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Research Article

Phytochemical Composition and Functional Properties of Fruit Purees Produced from Some Indigenous Varieties of Mango, Orange and Watermelon

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Abstract

This study explores the phytochemical content, and functional properties of mango, orange, and watermelon purees to evaluate their potential in food formulations and post-harvest loss reduction. Key findings revealed that watermelon puree exhibited the highest total phenolic content (559.03 mg/100 g), tannins (60.85 mg/100 g), and water holding capacity (93.03%), while mango puree had the highest bulk density (1.11 g/cm ^{3}), viscosity (3.84 cP), and oil holding capacity (27.01%). Orange puree contained the highest levels of flavonoids (37.78 mg/100 g) and alkaloids (22.52 mg/100 g). The results for bulk density recorded 1.11g/cm^3 for mango, 0.89g/cm^3 for watermelon and 0.93g/cm^3 for orange. Specific gravity recorded higher value for mango 1.13 followed by orange 1.05 then watermelon 0.92. Viscosity also recorded higher value for mango (3.84cP) then orange 2.04cP and least for watermelon (1.53cP). Water holding capacity took a different trajectory as it recorded higher in watermelon (93.03%), followed by orange (84.49%) then mango (83.74%). Oil holding capacity had mango with the highest (27.01%), orange with 23.01% then the least was watermelon with 18.03%. The results suggest that these fruit purees can be effectively utilized in various food products, contributing to both nutritional diversity and reduced food wastage in regions with high fruit production.

Keywords

Mango, Orange, Watermelon, Maltodextrin

1. Introduction

Fruit processing plays a vital role in reducing post-harvest losses and adding value to agricultural produce, particularly in tropical and subtropical regions where fruit production is abundant but preservation techniques are limited. Post-harvest losses, estimated at 40-50% for tropical fruits, continue to pose a significant challenge to food security and economic sustainability in developing countries [1]. Nigeria, with its substantial production of mango, orange, and watermelon, faces considerable losses due to inadequate storage and preservation methods, making fruit processing an essential

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strategy for mitigating these losses [2].

Mango (*Mangifera indica)*, orange (*Citrus sinensis*), and watermelon (*Citrullus lanatus*) are highly perishable fruits, rich in essential nutrients such as vitamins, minerals, and antioxidants. Processing these fruits into purees not only extends their shelf life but also preserves their nutritional quality, providing opportunities for the development of diverse food products. Recent studies have emphasized the potential of fruit purees in the food industry, where they serve as natural ingredients for beverages, baby foods, sauces, and desserts [3].

Furthermore, the functional properties of fruit purees, such as water holding capacity, oil holding capacity, and viscosity, are crucial for determining their applications in various food formulations. These properties can be optimized through the use of additives like maltodextrin, which improves stability, texture, and overall product quality [4]. Understanding these characteristics is essential for the effective incorporation of purees into food systems while maintaining desirable sensory and nutritional attributes.

This study aims to investigate the proximate composition and functional properties of mango, orange, and watermelon purees, focusing on their potential for reducing post-harvest losses and contributing to food product development. By analyzing key factors such as bulk density, viscosity, and holding capacities, this research provides valuable insights into how these fruit purees can be utilized effectively in the food industry, offering a sustainable solution to fruit wastage while enhancing the nutritional profile of processed foods.

2. Materials and Methods

2.1. Materials

The mango, orange varieties (20 kg each) and ten (10) fruits each were procured from the Gboko local market in Gboko Benue State Nigeria, while five (5) fruits of the 'Sugar Baby' variety of watermelon were sourced from the Makurdi Railway market also in Benue State, Nigeria.

All fruit varieties were transported in polyethylene bags to the Joseph Tarka Federal University of Agriculture, Makurdi, Nigeria for proper identification. They were then refrigerated in preparation for further proceesing and analysis.

