International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
IJABR 2024; SP-8(6): 367-372
www.biochemjournal.com
Received: 09-04-2024
Accepted: 19-05-2024

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Standardization of jaggery candy manufacturing process using two sugarcane varieties

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DOI: https://doi.org/10.33545/26174693.2024.v8.i6Se.1311

Abstract
Jaggery candy was prepared from two distinct varieties of sugarcane, CoH 119 and CoH 118, which were cultivated at the Regional Research Station of CCS Haryana Agricultural University in Karnal. The primary aim of this study was to manufacture jaggery candy from these sugarcane varieties and assess their physico-chemical and sensory characteristics. Sensory evaluations were conducted using a 9-point hedonic scale to evaluate attributes such as color, taste, texture, flavor, and overall acceptability. Furthermore, essential parameters including juice extraction and recovery percentages, moisture content, total soluble solids, and total plate count were meticulously measured. Preservation of the jaggery candy was efficiently achieved through the use of laminated wraps. Notably, jaggery candy derived from the CoH 118 sugarcane variety demonstrated superior results in both sensory analysis and physico-chemical evaluation compared to jaggery candy from the CoH 119 variety.

Keywords: Jaggery candy, Sugarcane, Physico-chemical evaluation, Sensory study

Introduction
Jaggery candy, a traditional sweet delicacy derived from sugarcane juice, holds a significant place in culinary traditions across various regions of the country (Srinivasan *et al.*, 2019) [23]. The process of producing jaggery candy involves intricate steps and techniques to ensure quality and consistency in the final product (Vijayanand *et al.*, 2012) [27]. In recent years, there has been a growing interest in standardizing the production process of jaggery candy, particularly concerning the use of different sugarcane varieties.

At the core of this endeavour lies the quest to optimize the production process to enhance the sensory attributes, shelf-life, and overall quality of jaggery candy (Rangana, 2007) [16]. With the diversity in sugarcane varieties available, each possessing unique characteristics, there arises a need to evaluate their suitability for jaggery candy production. Understanding how different sugarcane varieties influence the sensory properties and physico-chemical composition of jaggery candy is crucial for developing standardized production protocols (Joshi *et al.*, 2018) [10].

This study aims to explore the standardization of the production process of jaggery candy using two distinct sugarcane varieties. By systematically assessing various parameters such as moisture content, sensory attributes, juice extraction efficiency, and physico-chemical composition, we seek to identify the optimal conditions for producing high-quality jaggery candy (Natarajan *et al.*, 2015) [13]. The insights gained from this research endeavour will not only contribute to improving the production process but also pave the way for enhancing the market competitiveness of jaggery candy derived from different sugarcane varieties.

Materials and Methods
Sample Preparation
The cultivars CoH 118, classified as an early maturing variety, and CoH 119, categorized as a mid-maturing variety, were cultivated under controlled conditions at the fields of Regional Research Station, CCS Haryana Agricultural University, Karnal. Upon reaching maturity, the canes were harvested during the designated crushing season, and their juice was extracted to establish a standardized manufacturing process for the preparation of jaggery candy. The flow chart of jaggery candy manufacturing process involved the following steps as mentioned below:

