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Quality assessment of banana pseudostem candy developed with palm sugar and lime pre-treatment

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Abstract

The present study was conducted to evaluate the quality of banana pseudostem (central core) candy developed using palm sugar and lime (calcium hydroxide) pre-treatment. Banana pseudostem, an underutilized agro-waste rich in dietary fibre and minerals, was processed into candy after lime pre-treatment at different concentrations. Eleven treatments were formulated ranging from 0% lime (T₁) to 10% lime (T₁₁) and the candies were prepared using palm sugar as the sweetening agent. The developed products were analysed for key biochemical parameters including total soluble solids (TSS), total sugars, reducing sugars, acidity and protein content. Sensory evaluation was carried out by a panel of 15 semi-trained judges using a 9-point hedonic scale to assess colour, texture, taste, and overall acceptability. The results revealed that lime pre-treatment significantly influenced both the biochemical and sensory attributes of banana pseudostem candy. With increasing lime concentration notable variations were observed in sugar profile, acidity and protein content. Among the treatments, T₈ showed the highest overall acceptability followed by T₂ and T₁ indicating that moderate lime pre-treatment effectively improved texture, taste, colour and overall quality without imparting undesirable sensory characteristics. Excessive lime concentrations (T₉ to T₁₁) tended to adversely affect sensory scores despite certain improvements in nutritional attributes. The study concludes that banana pseudostem candy developed with palm sugar and an optimum level of lime pre-treatment particularly T₈, can serve as a nutritionally enriched and sensorially acceptable value-added product offering a promising approach for the utilization of banana pseudostem in functional confectionery products.

Keywords: Banana, waste, candy, palm sugar, lime

Introduction

Banana (*Musa* spp. L.) of the family Musaceae is one of the most widely cultivated tropical fruit crops and is consumed globally by people of all age groups (Jeetendra *et al.*, 2020) [5]. The tender inner core of the banana pseudostem is edible and possesses several health-promoting properties. It is rich in dietary fibre, making it particularly useful for weight management (Rajesh, 2017) [14]. The pseudostem also provides appreciable amounts of potassium and vitamin B6, which support insulin synthesis and haemoglobin formation and contribute to the regulation of blood pressure (Rajesh, 2017) [14]. Furthermore, pseudostem extract has been reported to help dissolve kidney and urinary bladder stones, while the central core is traditionally used in the management of digestive disorders and diabetes (Kumar *et al.*, 2012) [6]. Candying is a process where sugar syrup slowly penetrates the fruit tissues until a sufficiently high sugar concentration is achieved which suppresses the growth of spoilage microorganisms (Mohanta *et al.*, 2021) [11]. The application of natural sweeteners like palm sugar in candy preparation has gained attention due to its lower glycemic index, rich mineral content, and consumer preference for traditional sweeteners.

Pre-treatment of raw materials using lime (calcium hydroxide) is a common technique in fruit and vegetable processing to improve textural properties, reduce enzymatic browning and enhance the colour stability of the final product. Therefore, the combined use of lime pre-treatment and palm sugar could offer a novel approach to developing functional candy from banana pseudostem.

The present study aims to develop candy from banana pseudostem (central core) treated with lime and palm sugar and evaluate its quality characteristics during storage. The research focuses on assessing the physico-chemical and sensory parameters to establish its storage stability and consumer acceptability.

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Materials and Methods

The experimental work was undertaken in the Research Laboratory of the Department of Horticulture, NEHU, Tura Campus, Meghalaya, during the year 2024. The central edible core of the banana pseudostem served as the main ingredient for candy preparation. The banana pseudostems were collected from West Garo Hills district, while palm sugar and lime (calcium hydroxide) used in the study were purchased from the local market of Tura, Meghalaya.

Processing

The preparation process involved peeling off the outer layers of the pseudostem using a knife to extract the central core. The core was then washed thoroughly with tap water

and cut into uniform cubes of 3 cm × 3 cm × 3 cm size. These cubes were subjected to pre-treatment by soaking in a lime solution for one hour, with varying concentrations based on the treatment specifications. Sugar syrup was prepared separately using palm sugar and the pre-treated cubes were immersed in the syrup to promote osmotic dehydration. The steeping process continued until the syrup concentration reached 70°Brix for all treatments. After achieving the desired syrup strength, the candy pieces were drained, rinsed and spread evenly on trays for drying. The drying process was closely monitored to avoid excessive stickiness. Once properly dried, the candies were packed in polyethylene bags and stored for further quality assessment and sensory analysis.



Nutritional analysis

The biochemical composition of the candy samples was determined using standard analytical procedures. Total soluble solids (TSS) were measured in °Brix using a Hand Refractometer, while total sugars were estimated using the Lane and Eynon method (1923), titratable acidity (%) by AOAC (1984)^[2] and protein (%) by Lowry (1951)^[9].