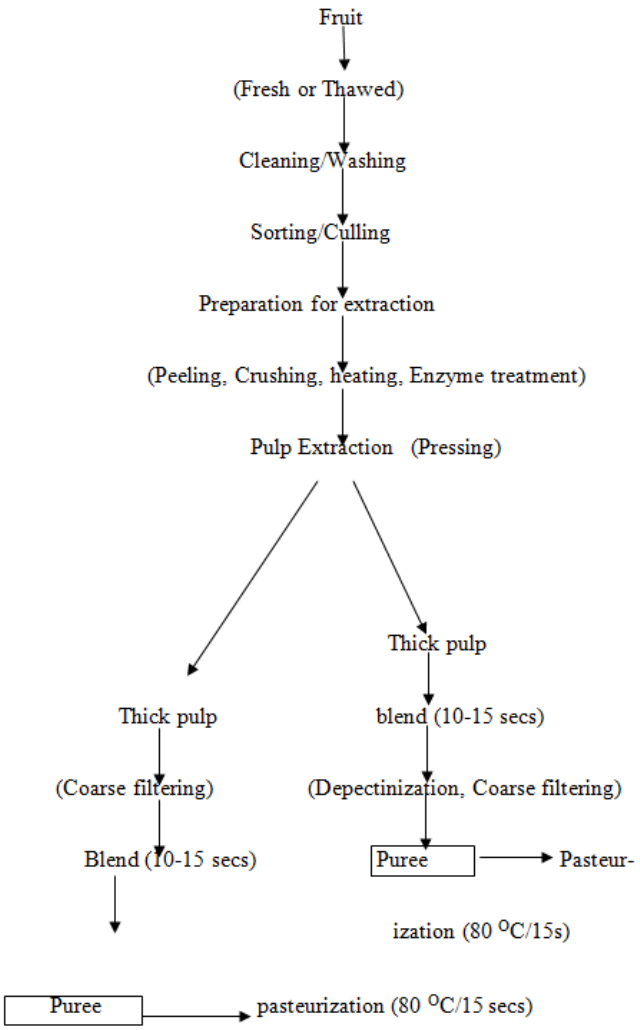
2.2. Methods

2.2.1. Preparation

The fruits were washed and their average weights taken and recorded. They were peeled and the weights of the peels measured and also recorded. The remaining processes to produce the puree prior to drying were according to the following flow charts.

Each puree type, depending on its stickiness and viscosity were mixed with 15%, 20%, 25% and 30% (w/w) commercial maltodextrin for water melon, orange and mango puree (the ratio of puree solids to carrier being 1:1.38; 1:1.95; 1:2.60; 1:3.35) respectively with Dextrose Equivalent (DE) 20 – 30. The purees were formulated into smoothies. With selected addition of maltodextrin, the most acceptable smoothie was subjected to the spray and freeze drying techniques.

2.2.2. Fruit Purees Production



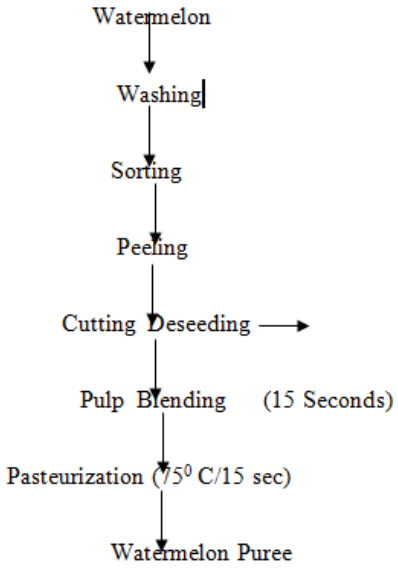
Source: [5]

Figure 1. *General Flow for Fruit Puree Prod.*

2.2.3. Watermelon Fruits Puree Production

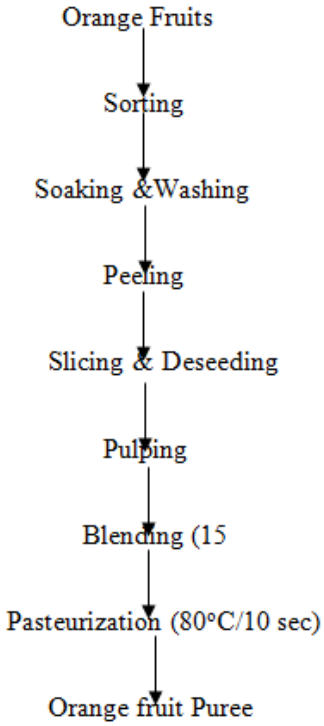
The flow chart for the production of watermelon puree is shown in Figure 2 using the method described by Akinwande and Ojo [6]. After washing and sorting, the fruits were peeled manually using stainless steel knives followed by slicing, removal of the seeds followed by blending of pulps in a household electric blender (Kenwood Electricals, UK) at speed number 3 for 15 s into smooth pastes which were pasteurized at 70 ℃ for 15 s in 250 ml glass beakers with aluminum foil coverings. After cooling, the watermelon purees

were kept in a refrigerator prior to use for composite purees formulation.