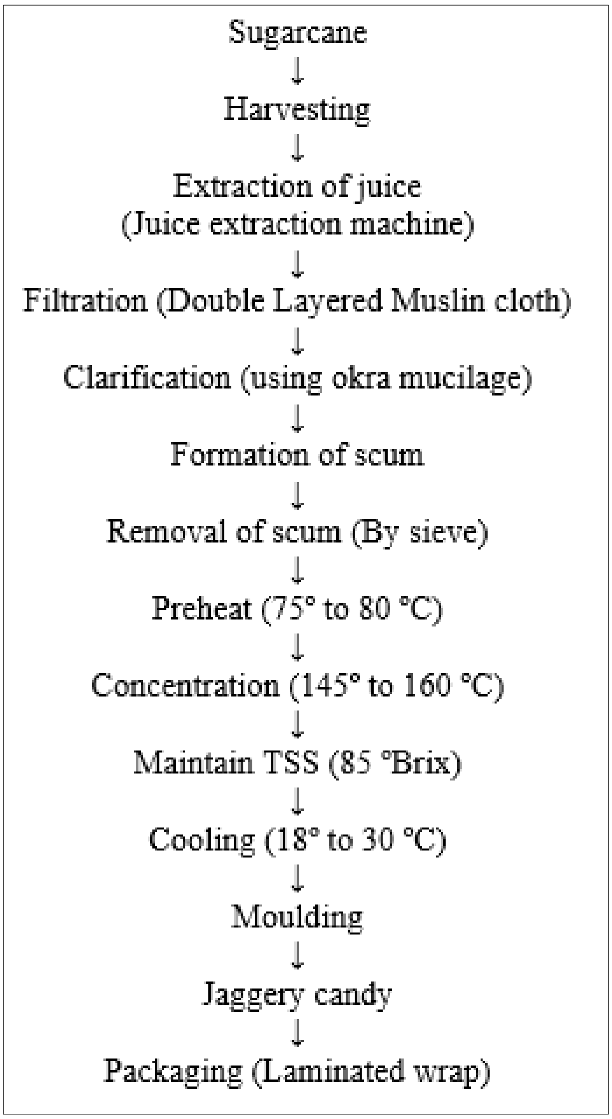


Fig 1: Flow sheet for preparation of *Jaggery candy* from sugarcane

Preparation of Bhindi (okra) mucilage

The fresh, green, mature okra stalks were obtained from the organic farms of CCSHAU in Hisar. The okra stems were chopped, mashed, and soaked in water with a ratio of 1:10 w/v. After allowing them to stand for 6 hours, the mixture was sieved through double-layer muslin cloth twice, following the method described by Chavan *et al.* (2007) [4]. The mucilage in the filtrate was flocculated using ethanol (50:50 v/v), separated, and washed with acetone to remove green pigments, as outlined by Rajalakshmi and Sangeetha (2023) [15]. Subsequently, the resulting transparent white mucilage was obtained and utilized for clarification of sugarcane juice which was further used in the preparation of jaggery candy.

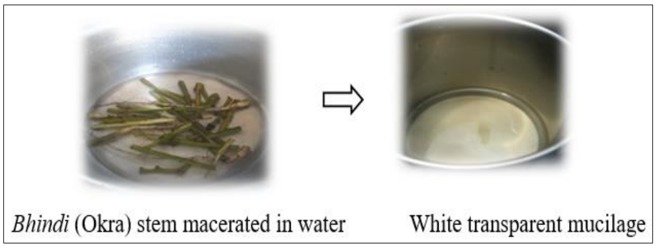


Plate 1: Preparation of bhindi (okra) mucilage

Juice extraction (%) and Jaggery recovery (%)

The juice extraction percentage was determined by dividing the weight of the juice by the weight of the sugarcane. Similarly, the jaggery recovery percentage was calculated by dividing the weight of the jaggery candy by the weight of the juice used for making the jaggery candy.

Total Soluble Solids (ºBrix)

The *Total Soluble Solids* (TSS) of a juice sample was obtained from the center of two randomly selected mature sugarcane stalks of each variety and was measured using a hand refractometer (0-30%). Similarly, TSS of the jaggery candy sample was measured during the boiling process of concentrated juice from each sugarcane variety using a hand refractometer (60-90%).

Moisture content (%)

Moisture content was estimated in samples using AOAC (2000) [1] method.

Sensory evaluation (9-point Hedonic scale)

Jaggery candy samples, derived from two distinct sugarcane varieties were subjected to sensory evaluation immediately after preparation. A panel of ten semi-trained or non-trained judges assessed the samples using a 9-point hedonic scale, following the method outlined by Rangana (2007) [16]. Various attributes of the jaggery candy, including color, appearance, taste, flavor, texture, and overall acceptability, were evaluated. The overall acceptability of the jaggery candy was determined based on the mean score derived from all sensory characteristics. Attributes scoring 6 and above out of 9 were deemed acceptable and chosen for further analysis.

