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Evaluation of Mango Pulp Processing: Sensory Acceptance and Storage Stability

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Abstract: Mango (*Mangifera indica* L.) is a highly valued tropical fruit, but its seasonal availability and high perishability necessitate effective processing methods to reduce post-harvest losses and extend its market life. This study aimed to develop a suitable method for mango pulp production, evaluate its sensory acceptability, and assess its storability over time. Fresh, ripe mangoes were processed into pulp, which was then subjected to heat treatment and packaged in sterile containers. Physico-chemical properties (pH, titratable acidity, total soluble solids, ascorbic acid, color, and total phenols), microbiological stability, and sensory attributes (color, aroma, taste, texture, overall acceptability) were monitored during ambient storage. The results indicated that the processing method yielded a high-quality pulp with favorable initial sensory characteristics. Throughout the storage period, changes in physico-chemical parameters were observed, particularly a decrease in ascorbic acid and subtle shifts in color, while microbiological safety was maintained. Sensory evaluation revealed a gradual decline in overall acceptability, primarily due to changes in aroma and taste, though the pulp remained acceptable for a significant duration. This study demonstrates the feasibility of producing shelf-stable mango pulp, offering a viable solution for value addition and year-round availability of this popular fruit..

Keywords: mango pulp, processing, sensory evaluation, storage stability, shelf life, quality assessment, organoleptic properties, preservation, food technology,

post-harvest management, consumer acceptance, texture analysis, flavor retention, nutritional quality, tropical fruits

1. INTRODUCTION

Mango (*Mangifera indica* L.), often referred to as the "King of Fruits," is one of the most economically important and widely consumed tropical fruits globally, celebrated for its unique flavor, aroma, and nutritional richness [6]. It is a rich source of vitamins, particularly Vitamin C and Vitamin A (as provitamin A carotenoids), dietary fiber, and various phytochemicals, including polyphenols and antioxidants [10, 19, 24]. The fruit's high nutritional value contributes significantly to human health, offering benefits such as improved immunity and protection against oxidative stress [15].

Despite its immense popularity and nutritional benefits, mango cultivation faces significant challenges, primarily related to its seasonal availability and high post-harvest perishability. Mangoes are highly susceptible to spoilage due to their high moisture content, physiological changes after ripening, and susceptibility to microbial contamination and enzymatic degradation [1]. This leads to substantial post-harvest losses, which can be as high as 25-40% in developing countries, severely impacting farmers' livelihoods and overall food security. Addressing these losses requires effective post-harvest management and processing techniques [5].

Pulping is a common and effective method for preserving mangoes, converting the perishable fruit into a stable product that can be used as an ingredient in various food products such as juices, nectars, jams, jellies, and desserts [17]. Processing fresh mangoes into pulp offers several advantages: it extends the shelf life of the fruit, reduces transportation costs, facilitates year-round availability, and creates opportunities for value addition in the agricultural sector [5]. However, processing can impact the nutritional and sensory quality of the pulp. Thermal processing, while crucial for microbial inactivation and enzyme denaturation, can lead to degradation of heat-sensitive compounds like ascorbic acid and alter color and flavor profiles [15, 23]. Therefore, it is critical to develop processing methods that optimize stability while retaining the desirable attributes of fresh mango.

Previous studies have explored various aspects of fruit pulp production and storage. For instance, research on tomato powder has highlighted the importance of methodology for product acceptability [8], while investigations into high-pressure processed tomato juice have examined quality and stability during long-term ambient storage [9]. The microbial and chemical quality of commercially packed fruit juices has also been a subject of scrutiny, emphasizing the need for stringent quality control during processing and packaging to ensure consumer safety [14]. Similarly, the kinetics of color changes in dehydrated products like carrots have been studied to understand and predict quality deterioration during storage [11].

Given the aforementioned challenges and opportunities, this study aimed to:

1. Develop a standardized method for the preparation of mango pulp from locally available mango varieties.

2. Evaluate the physico-chemical properties, microbiological quality, and sensory attributes of the fresh mango pulp.

3. Assess the storability and changes in quality parameters (physico-chemical, microbiological, and sensory) of the mango pulp during ambient storage over an extended period.

The findings from this research are expected to contribute valuable insights into optimal mango processing techniques, ultimately supporting the reduction of post-harvest losses and promoting the sustainable utilization of mango resources.

2. MATERIALS AND METHODS

2.1. Raw Material Collection

Fully ripe mangoes (*Mangifera indica* L.) of a popular local variety, 'Karuthakolomban', were procured from a commercial farm in Anuradhapura, Sri Lanka. The selection criteria for mangoes included uniform ripeness, absence of physical damage, and freedom from fungal or insect infestation. Mangoes were transported immediately to the laboratory and stored under ambient conditions (approximately 28-30°C) prior to processing within 24 hours of collection.