Source: [6].

Figure 2. *Flow chart for watermelon fruits puree production.*



Source: [7]

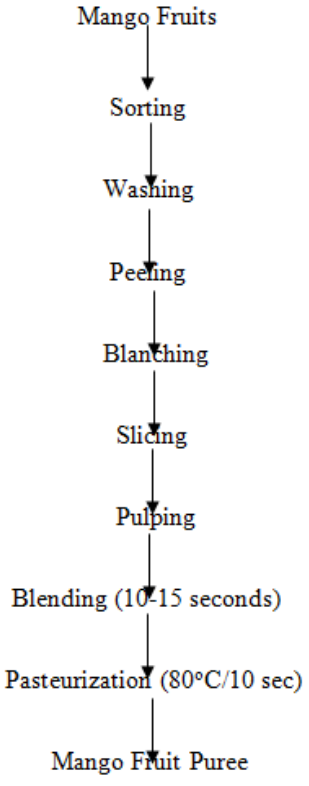
Figure 3. *Flow chart for production of orange fruits puree.*

2.2.4. Production of Orange Fruits Puree

Orange fruits puree was produced as described by Sharma and Anand [7]. Essentially, as shown in Figure 3, the fruits were sorted, washed, peeled and sliced using stainless steel knives. After removal of the seeds, the slices were blended into a smooth paste using the house hold electric blender. The orange puree was then pasteurized at 70 ℃ for 15 s in 250 ml glass beakers with aluminum foil covers. The pasteurized orange puree was rapidly cooled in an ice bath and promptly stored in a refrigerator prior to use for mixed purees formulation.

2.2.5. Production of Mango Fruits Puree

The production of the mango fruits puree was by the method of Aderoju and Adewale [8] as provided in Figure 4. The mango fruits were sorted, washed and blanched by immersion in a boiling hot water bath maintained at 98 ℃ for 5 min. The blanched mango fruits were then cooled in running tap water, peeled using stainless steel knives and the fleshy mesocarp sliced to obtain pieces which were blended in the Kenwood mixer in the presence of 0.2 M citric acid buffer (pH 5.2) into a smooth slurry. The slurry was then stored in the freezer compartment of a household refrigerator prior to use for composite purees formulation.



Source: [8]

Figure 4. *Flow chart for mango puree production.*

Each puree type was treated with commercial maltodextrin as a carrier agent respectively to obtain a dextrose equivalent (DE) of 30 for each group.

Determination of Phytochemicals

The phytochemical content of the samples was determined according to the methods described by AOAC [9].

10 ml of fresh samples was added to l00 mls of distilled water (at normal room temperature) inside a conical flask and plugged with cotton wood. After 24 hours (12 hours for fresh juice), the mixture was filtered using cheese cloth and then through Whatman No. 1 filter paper. The filterate was then concentrated using rotary evaporator [10].

Tannins

The Tannin content of the Samples was evaluated as described by Makkar *et al.* [11].

1 ml of the extract was added to a 10 ml volumetric flask containing 4 ml water. At times Zero minute, 0.3 ml of 5 % $NaNO_2$ was added to each volumetric flask. At 5 minutes, 0.3 ml of 10 % $A1CL_3$ was added; at 6 min, 3 ml of 1 m NaOH was added. Each reaction flask was then immediately diluted with 2 - 4 mL of H_2O and mixed. Absorbance upon development of pink colour was determined at 510 nm relative to a prepared blank. The total tannin content of the sample was expsressed in milligrams Gallic acid per 100 mL sample.

Total Phenolic Compounds

The total phenolic content of the Samples was carried out using Folin Ciocalteu's phenol reagent as described by Mujic *et al.* [12]. The concentrations of the phenolic compounds in the Samples were extrapolated from standard curve and expressed as mg gallic acid equivalent per g (mg GAE/g) taking into consideration the dilution factor of the samples.