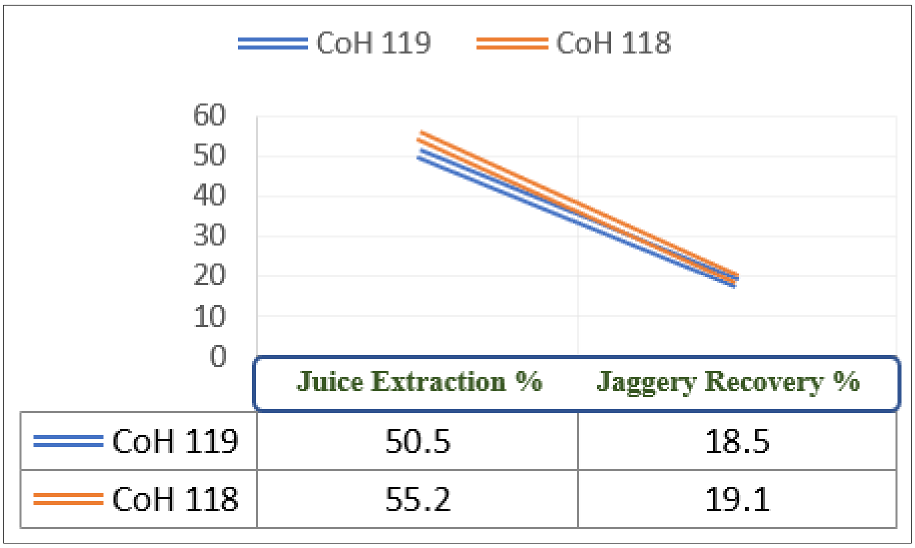
Total Plate count (log_{10}cfu/g)

The Total Plate Count analysis was conducted using the pour plate method (Goldman and Green, 2008) [9], employing total plate count using agar media (all procedures were conducted within a laminar flow chamber using sterilized glassware). The agar medium was prepared by autoclaving at 121 °C and 15 psi for 15 minutes. Subsequently, one gram of jaggery candy was diluted in nine milliliters of water blanks, poured onto plates, and then incubated at 28±10 °C for 24 to 48 hours. Following the incubation period, the colonies were enumerated.

Results and Discussion

A Comparative Analysis of Juice Extraction and Recovery Percentages for Jaggery Candy Production

Graph 1 illustrates the juice extraction percentage and jaggery candy recovery percentage obtained from different sugarcane varieties (CoH 119 and CoH 118). The data indicates that the juice extraction percentage ranged from 55.2% (CoH 118) to 50.2% (CoH 119) for the different sugarcane varieties. Jaggery candy was prepared from the juice extracted from these varieties, with the recovery percentage ranging from 18.1% (CoH 119) to 19.1% (CoH 118). The variation observed in juice extraction percentage and jaggery candy recovery percentage among different sugarcane varieties (CoH 119 and CoH 118) suggests potential differences in their agronomic and biochemical characteristics. The higher juice extraction percentage in CoH 118 compared to CoH 119 could be attributed to genetic factors influencing the moisture content, fiber composition, and sucrose concentration in the sugarcane stalks (Shukla *et al.*, 2018) [20]. Previous studies have indicated that certain sugarcane varieties exhibit higher juice content and better milling efficiency due to differences in stalk morphology and internal structure (Chandra *et al.*, 2015) [2]. The observed differences in jaggery candy recovery percentage between CoH 119 and CoH 118 may also reflect variations in sugar content and crystallization properties of the extracted juice. Sugarcane varieties with higher sucrose content and better sucrose-to-jaggery conversion efficiency are expected to yield higher jaggery recovery percentages (Venkatesan *et al.*, 2022) [25]. Additionally, environmental factors such as temperature and humidity during the jaggery-making process can influence crystallization kinetics and overall yield (Verma *et al.*, 2021) [26]. Further investigation into the biochemical composition of the sugarcane varieties, including sucrose, reducing sugars, and fiber content, could provide insights into the observed differences in juice extraction and jaggery recovery percentages. Additionally, exploring the impact of agronomic practices, soil fertility, and climatic conditions on sugarcane growth and sugar accumulation may help optimize jaggery production from different varieties. Overall, these findings underscore the importance of selecting suitable sugarcane varieties and optimizing processing parameters for maximizing jaggery yield and quality in agro-industrial settings.



