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Development and quality evaluation of sweetened paneer cubes by incorporating sugar and jaggery

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Abstract
Paneer is one of the most widely consumed indigenous dairy products in India due to its high nutritional value, versatility and widespread consumer acceptance. The present study was aimed to develop sweetened paneer cubes by using sugar and jaggery and to evaluate their physico-chemical and sensory attributes. Paneer was prepared from standardized milk through citric acid coagulation and subsequently cut into cubes. Two different treatment groups were formulated: (T_1) sugar-treated paneer cubes cooked in sugar syrup and (T_2) jaggery-treated paneer cubes cooked in jaggery syrup along with control (C) paneer cubes cooked in water. The prepared products were evaluated for product yield, water-holding capacity, juiciness, moisture content, total solids, protein, fat and energy value. Sensory evaluation was conducted using a nine-point hedonic scale. The results demonstrated that the incorporation of sweeteners significantly (P<0.05) enhanced product quality compared with the control. Among the treatments, jaggery-treated paneer cubes exhibited the highest product yield (94.40%), water-holding capacity (16.20%), juiciness (25.90%) and energy value (328.60 kcal/100 g). Sensory evaluation revealed significantly (P<0.05) higher scores for colour and appearance, aroma, juiciness, tenderness, texture, and overall acceptability in the jaggery-treated samples. The characteristic flavour of jaggery, coupled with its ability to enhance moisture retention, contributed to greater consumer preference. The findings of this study indicate that jaggery can be effectively utilized as a natural sweetening agent for the development of nutritionally enriched, highly acceptable, ready-to-eat paneer products.

Keywords: Paneer, jaggery, sugar, value-added dairy products, sensory evaluation, product quality

Introduction
Paneer is a widely consumed acid-coagulated indigenous dairy product in India and serves as an important source of high-quality proteins, fat, and micronutrients, particularly among vegetarian populations (Khan *et al.,* 2011; Kumar *et al.,* 2014) [6, 7]. In response to increasing consumer demand for innovative and convenient dairy products, considerable research has focused on the development of value-added paneer through the incorporation of functional ingredients, herbs, spices, fruits, and vegetables (Choudhary *et al.,* 2025) [4]. Simultaneously, growing awareness of health-promoting food ingredients has stimulated interest in replacing refined sugar with natural sweeteners. Jaggery, an unrefined sugarcane product, is recognized for its superior nutritional profile owing to its content of minerals such as calcium, iron, and potassium, as well as its characteristic flavour and aroma compounds (Lamdande *et al.,* 2018) [8]. Although jaggery has been successfully incorporated into various dairy products to enhance their sensory and nutritional attributes (Dhruvit *et al.,* 2025) [5]. limited information is available regarding its application in sweetened paneer cubes. Therefore, the present study was undertaken to develop sweetened paneer cubes by using sugar and jaggery and to evaluate their physico-chemical properties and sensory acceptability in relation to untreated paneer cubes.

Materials and Methods
Procurement of Raw Materials: Fresh milk was procured from the Livestock Farm Complex, Veterinary College and Research Institute, Orathanadu, Thanjavur. Commercial food-grade sugar and jaggery were purchased from the local market. All raw materials used in the study were of good quality and free from visible defects.

Preparation of Paneer: Paneer was prepared following the method described by Chawla *et al.* (1985) [3]. Fresh milk was filtered through a clean muslin cloth and standardized to 4.5% fat. The milk was heated to 90°C and subsequently cooled to 70°C. Coagulation was induced by the gradual addition of 1% citric acid solution with continuous stirring until complete coagulation was achieved. The coagulum was allowed to settle for approximately 10 min. The coagulated mass was collected in a muslin cloth and pressed to remove excess whey. The resulting paneer block was immersed in chilled water for approximately 2hr to improve its body and texture. After cooling, the paneer was cut into uniform cubes and stored under refrigeration until further use.

Experimental Design

The study consisted of two treatment groups *viz*., (T_1) (sugar treatment), comprising paneer cubes cooked in syrup prepared by dissolving 100g of sugar in 250mL of water and (T_2) (jaggery treatment), comprising paneer cubes cooked in syrup prepared by dissolving 100g of jaggery in 250mL of water along with (C) (control), comprising paneer cubes cooked in 250mL of water without the addition of any sweetener. For each treatment, 100g of paneer cubes were cooked in the respective medium at approximately 70°C for 10 min. Following cooking, the cubes were removed and allowed to drain and equilibrate at room temperature for 30 min prior to physico-chemical and sensory analyses.

Physico-chemical Analysis: The prepared paneer cubes were analyzed for product yield, water-holding capacity, juiciness, moisture content, total solids, protein content, fat content, and energy value using standard analytical procedures. Total solids content was calculated as the difference between 100 and the corresponding moisture content.

Sensory Evaluation: Sensory evaluation was conducted using a semi-trained panel of judges. The samples were assessed for colour and appearance, flavour juiciness, tenderness, texture, and overall acceptability using a nine-point hedonic scale, where a score of 9 indicated "Like Extremely" and a score of 1 indicated "Dislike Extremely".