100 mg of the extract of the sample was weighed accurately into a 100 ml of triple distilled water (TDW). 1 ml of this solution was transferred to a test tube, then 0.5 mL 2 N of Folin-(iocalteu reagent and 1.5 mL 20 % of Na_2CO_3 solution was added and ultimately, the volume was made to 8 ml with TDW followed by rigorous shaking and finally allowed to stand for 2 hours after which the absorbance was taken at 765 nm. These data was used to estimate the total phenolic content using a standard calibration curve obtained from various diluted concentrations of gallic acid [13].

Total Saponins

The spectrophotometric method used by Adewole, [14] for Saponin determination.

20 ml of the sample was placed in a conical flask and 100 mls of 20% aqueous ethanol added and heated in hot water (55 ° C) bath for 4 hrs with continuous stirring. The mixture was filtesred and the residue reextracted with another 200 mL 20 % ethanol. The extract was reduced to 40 ml over water bath at about 90 ° C. The concentrate was transferred into a 250 mL separator funnel and 20 mL diethyl ether was added and shaken rigorously. The aqueous layer was recovered while the ether layer was discarded. The purification process was repeated. 60 mL of n-butanol was added. The combined n-butanol extracts was washed twice with 10 ml of 5 % aqueous sodium chloride. The remaining solution was heated in a water bath. After evaporation, the samples were dried in the oven to a constant weight; the saponin content was calculated according to Obdoni and Ochuko [15].

Total flavonoids

Total flavonoids was determined according to the Aluminum Chloride (AlCl3) Colorimetric Method described by Ahmed *et al.* [16].

10 g of the sample was repeatedly extracted with 100 ml of 80% aqueous methanol at room temperature and 1 mL of extract mixed with 1 mL of 2% AlCl3 solution. 3 mL of methanol was added and incubatd at room temperature for 30 minutes. Using a spectrophotometer, absorbance at 415 nm was measured and the total flavonoids was calculated using a calibration curve with quercetin as standard. Equation:

$$\text{Total Flavonoids (mg/g or mg/mL)} = (A \times DF \times CF) / (\varepsilon \times l)$$

Where:

TF = Total Flavonoids (mg/g or mg/mL), A = Absorbance at 415 nm, DF = Dilution Factor, CF = Calibration Factor (mg/mL)

ε = Molar Extinction Coefficient (L/mol/cm), l = Path Length (cm)

Standard Curve: Using quercetin solutions (0-100 µg/mL)

Absorbance: at 415 nm; Plot: Absorbance vs. Concentration; Calibration Factor (CF): Slope of standard curve / Molar mass of standard; Molar Extinction Coefficient (ε): ε = 37,600 L/mol/cm (for quercetin)

Total alkaloids

Total alkaloids of the samples was determined using High-Performance Liquid Chromatography (HPLC) method described by Liu *et al*. [17]. The sample was extracted with methanol and the alkaloids was separated using HPLC with C18 column and mobile phase (acetonitrile: water, 80:20).

Extraction: 5 g of the sample was weighed into a 250 ml beaker and 200 ml of 10% acetic acid in ethanol was added and covered and allowed to stand for 4 hours. Alkaloids was detected at 280 nm using UV detector and the total alkaloids was calculated using peak area and calibration curve with standard alkaloids.

Equation:

$$\text{Alkaloid Content (mg/g)} = (PA / WA) \times (CF / DF)$$

Where:

PA = Peak Area of alkaloid, WA = Weight of sample (g), CF = Calibration Factor (mg/mL), DF = Dilution Factor

HPLC Parameters: Column: C18; Mobile Phase: Methanol: Water (70:30); Flow Rate: 1-2 mL/min; Injection Volume: 10-20 µL; Detection Wavelength: 280 nm; Calibration Curve: Using solutions of alkaloid (atropine); Plot: Peak Area vs. Concentration; Calculate: Calibration Factor (CF): Slope of standard curve / Molar mass of standard

Bulk Density

Bulk density of the samples (powders) was determined as described by Onwuka [18].

The bulk density: Fifty grams (50 g) of flour was poured into a 100 ml measuring cylinder and tapped to a constant volume

Bulk density will be calculated as weight of sample per unit volume of the sample g/ml as shown in the equation:

Bulk Density (g/ml) = wt of sample volume of sample after tapping (ml)

Determination of Specific Gravity

Specific gravity of the product samples was determined using a density bottle.