Graph 1: Juice extraction and jaggery recovery percent of two sugarcane varieties (CoH 119 and CoH 118) used for jaggery candy production

Total soluble solids

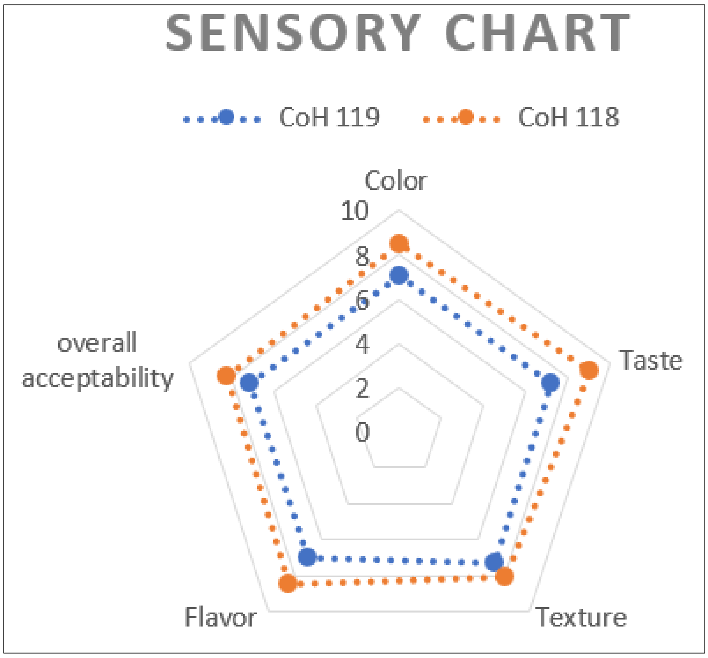
The clarified juice was concentrated in an open pan, evaporating at a temperature range of 115-120 ºC. The concentration of clarified juice to produce the hot, thick syrup is a critical step in jaggery candy production. Evaporation at the specified temperature range facilitates the removal of excess moisture and concentrates the sugars present in the juice, contributing to the desired texture and sweetness of the final product (Chauhan *et al.*, 2017) [3]. Temperature significantly influences both the Maillard reaction and caramelization, which are primary factors determining the color and appearance of jaggery. Higher temperature accelerates maillard reaction, leading to faster color development and flavor formation in the final product (Upadhyaya *et al.*, 2023) [24].

Samples were periodically checked during evaporation, and the total soluble solids (TSS) were analyzed to determine the endpoint of jaggery candy production. TSS of 85 ºBrix marks the completion of jaggery candy production. Monitoring the TSS levels during evaporation is essential for determining the endpoint of the process, ensuring that the syrup reaches the desired consistency and sugar concentration required for jaggery candy formation characterized by its sticky texture and ability to form thin thread-like structures (Kumar *et al.*, 2022) [11]. The resulting concentrate with a TSS of 85 ºBrix represents the ideal stage for molding into jaggery candy. At this concentration, the syrup had achieved the desired sweetness and consistency, making it suitable for shaping and cooling into the final candy form. The cooling and molding process further solidifies the syrup, giving it the characteristic texture and appearance of jaggery candy (Singh *et al.*, 2011) [22]. So, the hot syrup was left to cool down at room temperature before being transferred into molds for solidification. After cooling and molding, the obtained product is referred as jaggery candy. Overall, precise control of evaporation conditions and TSS levels is crucial for achieving consistent quality and sensory attributes in jaggery candy production.

Moisture Content

The jaggery candy prepared from two sugarcane varieties, were analyzed for proximate parameters, specifically moisture content. The moisture content percentage varied between 2.5 and 3.5 percent. The lowest moisture content was detected in jaggery candy from variety Co 119 (2.8%), whereas the highest moisture content was found in variety CoH 118 (3.2%). Also, the observed disparity in moisture content between the jaggery candies highlights the influence of genetic factors and environmental conditions on the final product's composition as also depicted by Gayathry *et al.* (2021) [8]. In the course of crystallization, bound moisture is liberated and evaporates under relatively high temperatures. Higher crystallinity in a sample typically correlates with lower moisture content compared to samples with lower crystallinity (Verma *et al.*, 2021) [26]. Sugarcane varieties may exhibit varying levels of water retention due to differences in cell structure and composition (Dos Anjos *et al*. 2023) [6], which can impact the moisture content of the resulting jaggery candy. Additionally, variations in processing techniques such as extraction methods and drying temperatures can also affect moisture levels (Shrivastava and Singh, 2020) [19]. Jaggery is rich in hygroscopic substances like reducing sugars and minerals such as chlorides, sodium, and potassium, which may vary between varieties. Monitoring the total moisture content is also crucial as it provides insights into the level of impurities present in the jaggery. Excessive moisture can lead to microbial growth and spoilage, compromising its taste and nutritional value (Pathak and Dwivedi, 2019) [14]. These findings emphasize the importance of selecting the appropriate sugarcane variety and optimizing processing methods to achieve desired moisture levels in jaggery candy production. Controlling moisture content is crucial for ensuring product quality, texture, and shelf stability (Singh *et al.*, 2020) [21].