Sensory evaluation

The sensory attributes of the banana pseudostem candy were assessed by a panel of 15 semi-trained evaluators. The panel members evaluated the samples for colour, taste, texture, and overall acceptability using a 9-point Hedonic Scale, following the method suggested by Amerine *et al.* (1965)^[1].

Statistical analysis

The experimental data collected from various observations were statistically analysed using the Completely Randomized Design (CRD) method as outlined by Panse and Sukhatme (1957)^[13].

Results

The effects of lime (calcium hydroxide) pre-treatment (0-10%) on the physicochemical and nutritional properties of banana pseudostem candy prepared with 70% palm sugar syrup are presented in Table 1. Treatment T₁ (0% lime)

served as the control, while T₂ to T₁₁ involved dipping pseudostem pieces in increasing lime concentrations for 1 hour prior to candying.

Total Soluble Solids (TSS)

The TSS content increased progressively from 37.27 °Brix (T₁) to 42.33 °Brix (T₁₁) with increasing lime concentration (Table. 1). This trend indicates enhanced osmotic uptake of soluble solids from the palm sugar syrup as the structural integrity of the tissue was modified by calcium.

Total sugars

According to Table 1, total sugar content increased significantly from 19.39% in the control (T₁) to 31.75% in T₁₁. The higher values in lime-treated samples suggest that pre-treatment facilitated greater penetration of palm sugar during processing. Calcium's role in reducing cell wall enzymatic degradation and improving structural stability likely allowed for improved solute diffusion into the pseudostem matrix.

Reducing sugar

Reducing sugars increased significantly from 9.07% (T₁) to 14.65% (T₁₁) likely due to sucrose hydrolysis under processing conditions and enhanced retention in the more stable lime-treated tissues.

Titrateable acidity: The data presented in Table 1 indicate that lime pre-treatment significantly influenced the acidity of banana pseudostem candy. Acidity initially increased from 0.13% in T₁ to a maximum of 0.38% in T₂, followed by a gradual decline with further increase in lime concentration, reaching the minimum value of 0.10% in T₁₁ (10% lime).

Protein: Protein content showed a decreasing trend with

increasing lime concentration. The highest protein content was recorded in T₁ (14.41%), which gradually declined to 8.44% in T₁₁. The decline in protein content may be attributed to leaching of soluble nitrogenous compounds during lime soaking, dilution effects due to increased sugar uptake during candy preparation and thermal degradation during processing. Acid-mediated denaturation of proteins during lime treatment may also contribute to lower measurable protein levels at higher concentrations.

Table 1: Influence of lime pre-treatment on TSS, total sugar, reducing sugar, acidity and protein content in banana pseudostem candy

Treatments	TSS (°Brix)	Total Sugar (%)	Reducing sugar (%)	Acidity (%)	Protein (%)
T ₁	37.27	19.39	9.07	0.13	14.41
T ₂	38.13	22.41	9.13	0.38	13.53
T ₃	38.73	23.15	9.26	0.34	12.78
T ₄	38.93	24.07	10.02	0.30	12.23
T ₅	39.27	26.19	10.72	0.27	11.92
T ₆	39.93	27.38	11.33	0.26	11.58
T ₇	40.53	28.57	12.01	0.23	11.15
T ₈	40.6	28.97	12.25	0.23	11.08
T ₉	41.13	30.16	12.31	0.17	9.84
T ₁₀	41.87	30.56	13.37	0.13	8.86
T ₁₁	42.33	31.75	14.65	0.10	8.44
SE.d±	0.690	2.160	0.590	0.014	0.267
CD (5%)	1.940	6.080	1.660	0.03	0.557
CV%	2.12	9.93	6.40	7.646	2.854

TSS: Total Soluble Solids,

Sensory evaluations

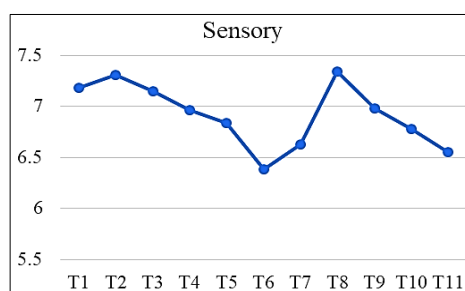


Fig 1: Sensory evaluation of lime pre-treated banana pseudostem candy

According to Fig no. 1 the overall sensory scores ranged from 6.38 to 7.34, indicating that all treatments were acceptable with noticeable differences among lime concentrations. The control sample (T₁, 0% lime) recorded a score of 7.18 while lime-treated samples showed both improvement and decline depending on concentration. The highest sensory score was observed in T₈ (7% lime 7.34) followed by T₂ (7.31). This suggests that moderate lime

concentration significantly enhanced the sensory quality of banana pseudostem candy.

Storage study

Further storage study was carried out only for the best treatment i.e T₈ (7% lime). Here the duration of the storage was considered as treatments and biochemical analysis was carried out.

