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Chemical Assessment of Iron and Calcium Enhancement in Petha Sweet Using Honey as a Natural Sweetner

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Abstract

The study investigated the influence of honey incorporation on the mineral composition, specifically iron (Fe) and calcium (Ca), of *Petha* sweet prepared from Benincasa hispida (ash gourd). Honey, a natural sweetener rich in essential nutrients such as vitamins, minerals, and antioxidants, possesses notable antimicrobial, anti-inflammatory, and antioxidant properties. It supports digestion, enhances immunity, and serves as a healthier alternative to refined sugar. In the present study, honey was incorporated as a partial substitute for refined sugar to improve the nutritional and functional quality of traditional *Petha* sweet. The control sample was prepared by using only ash gourd and refined sugar with ratio 40:60 (T_0). Honey enrich *Petha* sweet was prepared with 5 different combinations of refined sugar and honey i.e. 50:10 (T1), 40:20 (T2), 30:30 (T3), 20:40 (T4), 10:50 (T5). The incorporation of honey resulted in a significant ($p < 0.05$) increase in both calcium and iron content compared to the control. Calcium content exhibited a progressive increase from 12.60 mg/100 g in the control (T_0) to 14.95 mg/100 g in the highest honey-incorporated sample (T_5), indicating a positive correlation between honey substitution level and calcium enrichment. Similarly, iron content increased gradually from 4.78 mg/100 g in the control (T_0) to 4.93 mg/100 g in the T_5 formulation, demonstrating a consistent enhancement in iron concentration with higher honey incorporation levels. The enhancement in mineral content is attributed to the inherent mineral richness of honey and its synergistic interaction with the product matrix, which may improve mineral retention and bioavailability during processing. Thus, the partial replacement of refined sugar with honey, optimally at a 30:30 ratio, not only enriches the mineral profile of *Petha* sweet but also transforms it into a more nutritionally superior and functionally enhanced traditional confection.

Keywords: *Petha* sweet; Honey; Mineral fortification; Iron; Calcium; Nutritional enhancement; Functional confection

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Introduction

Petha sweet, a traditional confection originating from Agra, India, is widely recognized for its translucent appearance, chewy texture, and cultural significance. Agra has emerged as a major hub for the production and processing of this delicacy, which is primarily derived from ash gourd (*Benincasa hispida*). Ash gourd, also referred to as white gourd, wax gourd, winter melon, or Chinese preserving melon, is a versatile cucurbit vegetable in India with high potential for value addition [1]**.** With an average yield potential of 25–30 tons per hectare [2]**,** ash gourd (*Benincasa hispida*) serves as an economically and nutritionally important cucurbit crop. The edible portion of the fruit contains approximately 96.3% moisture, 0.12% acidity, 3.5°Brix total soluble solids, and 0.5% mineral content [3, 4]**.** These minerals are vital for maintaining metabolic balance, electrolyte regulation, and overall physiological functions. Furthermore, the fruit's high dietary fiber content aids in lowering cholesterol levels and mitigating the risk of cardiovascular and digestive disorders [5]**.** Due to its low carbohydrate content, ash gourd is also recommended for individuals with diabetes or hypertension who require a diet with reduced sugar intake [6]**.**

Honey is a naturally sweet and viscous product synthesized by *Apis mellifera* bees from the nectar collected from floral nectaries. It is predominantly composed of carbohydrates (approximately 82%), along with water (17%), proteins (0.3%), and minerals (0.7%). In addition, it contains a variety of bioactive constituents such as enzymes, vitamins, phenolic acids, flavonoids, and organic acids that contribute to its functional and nutritional value. The major monosaccharides in honey are fructose (around 38%) and glucose (about 31%), with only trace amounts of sucrose (<8%). Despite its high sugar content, honey is considered a functional food due to the presence of numerous bioactive compounds and enzymes that impart antioxidant, antimicrobial, anti-inflammatory, and potential anticancer activities

[7]. Honey possesses distinct hygroscopic and viscous properties due to its high sugar content, primarily fructose and glucose. It serves as a natural sweetener and an efficient source of energy, with its characteristic sweetness and aroma arising from trace compounds such as alcohols, esters, and aldehydes [8]. As a traditional natural sweetener, honey provides a healthier alternative to refined sugar, aligning with current nutritional trends toward functional and wellness-oriented foods. Its lower glycemic index aids in better regulation of blood glucose levels, while inherent antimicrobial and preservative properties contribute to product stability. Moreover, honey's unique flavor and aroma enhance sensory appeal, making it an ideal ingredient for developing nutritionally improved and health-promoting versions of traditional foods.