Statistical Analysis

The experiment was repeated six times. The data generated from each experiment were analyzed statistically by following standard procedures for Analysis of Variance (ANOVA) comparing the means and to determine the effect of treatment by using SPSS-16 (SPSS Inc., Chicago, IL., USA).

Results and Discussion

Physico-chemical Characteristics of Sweetened Paneer Cubes

The physico-chemical characteristics of sweetened paneer cubes prepared using sugar and jaggery along with control are presented in Table 1. Significant differences (P<0.05) were observed among treatments with respect to product yield, water-holding capacity (WHC), juiciness, and energy value, whereas moisture, total solids, protein and fat contents did not differ significantly.

Product yield is an important quality and economic parameter in paneer production, as it influences processing efficiency and product recovery. The incorporation of sweeteners significantly (P<0.05) increased the yield of paneer cubes compared with the control. Among the treatments, jaggery-treated paneer cubes (T_2) exhibited the highest yield (94.40%), followed by sugar-treated cubes (T_1) (87.50%), whereas the control (C) recorded the lowest yield (78.90%). The increased yield observed in sweetener-treated samples may be attributed to enhanced moisture retention and the absorption of dissolved solids from the cooking syrups. The higher yield obtained in the jaggery-treated samples could be due to the presence of various sugars and soluble solids that facilitated greater uptake within the paneer matrix, thereby improving product recovery. Similar observations have been reported by Shiza *et al.* (2022) [11], who noted that the incorporation of sweetening agents enhanced moisture retention and yield in dairy-based products.

Water-holding capacity (WHC) is an important quality attribute that influences the texture, juiciness, and overall acceptability of paneer products. Significant differences (P<0.05) were observed among the treatments, with the highest WHC recorded in jaggery-treated paneer cubes (16.20%), followed by sugar-treated samples, while the control exhibited the lowest value. The improved WHC observed in sweetened paneer cubes may be attributed to interactions between dissolved sugars and milk proteins, which enhance moisture retention within the protein matrix. Greater water retention contributes to improved tenderness, juiciness, and overall product quality. Similar findings were reported by Morr (1989) [9], who noted that interactions between food constituents and proteins can influence water-binding properties and improve moisture retention in dairy products.

A trend similar to that observed for water-holding capacity was recorded for juiciness. Jaggery-treated paneer cubes exhibited significantly (P<0.05) higher juiciness (25.90%) than sugar-treated and control samples. The enhanced juiciness may be attributed to increased moisture retention and greater absorption of syrup during the cooking process. Juiciness is an important sensory attribute that contributes to improved mouthfeel and overall consumer satisfaction. Therefore, the higher juiciness observed in jaggery-treated paneer cubes likely played a significant role in their enhanced sensory acceptability. Similar findings have been reported by Ashritha *et al.* (2022) [1].

The moisture content of paneer cubes ranged from 65.50 to 68.80%, with sweetener-treated samples exhibiting slightly higher values than the control. However, the differences were not statistically significant (P>0.05). As expected, total solids content showed an inverse relationship with moisture content. The marginal increase in moisture content observed in the sweetened treatments may have contributed to the improved tenderness and juiciness recorded during sensory evaluation. However, the absence of significant differences indicates that the incorporation of sugar or jaggery did not markedly affect the basic compositional characteristics of paneer. Similar observations were reported by Bhunia (2026) [2], who found that the addition of sweetening agents had minimal influence on the moisture and total solids content of value-added dairy products.

Table 1: Physico-chemical characteristics of sweetened paneer cubes

Physico-chemical parameters*	C (Control)	T_1 (Sugar)	T_2 (Jaggery)
Product Yield (%)	78.90±0.12^c	87.50±0.12^b	94.40±0.13^a
Water-Holding Capacity (%)	12.35±0.20^c	13.40±0.22^b	16.20±0.18^a
Juiciness (%)	15.70±0.13^c	22.10±0.17^b	25.90±0.15^a
Moisture (%)	65.50±0.22^a	68.40±0.20^a	68.80±0.24^a
Total Solids (%)	34.50±0.22^a	31.60±0.20^a	31.20±0.24^a
Protein (%)	17.68±0.12^a	19.12±0.14^a	19.44±0.14^a
Fat (%)	24.10±0.11^a	25.82±0.10^a	25.75±0.12^a
Energy Value (kcal/100 g)	305.50±0.25^c	312.25±0.20^b	328.60±0.22^a

*No. of observations - 6,
Mean with common superscripts in a row (alphabets) did not differ significantly (P<0.05).

Protein content ranged from 17.68 to 19.44%, while fat content varied from 24.10 to 25.82% among the treatments. Although slightly higher values were observed in the sweetener-treated samples, the differences were not statistically significant (P>0.05). These findings indicate that cooking paneer cubes in sugar or jaggery syrup had minimal influence on their protein and fat composition. Similar results were reported by Lamdande *et al.* (2018) [8], who observed that the incorporation of sweetening agents did not significantly alter the major nutritional constituents of dairy products. Therefore, the nutritional quality of paneer was largely retained following sweetener incorporation.