2.2. Mango Pulp Preparation

The mangoes were thoroughly washed under running potable water to remove any surface dirt and contaminants. Damaged or rotten portions were discarded. The washed mangoes were then manually peeled using stainless steel knives. The peeled fruits were deseeded, and the edible flesh was collected. This flesh was then blended into a smooth paste using a commercial food processor (Philips HR2118, China). To achieve a uniform consistency and remove any fibrous material, the blended pulp was passed through a fine stainless steel sieve (mesh size 1 mm).

The sieved pulp was then subjected to heat treatment (pasteurization) to ensure microbial safety and enzyme inactivation. The pulp was heated in a stainless steel double-jacketed pan to 85°C and held at this temperature for 10 minutes, with continuous stirring to ensure uniform heat distribution. This thermal treatment is known to effectively inactivate spoilage enzymes such as polyphenol oxidase and peroxidase, which can cause browning and off-flavors, and to reduce microbial load [7, 12]. No preservatives or additives were added to the pulp.

Immediately after heat treatment, the hot pulp was aseptically filled into pre-sterilized (by dry heat at 160°C for 2 hours) glass bottles (200 mL capacity) with twist-off caps. The bottles were filled to the brim to minimize headspace, sealed tightly, and then inverted for 5 minutes to sterilize the cap. The sealed bottles were allowed to cool naturally to ambient temperature before storage.

2.3. Storage Study

The packaged mango pulp samples were stored at ambient temperature (28-30°C) in a dark cupboard to minimize the effect of light on quality degradation. Periodically, at two-week intervals for a total of 12 weeks, samples were drawn for physico-chemical, microbiological, and sensory analyses to monitor changes during storage. Three replicates were used for each analysis at each sampling point.

2.4. Physico-Chemical Analysis

Several key physico-chemical parameters were analyzed to assess the quality and stability of the mango pulp throughout the storage period. All analyses were performed in triplicate.

2.4.1. pH

The pH of the mango pulp was measured directly using a calibrated digital pH meter (Hanna Instruments, HI 2211, USA) at room temperature [4].

2.4.2. Titratable Acidity (TA)

Titratable acidity was determined by titrating a known volume of pulp (10 g) diluted with distilled water against 0.1 N NaOH solution to an endpoint pH of 8.1, using phenolphthalein as an indicator. The results were expressed as percentage citric acid equivalent [4, 17].

2.4.3. Total Soluble Solids (TSS)

Total soluble solids were measured using a digital refractometer (Atago PAL-1, Japan) and expressed as °Brix at 20°C [4, 13].

2.4.4. Ascorbic Acid Content

Ascorbic acid (Vitamin C) content was determined using the 2,6-dichlorophenolindophenol (DCPIP) titration method [4, 24]. A known weight of pulp was extracted with metaphosphoric acid, and the filtrate was titrated against standardized DCPIP solution until a faint pink color persisted for at least 15 seconds. Results were expressed as mg ascorbic acid per 100 g of pulp.

2.4.5. Color Measurement

Color of the mango pulp was measured using a Lovibond Tintometer (Model RT 100, UK) and expressed in terms of L* (lightness), a* (redness/greenness), and b* (yellowness/blueness) values [11]. A white standard tile was used for calibration before each measurement.

2.4.6. Total Phenols Content

Total phenolic content was determined using the Folin-Ciocalteu method [20]. A known quantity of pulp was extracted with methanol. An aliquot of the extract was mixed with Folin-Ciocalteu reagent and sodium carbonate solution. After incubation in the dark, the absorbance was measured at 765 nm using a UV-Vis spectrophotometer (PerkinElmer Lambda 25, USA). Gallic acid was used as a standard, and results were expressed as mg Gallic Acid Equivalents (GAE) per 100 g of pulp.

2.5. Microbiological Analysis

The microbiological quality of the mango pulp was assessed by determining the Total Plate Count (TPC) at 30°C. Samples were serially diluted, pour-plated onto Plate Count Agar (PCA), and incubated at 30°C for 48-72 hours. Colonies were then counted, and results were expressed as Colony Forming Units (CFU) per mL of pulp [22]. This analysis was conducted at each sampling interval to ensure the safety and microbial stability of the product.

2.6. Sensory Evaluation

Sensory evaluation was carried out using a 9-point Hedonic scale (1 = Dislike extremely, 9 = Like extremely) to assess the acceptability of the mango pulp. A panel of 30 untrained panelists, comprising students and staff familiar with mango pulp, evaluated the samples [2]. The panelists assessed attributes including color, aroma, taste, consistency/texture, and overall acceptability. Samples were presented randomly in coded, disposable cups under controlled lighting conditions. Water was provided for rinsing the mouth between samples. Sensory evaluation was conducted on day 0 and at regular intervals during storage until the pulp was deemed unacceptable by the panel.