Excessive consumption of white sugar (approx. 99.7% sucrose) is associated with various health issues, including cardiovascular disorders [9], prompting the exploration of natural alternatives such as honey. Previous studies have explored jaggery-based *petha* with improved shelf life [10], highlighting the potential of sugar substitutes in traditional confections. Minerals are vital dietary components that perform diverse physiological and biochemical functions. They serve as structural elements for bones and teeth, regulate muscle and nerve activity, and maintain the body's fluid balance [11]. In addition, minerals form integral parts of enzymes, hormones, and other bioactive compounds, contributing to immune system efficiency and influencing susceptibility to infections and chronic diseases [12, 13]. Although a balanced diet generally provides adequate mineral intake, deficiencies may occur in certain groups such as the elderly, pregnant women, vegetarians, and athletes following restrictive diets. In such cases, professional dietary guidance is essential to ensure proper mineral intake and prevent potential interactions with medications [14].
Traditional sweets like *Petha*, prepared primarily with refined sugar, are typically low in essential minerals, limiting their nutritional value. Incorporating natural ingredients rich in micronutrients, such as honey, provides an opportunity to enhance the mineral profile of these confections. Honey contains trace amounts of minerals, including iron, calcium, potassium, magnesium, and zinc, which can contribute to the fortification of the final product. Evaluating the effect of honey incorporation on the iron and calcium content of *Petha* sweet is therefore crucial for developing a nutritionally enriched and functionally improved traditional confection [15].

The present study investigates the impact of partially replacing refined sugar with honey in the preparation of *Petha* sweet. The study focuses on assessing the effect of honey incorporation on mineral content, particularly iron and calcium, as well as evaluating the sensory and nutritional improvements.

Treatments

Table 1 Formulation for *Petha* Sweet

Treatment	Formulation Description
T_0	Control – 40 g ash gourd pieces steeped in 60 g sugar
T_1	40 g ash gourd + 50 g sugar + 10 g honey
T_2	40 g ash gourd + 40 g sugar + 20 g honey
T_3	40 g ash gourd + 30 g sugar + 30 g honey
T_4	40 g ash gourd + 20 g sugar + 40 g honey
T_5	40 g ash gourd + 10 g sugar + 50 g honey

Materials and Methods

Raw Materials

Fresh, mature, bright-colored, and disease-free ash gourds (*Benincasa hispida*) were sourced from the local market of Prayagraj. Refined sugar and honey were procured from local suppliers. All experimental analyses and processing were carried out in the Department of Food Science and Technology, Warner College of Dairy Technology, SHUATS, Prayagraj.

Preparation of Honey-Based Petha Sweet

Ash gourd fruits were peeled, deseeded, and cut into uniform cubes to ensure even cooking. The cubes were soaked in a 1–2% calcium hydroxide solution for 2–3 hours to improve firmness, followed by thorough rinsing with potable water to remove any residual lime. Blanching was carried out by immersing the cubes in hot water at 70 ± 2°C for 5–10 minutes to inactivate enzymes and initiate partial cooking. The blanched cubes were then immediately cooled in cold water to stop further cooking. A sugar syrup was prepared by dissolving sugar in water according to the treatment formulations and heating it to boiling. The blanched ash gourd cubes were then added and cooked at 40 ± 5°C for 50–55 minutes until the syrup reached a one-thread consistency and the cubes turned translucent, indicating complete absorption of syrup. Gentle stirring was maintained throughout the process to prevent breakage. For honey-based variants, honey was incorporated as per the formulation ratios and gently warmed in a double-jacketed steam kettle without boiling to preserve its bioactive properties. After cooking, the prepared *petha* pieces were drained on a strainer or wire rack and cooled to room temperature. To obtain a firmer texture, the pieces were optionally air-dried or dehydrated at a low temperature until the desired consistency was achieved.