Table 2: Changes in TSS, total sugar, reducing sugar, acidity, protein content and sensory quality during storage

Treatments/Duration (Months)	TSS (°Brix)	Total Sugar (%)	Reducing sugar (%)	Acidity (%)	Protein (%)	Sensory evaluation
0	38.47	21.48	10.02	0.23	11.08	7.34
1	38.73	22.22	10.18	0.27	10.95	7.29
2	39.07	23.15	10.53	0.30	10.19	7.24
3	39.33	24.07	10.72	0.34	9.22	7.18
4	39.60	25.00	10.92	0.38	8.77	7.05
5	39.73	26.19	11.11	0.43	8.38	6.93
6	40.00	27.38	11.33	0.47	7.58	6.81
7	40.07	28.57	11.55	0.51	7.21	6.68
8	40.33	30.16	11.76	0.55	6.77	6.57
9	40.60	31.75	12.01	0.60	6.44	6.39
SE.d±	0.079	1.424	0.263	0.003	0.162	0.165
CD (5%)	0.166	2.991	0.552	0.006	0.34	0.335
CV%	0.24	6.70	2.92	0.86	2.28	3.76

Total soluble solids

A progressive and significant increase in TSS content was observed throughout the storage period. At the initial stage (0 month), the TSS was recorded as 38.47 °Brix, which gradually increased to 40.60 °Brix after nine months of storage (Table 2).

Total sugar

Total sugar content as shown in Table 2 exhibited a steady and marked increase with advancement of storage period, rising from 21.48% at the beginning to 31.75% at the end of nine months.

Reducing sugar

Reducing sugar content also followed an increasing trend during storage, ranging from 10.02% at 0 month to 12.01% after nine months (Table 2).

Acidity

The data presented in Table 2 show that acidity of banana pseudostem candy increased significantly with storage period (0 to 9 months).

Protein

Protein content showed a declining trend with increase in storage duration. The values decreased from 11.08% to 6.44% (Table 2).

Sensory evaluation

The overall sensory acceptability score as shown in Table 2, gradually decreased with increase in storage duration, declining from 7.34 at the beginning to 6.39 after nine months of storage.

Discussions

- **TSS:** The rise in TSS during storage may be attributed to moisture loss and hydrolysis of complex carbohydrates and polysaccharides into simpler soluble components, resulting in concentration of soluble solids. Similar results were found by Kaur and Singh (2021)^[7] in kinnow peel candy.
- **Total sugar:** The increase in total sugars during storage may be due to inversion of non-reducing sugars into reducing sugars and breakdown of polysaccharides into simpler sugar fractions. Kaur and Singh (2021)^[7] reported similar results in kinnow peel candy. Lime pre-treatment possibly enhanced stability of the tissue matrix initially, however, prolonged storage still resulted in gradual biochemical conversions leading to sugar accumulation.
- **Reducing sugar:** The increase in reducing sugars is commonly associated with the hydrolysis of sucrose and degradation of complex carbohydrates during storage. Adhau *et al.*, (2025)^[3] observed similar increase in reducing sugar content in kokum candy developed from rind waste.
- **Acidity:** The acidity rose steadily from 0.23% at 0 month to 0.60% at 9 months, indicating progressive acid development during storage. The increase in acidity during storage may be attributed to hydrolysis of carbohydrates and formation of organic acids, concentration effects due to moisture loss, and biochemical changes occurring in the product over time. Similar findings were reported by Muzzaffar *et*

al., (2016)^[12] also reported an increase in titratable acidity in pumpkin candy stored at room temperature.

- **Protein:** The decrease in protein during storage may be due to dilution caused by sugar uptake, thermal effects during processing, and possible Maillard reactions between proteins and sugars, which reduce measurable protein fractions in high-sugar products during prolonged storage. Adhau *et al.*, (2025)^[3] reported a similar trend in kokum candies, noting that protein content tended to decrease with increasing sugar solution concentration
- **Sensory evaluation:** Although a slow reduction in sensory quality was evident, the product remained within the acceptable range throughout the storage period. The decline in sensory scores could be attributed to slight darkening of colour, softening or hardening of texture, flavour changes and development of mild off-notes during prolonged ambient storage similar trend in banana pseudostem candy.

Conclusion

It can be concluded that lime (calcium hydroxide) pre-treatment in combination with 70% palm sugar syrup significantly influences the quality of banana pseudostem candy, particularly its sugar profile, acidity, texture and sensory acceptability. The highest overall sensory score was obtained in T₈ (7% lime) followed by T₂ and T₁ demonstrating that moderate lime pre-treatment provides the most desirable balance of sweetness, texture, colour and mouthfeel. Higher lime concentrations despite improving sugar uptake tended to reduce sensory quality likely due to excessive firmness and slight alkaline notes. Further studies on microbial load, textural changes, mineral retention and consumer preference across different age groups are recommended to support the commercial development of this value-added functional confectionery product derived from banana pseudostem.

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