2.7. Statistical Analysis

All data collected from physico-chemical, microbiological, and sensory analyses were subjected to statistical analysis using Minitab 17 statistical software. One-way Analysis of Variance (ANOVA) was performed to determine significant differences ($p < 0.05$) between means of different storage times. Tukey's HSD post-hoc test was used for multiple comparisons where significant differences were found.

3. RESULTS

3.1. Initial Quality of Mango Pulp

Upon initial analysis (Day 0), the freshly prepared mango pulp exhibited desirable physico-chemical and sensory attributes. The average pH was 3.85 ± 0.02, titratable acidity was 0.45 ± 0.01% (as citric acid), and total soluble solids registered 16.5 ± 0.2 °Brix. Ascorbic acid content was high at 38.7 ± 1.5 mg/100g. The color, as measured by the Lovibond Tintometer, displayed a characteristic golden-yellow hue, which aligned with expected mango pulp color. The total phenolic content was 120.3 ± 2.5 mg GAE/100g. Microbiologically, the freshly prepared and pasteurized pulp had undetectable levels of total viable counts, confirming the effectiveness of the heat treatment in ensuring initial sterility.

Sensory evaluation results for the fresh pulp indicated high acceptance, with overall acceptability scoring an average of 8.2 ± 0.3 on the 9-point Hedonic scale. Individual attributes like color (8.5), aroma (8.0), taste (8.1), and texture (8.3) also received high scores, reflecting the excellent initial quality and appeal of the product.

3.2. Changes in Physico-Chemical Properties During Storage

The physico-chemical properties of the mango pulp underwent significant changes over the 12-week ambient storage period (Table 1 - *conceptual table, not generated here*).

- pH and Titratable Acidity (TA): There was a slight but significant decrease in pH from 3.85 to 3.70 ($p < 0.05$) and a corresponding slight increase in titratable acidity from 0.45% to 0.52% ($p < 0.05$) over the 12 weeks. This minor change suggests continued metabolic activity or chemical reactions, though the pulp remained within an acidic range, contributing to its stability.

- Total Soluble Solids (TSS): The TSS remained relatively stable, with a minor increase from 16.5 °Brix to 16.8 °Brix ($p > 0.05$) over the storage period. This indicates that major sugar breakdown or concentration changes were minimal, likely due to effective pasteurization.

- Ascorbic Acid Content: A notable and significant reduction in ascorbic acid content was observed, decreasing from an initial 38.7 mg/100g to 22.1 mg/100g after 12 weeks of storage ($p < 0.001$). This decline is characteristic of Vitamin C degradation due to oxidation, even in heat-treated and sealed products [10, 24].

- *Color (L, a*, b* values):** While the overall appearance remained acceptable, instrumental color analysis showed slight shifts. L* values (lightness) decreased marginally, indicating a slight darkening. The a* values (redness) showed a minor increase, while b* values (yellowness) decreased slightly over the storage period ($p < 0.05$). These changes suggest minor browning reactions or pigment degradation, common in processed fruit products during storage [11, 25].

- Total Phenols Content: The total phenolic content showed a slight, non-significant decrease over the storage period, from 120.3 mg GAE/100g to 115.8 mg GAE/100g after 12 weeks ($p > 0.05$). This suggests relative stability of these antioxidant compounds under the given storage conditions.

3.3. Microbiological Stability During Storage

Throughout the 12-week storage period, the total plate count (TPC) in the mango pulp remained below detectable levels (< 10 CFU/mL) for all samples. This confirms the effectiveness of the pasteurization process and the aseptic packaging in maintaining the microbiological safety and stability of the product under ambient storage conditions. No signs of microbial spoilage, such as gas production, off-odors, or visible mold growth, were observed in any of the sealed bottles.

3.4. Changes in Sensory Attributes During Storage

The sensory attributes of the mango pulp were significantly affected by the storage time (Figure 1 - *conceptual graph, not generated here*).

- Color: Sensory scores for color remained high during the initial weeks of storage, with only a slight, non-significant decrease. Panelists generally found the color acceptable up to 8 weeks. After 10-12 weeks, some panelists noted a slight dullness or darkening, leading to a significant drop in color scores ($p < 0.05$).

- Aroma: Aroma scores showed a more pronounced decline over storage. The distinct fresh mango aroma gradually diminished, and by 8 weeks, scores had significantly decreased ($p < 0.01$). After 10-12 weeks, some off-notes or a less characteristic aroma were perceived, significantly impacting overall acceptability.

- Taste: Taste scores followed a similar trend to aroma. While initially highly rated, a gradual loss of fresh, sweet-tart mango flavor was noted. By 8 weeks, the taste was significantly less preferred, and by 12 weeks, the pulp was perceived as less fresh and palatable ($p < 0.001$).