Figure 1 Processing Flowchart for Developing *Petha*

Mineral analysis
Calcium Estimation

The calcium content was estimated through a titrimetric method. Calcium ions were first precipitated as calcium oxalate, which was then dissolved in hot dilute sulfuric acid (H_2SO_4) and titrated against a standard potassium permanganate ($KMnO_4$) solution. The endpoint was identified by the appearance of a stable pink coloration. The calcium concentration was calculated based on the titrant volume, following the standard procedure outlined by AOAC (2000) [16].

Iron Estimation

Iron content was determined using a colorimetric technique. The iron in the sample was oxidized to the ferric (Fe^{3+}) state using potassium persulfate or hydrogen peroxide and subsequently reacted with potassium thiocyanate to form a red ferric thiocyanate complex. The intensity of the color was measured spectrophotometrically at 480 nm, and the iron concentration was derived from a standard calibration curve in accordance with AOAC (2000) [16].
Overall, calcium and iron contents were quantified using standardized titrimetric and colorimetric methods, respectively, to accurately evaluate the mineral fortification achieved in honey-incorporated *Petha* samples.

Statistical analysis

The collected data were examined statistically for upto five replications. Means and one-way analysis of variance (ANOVA) were computed using Microsoft Excel software. A 5% significance threshold was used to evaluate differences in mean values at $p<0.05$.

Result and discussion

The present study, titled "Development and Value Enhancement of *Petha* Sweet with Honey (*Apis mellifera*) and Date Syrup (*Phoenix dactylifera*)," was conducted at the Research Laboratory of Warner College of Dairy Technology, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj. The work aimed to improve the nutritional properties of *Petha* by partially replacing refined sugar with honey. For this purpose, mineral analysis focusing on calcium and iron was carried out for both control and treated samples. The results showed a clear increase in calcium and iron content in the honey-incorporated formulations compared with the refined-sugar control. This improvement is attributed to the natural mineral constituents of honey. Statistical analysis confirmed significant differences among treatments, indicating that even partial substitution of sugar with honey effectively enhanced the mineral profile of Petha. These findings demonstrate the potential of honey incorporation to improve the nutritional value and functional quality of this traditional sweet.

Mineral profile (iron and calcium) of honey-incorporated petha

The incorporation of honey into Petha sweet significantly influenced its mineral composition, particularly the concentrations of iron (Fe) and calcium (Ca). Gradual replacement of refined sugar with honey at 10%, 20%, 30%, 40%, and 50% levels resulted in a progressive enhancement of mineral content.

Table 2 Table Presenting the Mean Value of Minerals Analysis Developed Honey *Petha* Sweet

Treatment	Calcuim(mg/100g)	Iron(mg/100g)
T0	12.60	4.78
T1	13.07	4.81
T2	13.54	4.84
T3	14.01	4.87
T4	14.48	4.90
T5	14.95	4.93

Calcium content of developed petha sweet

The calcium content of the developed *Petha* samples showed a clear improvement with the incorporation of honey. The control sample (T_0) recorded a calcium value of 12.60 mg/100 g, which was significantly lower than all honey-based formulations (T_1–T_5). The honey-incorporated samples exhibited calcium values ranging from 13.07 to 14.95 mg/100 g, indicating a gradual increase as the level of honey addition increased. The observed values were 13.07, 13.54, 14.01, 14.48, and 14.95 mg/100 g for the treatments containing 10, 20, 30, 40, and 50 g of honey, respectively. This progressive rise in calcium content can be attributed to the natural mineral composition of honey, which has been reported to contain 3–31 mg/100 g calcium [15]. Overall, the results confirm that blending honey into *Petha* contributes to enhanced calcium levels compared to the refined sugar-based control.

