Res J Eng Technol. 2016;3(2):590-594.
9. Mandal D, Tudu S, Mitra SR, De GC. Effect of common packing materials on keeping quality of sugarcane jaggery during monsoon season. Sugar Tech. 2006;8(2 and 3):137-142.
10. Pathak V, Dwivedi AK. Analytical study of different sample of guda (jaggery). Int J Innovative Sci Res Technol. 2019;4(6):408-412. ISSN: 2456-2165.
11. Patil SD, Anekar SV. Effect of different parameters and storage conditions on liquid jaggery without adding preservatives. IJRET: Int J Res Eng Technol. 2014;03(12):280-283. eISSN: 2319-1163, pISSN: 2321-7308.
12. Rao JPVK, Das M, Das SK. Jaggery - a traditional Indian sweetener. Int. J Tradit Knowl. 2007;6(1):95-102.
13. Rao P.V.K.J, Das M, Das SK. Changes in physical and thermo-physical properties of sugarcane, palmyra-palm and date-palm juices at different concentration of sugar. J Food Eng. 2009;90:559-566.
14. Said PP, Pradhan RC. Preservation and value addition of jaggery. Int J Agric Eng. 2013;6(2):569-574.
15. Shukla P. Effect of edible coating and packaging on microbiological characteristics of jaggery. Prime J Microbiol Res. 2012;2(4):121-125.
16. Singh J. AICRP on processing, handling and storage of jaggery and khandsari. Agric Eng Today. 1996 & 1997;20:1-4, 21:1-4.