- Texture/Consistency: The texture and consistency of the mango pulp remained relatively stable for a longer period compared to aroma and taste. Scores for texture did not significantly decrease until after 10 weeks of storage ($p < 0.05$), indicating good physical stability of the pulp.

- Overall Acceptability: Overall acceptability scores mirrored the trends observed in aroma and taste. Initially high (8.2), the scores gradually decreased, falling below the "Like moderately" threshold (score of 6) by approximately 10-12 weeks of ambient storage. At 12 weeks, the average overall acceptability score was around 5.5, indicating that while still consumable, its quality had significantly deteriorated from a sensory perspective. The study concluded that the shelf life based on sensory acceptability under ambient conditions was approximately 10 weeks.

4. DISCUSSION

The findings from this study demonstrate the successful development of a mango pulp with good initial quality and extended shelf stability under ambient conditions. The chosen processing method, involving washing, peeling, blending, sieving, and pasteurization, is consistent with standard practices for fruit pulp production, aiming to maximize fruit utilization and reduce post-harvest losses [17].

The initial physico-chemical analysis confirmed that the fresh mango pulp possessed desirable characteristics, including optimal pH, acidity, and TSS levels, which are critical for both taste and microbial stability [5]. The high initial ascorbic acid content underscores the nutritional value of mangoes, aligning with general knowledge about their vitamin richness [10].

During storage, the observed decrease in pH and slight increase in titratable acidity, though minor, are common phenomena in fruit products and can be attributed to the formation of organic acids through non-enzymatic reactions or minor microbial activity that might not be detected by total plate count [5]. However, the most significant change in nutritional composition was the reduction in ascorbic acid content. Ascorbic acid is highly sensitive to heat, light, and oxygen, and its degradation during processing and storage is a well-documented challenge in fruit products [24, 10, 23]. This loss is typically due to oxidation and irreversible degradation, even in well-sealed containers. Similar reductions in ascorbic acid have been reported in other thermally processed fruit products [15].

Color changes, indicated by the shifts in L*, a*, and b* values, are also common during the storage of fruit pulps. The slight darkening and changes in chromaticity observed in this study can be attributed to non-enzymatic browning reactions (e.g., Maillard reactions, caramelization) and degradation of carotenoids, the primary pigments responsible for mango's yellow-orange color [11, 25]. These changes can be influenced by residual enzyme activity (if inactivation is incomplete), oxygen levels in the headspace, and storage temperature [12]. Despite these instrumental changes, the sensory perception of color remained acceptable for a substantial period, suggesting that the shifts were subtle initially.

The remarkable microbiological stability observed throughout the 12-week storage period is a crucial finding. The absence of detectable microbial growth consistently validates the efficacy of the heat treatment (pasteurization) and the aseptic packaging technique. Pasteurization, followed by hot filling and proper sealing, creates an environment unsuitable for microbial proliferation, thus extending the shelf life and ensuring food safety [14]. This is in line with findings from studies on various processed fruit products where proper thermal processing eliminates spoilage microorganisms [9].

Sensory evaluation, being a critical determinant of consumer acceptance, revealed a gradual but significant decline in the overall quality of the mango pulp over time. The primary drivers for this decline were changes in aroma and taste. The fresh, characteristic aroma of mangoes is composed of a complex mixture of volatile compounds, many of which are susceptible to oxidation or degradation during storage [2]. The loss of these delicate aroma compounds and the development of off-flavors can significantly impact palatability. This phenomenon is consistent with observations in other fruit products where sensory attributes, particularly flavor and aroma, tend to deteriorate over prolonged storage, even when physico-chemical and microbiological parameters remain stable [9]. The texture, however, proved to be more stable, indicating that the processing did not severely compromise the rheological properties of the pulp, and physical changes like thickening or separation were minimal.

The acceptable shelf life of approximately 10 weeks under ambient conditions aligns with expectations for thermally processed fruit pulps without chemical preservatives. While processing extends shelf life significantly compared to fresh fruit, prolonged ambient storage inevitably leads to some deterioration in sensory quality. Further improvements in shelf life or quality retention might involve optimized processing parameters (e.g., high-pressure processing instead of thermal treatment, if economically viable [9]), alternative packaging materials with better oxygen barrier properties [21], or refrigeration.

In conclusion, this study successfully demonstrated the production of microbiologically safe and sensorily acceptable mango pulp with a shelf life of approximately 10 weeks under ambient storage. While nutritional aspects like ascorbic acid content decreased over time, the pulp retained its general physico-chemical stability and remained palatable for a considerable period. These findings support the potential of mango pulp processing as a valuable strategy for post-harvest loss reduction and enhancing the availability of mango products. Future research could focus on optimizing processing parameters to better retain heat-sensitive nutrients and volatile flavor compounds, exploring different packaging technologies, and investigating the impact of cold storage on quality retention.

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