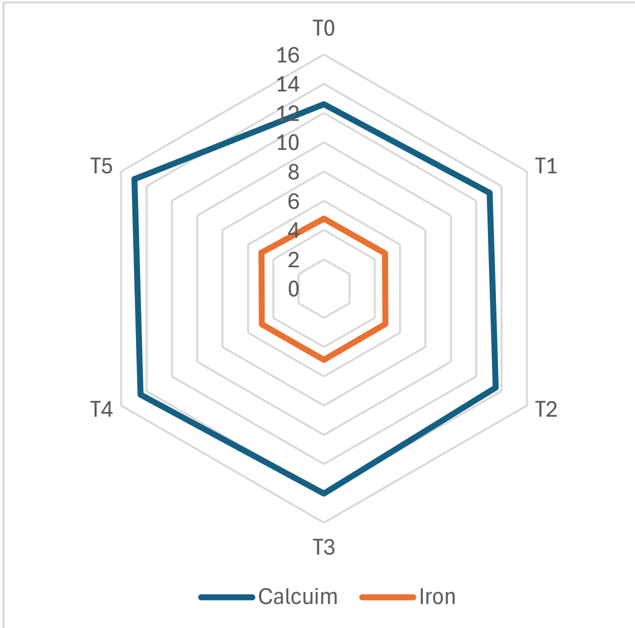

Figure 2 Graph Presenting the Mean Value of Minerals Analysis Developed Honey *Petha* Sweet

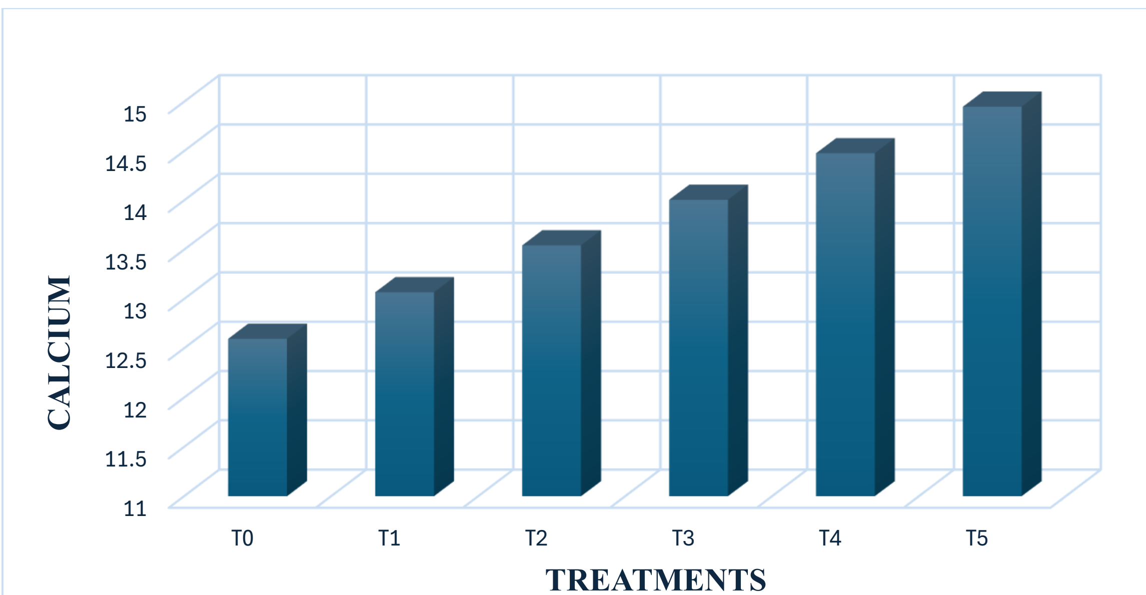

Figure 3 Graphical Representation of Average Calcium Content of Developed Honey *Petha* Sweet

Iron content of developed petha sweet

The iron content of the Petha samples showed a slight but consistent increase with the incorporation of honey. The control sample (T_0) contained 4.78 mg/100 g iron, whereas the honey-treated formulations (T_1–T_5) exhibited values ranging from 4.81 to 4.93 mg/100 g. The recorded iron contents for the treatments with 10, 20, 30, 40, and 50 g of honey were 4.81, 4.84, 4.87, 4.90, and 4.93 mg/100 g, respectively, indicating a gradual improvement as honey levels increased. Although the increment was modest, it remained consistently higher than the control across all treatments, reflecting the contribution of honey's natural mineral composition. Ajibola et al. [15] also reported that honey contains measurable iron (0.03–4 mg/100 g), which supports the enhanced iron levels observed in the honey-enriched samples. Overall, the results confirm that even partial substitution of refined sugar with honey leads to a measurable increase in the iron content of *Petha* sweet.