Sensory evaluation: The sensory characteristics of a product developed from two sugarcane varieties, namely CoH 119 and CoH 118, were examined using a nine-point hedonic scale. The evaluators primarily consisted of staff, students, and non-teaching personnel from the Centre of Food Science and Technology, CCSHAU, Hisar. These judges were briefed on quality attributes such as color, taste, flavor, texture, and overall acceptability, and were tasked with scoring the samples accordingly. The sensory evaluation results, depicted in Graph 2, encompassed five parameters: color, taste, texture, flavor, and overall acceptability. CoH 118 demonstrated superior outcomes as compared to CoH 119. Specifically, CoH 118 exhibited maximum ratings in color, taste, flavor, and overall acceptability (8.5, 9.0, 8.1, 8.5 and 8.2 respectively), whereas CoH 119 recorded lower scores (7.0, 7.1, 7.3, 7.0, and 7.1 respectively). These findings were similar to those observed in a study on jaggery-based hard-boiled candy (Sairagul *et al.*, 2020) [17] and in citron peel candy (Shamrez *et al.*, 2013) [18]. The significant differences in sensory attributes between CoH 118 and CoH 119 could be attributed to variations in genetic makeup, environmental factors, or processing methods. CoH 118 may possess inherent qualities that contribute to its favourable sensory profile, making it more appealing to consumers. Further research into the specific compounds responsible for the observed differences could provide valuable insights into enhancing the sensory properties of sugarcane-derived products.



Graph 2: Comparative study of sensory evaluation between jaggery candies from two different sugarcane varieties (CoH 119 and CoH 118) on 9-point hedonic scale

Total Plate count: The jaggery candy, derived from two different sugarcane varieties, underwent analysis for total plate count. No microbial load was detected in the freshly prepared jaggery candy at the initial stage of its production process. The absence of microbial contamination in the freshly prepared jaggery candy is crucial for ensuring its safety and shelf-life. The stringent hygiene measures employed during the manufacturing process likely contributed to this result. Additionally, factors such as high sugar concentration and low water activity in jaggery can create an unfavorable environment for microbial growth (Lievens *et al.*, 2015) [12]. These findings underscore the importance of good manufacturing practices (GMP) and sanitation protocols in jaggery candy production to prevent microbial contamination and ensure product quality. Regular monitoring of microbial counts throughout the production process is essential for maintaining food safety standards and compliance with regulatory requirements (Crandall *et al.*, 2023; FSSAI, 2011) [5, 7].

Conclusion

Organic jaggery, derived from sugarcane cultivated without the use of chemical fertilizers or pesticides, represents a biologically safe product. Our study indicates that jaggery prepared from 85 ºBrix slurry is best suited for commercial purposes. Sugarcane variety CoH 118 exhibited superior sensory attributes, making it an ideal choice (quality, texture and shelf stability). Its delightful taste, coupled with its health benefits, positions it as a favorable option for consumers across all age groups. These findings underscore the potential of organic farming practices to produce high-quality, nutritious jaggery products with broad market appeal.

Conflict of interest

The authors declare that they have no conflict of interest.

Acknowledgements

The first author expresses gratitude to the Center of Food Science and Technology, CCSHAU, Hisar, and the Regional Research Station, Karnal, Haryana, India. The support from professors and laboratory attendants, as well as the provision of instrumental facilities and sponsorship during the research work, is highly appreciated.

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