The samples were poured into a 50 ml density bottle and weighed. Each weight is known as the mass. The mass was divided by the volume of the density bottle to get the density

The specific gravity will be calculated according to the equation:

Density of sample x X (g/ml)/ Density of water (0.998 g/ml).

Where:

$X = (W_2 - W_1 (g))/Vml$

W_2 = Weight of sample + density bottle

W_1 = Weight of density bottle

V = Volume of the density bottle (50 ml)

The use of a hygrometer is a factor and easier method.

Viscosity (cP)

The viscosity of the samples was determined by a viscometer (DV-E Brookfield LV viscometer, USA) with spindle No.62 at 25 ℃ and

Determination of Water Holding Capacity

This was determined using the method of Onwuka [18]. One gram of the sample was dispensed into a weighed centrifuge tube with 10 ml of distilled water and mixed thoroughly. The mixture was allowed to stand for 1 hour before centrifuged at 3,500 rpm for 30 minutes. The excess water (unabsorbed) was decanted and the tube inverted over an absorbent paper to drain dry. The weight of water absorbed was determined by difference. The water absorption capacity was calculated as:

WAC (%) = Volume of Water used-Volune of free water Weight of sample used

Statistical Analyses

All the experiments were conducted in triplicate samples and the data was mean of the three replications. All data obtained were statistically analysed using the Analysis of Variance (ANOVA) using SPSS Version 20 and the Duncan Multiple range test to separate means with significance level $p<0.05$ [19].

3. Results and Discussion

Table 1. *Phytochemical composition of fresh mango puree, orange puree and watermelon puree (mg/100 g).*

Puree	Total phenols	Alkaloids	Tannins	Total saponins	Flavonoids
Mango	$25.58^{c} \pm 0.01$	$0.06^{b} \pm 0.02$	$1.09^{c} \pm 0.01$	$0.38^{c} \pm 0.01$	$35.88^{b} \pm 0.02$
Watermelon	$559.03^{a} \pm 0.03$	$0.01^{a} \pm 0.02$	$60.85^{a} \pm 0.02$	$1.18^{b} \pm 0.01$	$4.58^{c} \pm 0.03$
Orange	$170.78^{b} \pm 0.03$	$22.52^{a} \pm 0.02$	$35.73^{b} \pm 0.01$	$1.77^{a} \pm 0.02$	$37.78^{a} \pm 0.01$

Values are mean ± standard deviation (SD) of triplicate determinations. Samples with different superscripts within the same column were significantly ($p<0.05$) different.

Significant Differences between Samples

Total Phenols

Watermelon had the highest total phenolic content (559.03 mg/100 g), significantly higher than Orange (170.78 mg/100 g) and Mango (25.58 mg/100 g).

The high phenolic content in watermelon reflects its antioxidant potential. Phenolic compounds are known for their health benefits, including reducing oxidative stress and inflammation [20]. Watermelon's high phenolic content is corroborated by similar studies [21].

Alkaloids

Orange had the highest alkaloid content (22.52 mg/100 g), with Watermelon and Mango showing significantly lower levels (0.01 mg/100 g and 0.06 mg/100 g, respectively). Alkaloids, present in higher amounts in orange, have pharmacological effects and are less common in fruits, which aligns with findings of higher alkaloid content in certain citrus fruits [22].

Tannins

Watermelon had the highest tannin content (60.85 mg/100 g), compared to Orange (35.73 mg/100 g) and Mango (1.09 mg/100 g).

High tannin content in watermelon could contribute to its astringency and may impact its antioxidant capacity [23]. This is supported by research on watermelon and its phytochemical profile [24].

Total Saponins

Orange had the highest total saponin content (1.77 mg/100 g), with Watermelon (1.18 mg/100 g) and Mango (0.38 mg/100 g) being lower.

Saponins are known for their immune-boosting and anti-inflammatory properties [25]. The variation in saponin

levels among the fruits reflects their diverse biological activities.

Flavonoids

Orange had the highest flavonoid content (37.78 mg/100 g), compared to Mango (35.88 mg/100 g) and Watermelon (4.58 mg/100 g).

The high flavonoid content in orange, particularly in comparison to watermelon and mango, is consistent with findings that citrus fruits are rich in flavonoids, which have various health benefits [26].