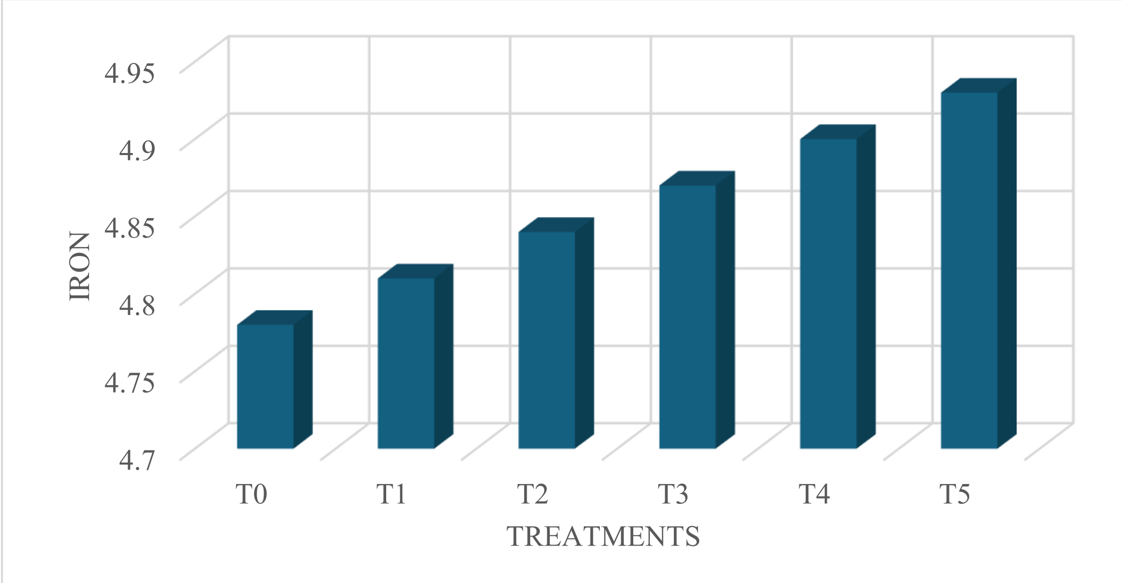

Figure 4 Graphical Representation of Average Iron Content of Developed Honey *Petha* Sweet

Conclusion

The mineral analysis of the developed honey-incorporated Petha sweet showed a noticeable improvement in calcium and iron levels compared with the control sample. The control formulation (T_0), prepared with 40% ash gourd and 60% sugar, recorded the lowest calcium (12.60 mg/100g) and iron (4.78 mg/100g) contents. In contrast, the honey-based treatments (T_1–T_5) demonstrated progressively higher mineral values as the proportion of honey increased. The calcium content ranged from 13.07 mg/100g in T_1 to 14.95 mg/100g in T_5, while iron content increased from 4.81 mg/100g in T_1 to 4.93 mg/100g in T_5. Among all honey formulations, treatment T_3 exhibited the optimum mineral profile, with 14.01 mg/100g calcium and 4.87 mg/100g iron, indicating that moderate incorporation levels were most effective in enhancing mineral concentration. The observed increases align with the intrinsic mineral composition of honey, which contains measurable amounts of calcium and iron as reported by Ajibola et al. (2016). These findings clearly show that substituting refined sugar with honey enhances the mineral content of *Petha* without compromising product quality. The T_3 formulation (30:30 sugar:honey ratio) demonstrates that honey can be effectively utilized to enhance the nutritional and functional attributes of traditional Petha sweet. The findings confirm the functional potential of honey as a natural fortifying agent, offering a viable pathway for producing value-added *Petha* with improved nutritional attributes.

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