The energy value of paneer cubes increased significantly (P<0.05) with the incorporation of sweeteners. Among the treatments, jaggery-treated paneer cubes recorded the highest energy value (328.60 kcal/100 g), followed by sugar-treated cubes (312.25 kcal/100 g), while the control exhibited the lowest value. The increase in energy content may be attributed to the additional carbohydrates contributed by the sweetening agents. The higher calorific value observed in jaggery-treated paneer cubes, together with their improved physicochemical and sensory characteristics, suggests their potential as a nutritious and convenient ready-to-eat dairy product. Similar findings were reported by Sharma *et al.* (2025) [10], who observed an increase in the energy value of dairy products following the incorporation of natural sweeteners.

Sensory characteristics of sweetened paneer cubes

Sensory evaluation is an important criterion for determining the consumer acceptability of novel food products. The sensory scores obtained for sweetened paneer cubes along with control are presented in Table 2. Significant differences (P<0.05) were observed among the treatments for all sensory attributes evaluated. Jaggery-treated paneer cubes received the highest scores for colour and appearance. The attractive golden-brown colour developed during cooking in jaggery syrup enhanced the visual appeal of the product and contributed to greater consumer preference. Sugar-treated paneer cubes also exhibited improved appearance compared with the control; however, their scores were lower than those of the jaggery-treated samples. Similar observations have been reported by Lamdande *et al.* (2018) [8], who attributed the enhanced appearance of jaggery-based dairy products to the natural pigments and caramelized compounds present in jaggery.

Flavour scores were significantly higher for jaggery-treated paneer cubes. The characteristic caramelized flavour compounds naturally present in jaggery imparted a pleasant and distinctive aroma that was highly appreciated by the sensory panel. In contrast, sugar-treated samples exhibited comparatively lower aroma scores due to the relatively neutral flavour profile of refined sugar. Similar findings were reported by Dhruvit *et al.* (2025) [5], who observed enhanced aroma and flavour in dairy products supplemented with jaggery. The sensory evaluation of juiciness closely corresponded with the physico-chemical findings. Jaggery-treated paneer cubes received the highest juiciness scores, reflecting their superior moisture retention and enhanced mouthfeel. Improved juiciness is generally associated with greater palatability and consumer satisfaction, thereby contributing positively to overall product acceptance. These results are in agreement with those reported by Ashritha *et al.* (2022) [1]. Significant improvements in tenderness and texture were observed in sweetener-treated samples compared with the control. The enhanced moisture retention and syrup absorption associated with jaggery treatment likely contributed to a softer body and a more desirable textural profile. Consequently, jaggery-treated paneer cubes received higher sensory scores for these attributes. Similar observations were reported by Choudhary *et al.* (2025) [4], who found that increased moisture retention improved the textural quality of value-added paneer products.

Table 2: Sensory characteristics of sweetened paneer cubes

Sensory characteristics**	C (Control)	T_1 (Sugar)	T_2 (Jaggery)
Colour and Appearance	6.50±0.12^c	7.00±0.10^b	8.00±0.12^a
Flavour	6.00±0.10^c	7.00±0.13^b	8.50±0.12^a
Juiciness	6.50±0.14^c	7.00±0.10^b	8.50±0.12^a
Tenderness	7.00±0.12^c	7.50±0.12^b	8.00±0.10^a
Texture	7.00±0.12^c	7.50±0.14^b	8.00±0.12^a
Overall Acceptability	6.60±0.11^c	7.20±0.12^b	8.40±0.11^a

**Number of observations: = 42
**Sensory attributes were evaluated on a 9 - point descriptive scale (wherein 1 = extremely undesirable; 9 = extremely desirable).
Means bearing different superscripts row- wise differ significantly (p<0.05).

Overall acceptability scores clearly indicated a preference for jaggery-treated paneer cubes. The combination of attractive appearance, pleasant aroma, superior juiciness, and desirable texture resulted in significantly higher acceptability compared with sugar-treated and control samples. These findings demonstrate the positive influence of jaggery on the sensory quality of paneer cubes and highlight its potential as a value-adding ingredient in dairy products. Similar results have been reported by Sharma *et al.* (2025) [10], who observed higher consumer acceptance for dairy products prepared with natural sweeteners than for those prepared with refined sugar.

Conclusion

The present study demonstrated that the incorporation of sugar and jaggery improved the physicochemical and

sensory characteristics of paneer cubes compared with the control. Among the treatments, jaggery-treated paneer cubes exhibited superior product yield, water-holding capacity, juiciness, energy value, and overall sensory acceptability. The findings suggest that jaggery can be effectively utilized as a natural sweetener for the development of value-added, ready-to-eat paneer products with enhanced consumer appeal.

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