Table 2. *Functional properties of mango puree, orange puree and watermelon.*

Puree	Bulk density g/cm^3	Specific gravity	Viscosity (cP)	Water holding capacity (%)	Oil holding capacity (%)
Mango	1.11^{a} ±0.02	1.13^{a} ±0.02	3.84^{a} ±0.04	83.74^{c} ±0.03	27.01^{a} ±0.02
Watermelon	0.89^{c} ±0.02	0.92^{c} ±0.01	1.53^{c} ±0.03	93.03^{a} ±0.03	18.03^{c} ±0.03
Orange	0.93^{b} ±0.02	1.05^{b} ±0.02	2.04^{b} ±0.02	84.49^{b} ±0.39	23.01^{b} ±0.02

Values are mean ± standard deviation (SD) of triplicate determinations. Samples with different superscripts within the same column were significantly ($p<0.05$) different.

Key:

cP = Centipoise

Significant Differences:

Bulk Density and Specific Gravity

Mango has the highest bulk density (1.11 g/cm^3) compared to Orange (0.93 g/cm^3) and watermelon (0.89 g/cm^3). The significant difference among these values (with mango being the highest and melon the lowest) indicates that mango puree is denser than both orange and melon purees.

Mango also exhibits the highest specific gravity (1.13), followed by Orange (1.05) and watermelon (0.92). This trend aligns with the bulk density results, suggesting that mango puree is denser in terms of mass per unit volume compared to the other two.

Bulk density and specific gravity are directly related to the composition and structure of the puree. Mango puree's higher bulk density and specific gravity may be due to its higher content of solids and fibers, which contribute to its denser consistency. Studies have shown that the physical properties of fruit purees, such as density, are influenced by the concentration of solids and their interaction with water [27].

Viscosity

The viscosity of Mango puree (3.84 cP) is notably higher than both Orange (2.04 cP) and watermelon (1.53 cP). This means that mango puree is more resistant to flow than the other purees, indicating a thicker or more viscous texture.

The higher viscosity of mango puree could be attributed to its higher pectin content and fiber composition, which increase the puree's resistance to flow. Pectin and fibers are known to form a gel-like structure that can enhance viscosity [28]. The viscosity differences among purees are also influenced by their water-soluble and insoluble solids content.

Water Holding Capacity

Watermelon puree has the highest water holding capacity (93.03%), significantly greater than Orange (84.49%) and Mango (83.74%). This suggests that melon puree can retain more water compared to the other purees.

The higher water holding capacity of melon puree might be related to its cellular structure and high water content. Melons typically have a higher water content compared to mangoes and oranges, which can lead to a higher capacity to retain water [29].

Oil Holding Capacity

Mango has the highest oil holding capacity (27.01%), compared to Orange (23.01%) and Melon (18.03%). This indicates that mango puree can absorb and retain more oil, which could affect its textural properties.

The oil holding capacity is influenced by the presence of fat and the structure of the puree. Mango puree's higher oil holding capacity could be due to its higher fat content compared to orange and melon purees, which allows it to absorb and retain more oil [30].

4. Conclusion

The processing of mango, orange, and watermelon into purees presents a practical and sustainable solution to mitigate post-harvest losses, enhance the economic value of these fruits, and promote food security. By investigating the proximate composition and functional properties of the purees, this study has highlighted the potential of these fruit purees as valuable ingredients in various food products. Mango, with its rich nutrient profile, orange with its high vitamin C content, and watermelon with its hydrating properties, offer significant benefits when converted into puree form, extending their shelf life and usability.

The incorporation of functional additives like maltodextrin can improve the texture, stability, and usability of the purees in processed food formulations. The analysis of the bulk density, viscosity, water holding capacity, and oil holding capacity of the purees provides crucial information for optimizing their integration into food systems, ensuring that they maintain desirable sensory and physical attributes.

This study underscores the importance of fruit puree production as a viable approach to reducing fruit wastage, especially in regions like Nigeria where fruit production is abundant but post-harvest losses are high. By transforming highly perishable fruits into shelf-stable, value-added products, the food industry can benefit from extended market reach and improved profitability, while consumers gain access to nutritious, convenient, and versatile fruit-based products.

Overall, the findings of this research contribute to ongoing efforts to promote sustainable fruit utilization, enhance nutritional diversity in food products, and support the agricultural sector's growth through innovative fruit processing techniques.

Conflicts of Interest

The authors declare no conflicts of interest.

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