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RESEARCH ARTICLE

DEVELOPMENT OF INSTANT PASTA INCORPORATED WITH A NOVEL COMPOSITE FLOUR BLEND OF UNRIPE BANANA (*Musa acuminata* L.) FLESH AND JACKFRUIT SEEDS (*Artocarpus heterophyllus* L.) AND EVALUATE ITS QUALITY PARAMETERS

Jayampathi HGN[1], Kariyawasam KMGMM[1*] and Fernando GSN[2]

[1]Department of Biosystems Technology, Faculty of Technological Studies, Uva Wellassa University, Badulla, Sri Lanka

[2]Department of Food Science and Technology, Faculty of Agriculture, University of Ruhuna, Mapalana, Kamburupitiya, 81100, Sri Lanka

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Abstract

The development of instant pasta enriched with jackfruit seed powder and unripe banana flesh powder presents a novel approach to sustainable food innovation. In the present study, various composite flour mixtures were developed by combining different proportions of unripe banana flesh (UGB) and jackfruit seed (JFS) flour with refined wheat flour (T1- 15% UGB, 5% JFS, 80% wheat, T2- 20% UGB, 10% JFS, 70% wheat, T3 - 25% UGB, 15% JFS, 60% wheat, and T4- 100% (w/w) wheat, serving as the control). Thirty semi-trained panelists were used to conduct the sensory evaluation using a 5-point hedonic scale, while standard methods were applied to analyze the proximate composition and physicochemical properties of the developed product. T1 formulation showed superior sensory attributes with higher protein (7.56±0.01%), and carbohydrate (67.44±0.01%) content while showing lower fat (16.07±0.00%) and moisture (5.77±0.00%) levels than the control sample ($p<0.05$). Texture analysis of the T1 sample indicated the hardness at 1728.0±110.9 g, adhesiveness at 3.03±0.65 mJ, springiness at 1.37±0.23 mm, cohesiveness at 0.34±0.30, and gumminess at 897.3±65 g. T1 exhibited lower water activity (0.78±0.01) and pH (5.86±0.01) than the control sample. In conclusion, jackfruit seed flour and unripe banana flesh powder can effectively substitute wheat flour when preparing instant pasta.

Keywords: Instant pasta, jackfruit seed flour, nutritional supplement, texture profile, unripe banana flesh powder

INTRODUCTION

In recent years, there has been a growing interest in exploring alternative sources of ingredients to enhance the nutritional profile of food products. Utilizing unconventional ingredients, such as fruit seeds and underutilized crops, offers promising opportunities to develop innovative food formulations with added health benefits. Unripe bananas (*Musa acuminata*) and jackfruit seeds (*Artocarpus heterophyllus*) have gained attention due to their rich nutrient composition and potential functional properties.

Pasta, an age-old staple food, is characterized by its doughy texture, available in a variety of shapes, and cooked through extrusion or stamping methods (Padalino *et al*., 2016). It boasts global popularity owing to its affordability, ease of preparation, extended shelf-life, and versatility in culinary applications (Nochera and Ragone, 2019). Pasta is notably low in sodium and total fat whereas rich in complex carbohydrates (comprising 74-77% of its composition) and protein (11-15%) (Kaur *et al*., 2017). The finest quality pasta is traditionally derived from durum wheat (*Triticum aestivum*) flour, known as semolina, renowned for its high gluten content, ensuring a superior final product (Ficco *et al*., 2016). Semolina, milled from durum wheat, serves as the primary ingredient in pasta dough, typically combined with water, salt, eggs, vegetable oil, and

Corresponding author: menaka.k@uwu.ac.lk

occasionally vegetable coloring (Padalino *et al*., 2016). The choice of semolina over regular wheat flour is preferred due to its ability to form dough with minimal water content, facilitating the subsequent drying process (Bernard, 1988).

The evolution of pasta products has seen diversification through the incorporation of various vegetable materials, enhancing flavors, colors, and nutritional profiles (Banasik, 1981; Matsuo *et al*., 1972). Innovations in pasta manufacturing have led to instant noodles, eliminating the need for lengthy cooking times (Kim and De Ruther, 1996). Researchers have explored the utilization of composite flour, a blend of wheat flour with non-gluten flours such as cassava, sweet potato, soybean, and maize, among others, in pasta production (Sanni *et al*., 2007; Orunkoyi, 2009). In Nigeria, the adoption of composite wheat flour by snack industries has emerged as a cost-effective alternative to whole wheat pasta, contributing to reduced production expenses across pasta and baked confectionery sectors (Anyobodeh *et al*., 2016).

The jackfruit (*Artocarpus heterophyllus*) is native to Sri Lanka and significant perennial species known locally as "*Kos*" in Sinhala and "*Pala*" in Tamil. It has diverse edible parts, including immature, mature, and ripe fruits and serves as a crucial staple during periods of food scarcity (Lakmali and Arampath, 2021). Jackfruit seeds, often overlooked despite their nutritional value, are rich in phytonutrients like lignan, isoflavones, and saponins, making them suitable for the development of functional foods. They offer antioxidant and prebiotic benefits, potentially offering protection and functional properties (Tangthanantorn *et al*., 2022). Moreover, jackfruit seeds have a low glycemic index (GI) due to their elevated fibre content, slowly available glucose, intact starch granules in the seeds, and the diverse influence of carbohydrates from various sources. Despite these advantages, their utilization remains limited. Jackfruit seeds are a good source of insoluble fiber, protein, and starch, making them viable substitutes for wheat flour in food processing.

Bananas, a widely cultivated fruit crop thriving in tropical regions, are renowned for their rich mineral content, particularly high potassium levels, solidifying their status as a nutritional powerhouse (Agama-Acevedo *et al*., 2021). Recent research showed that the incorporation of banana flour into wheat bread formulations revealed enhanced potassium and fiber levels, showcasing the fruit's potential for nutritional enrichment (Agama-Acevedo *et al*., 2009). Furthermore, diverse banana varieties have demonstrated the presence of bioactive compounds with antioxidant and antitumor properties, highlighting their multifaceted health benefits (Falcomer *et al*., 2019). Banana is rich in fiber, vitamin C, vitamin B6, potassium, phytonutrients, and antioxidants while exhibiting varying carbohydrate compositions depending on ripeness, with a relatively low glycemic index attributed to their high content of resistant starch and fiber (Castelo-Branco *et al*., 2017).

The main aim of this research is to develop pasta by utilizing a composite flour blend comprising unripe banana flesh powder, jackfruit seed flour, and refined wheat flour. This novel approach is designed to enrich the nutritional content, introduce distinctive flavors, and potentially enhance the functional properties while producing a low-cost pasta product. Therefore, this research was conducted to assess the optimal proportions of green banana and jackfruit seed flour to maximize pasta quality, as well as to evaluate the physicochemical, textural, and sensory characteristics of the developed pasta. Ultimately, this research aims to surpass traditional standards in taste, texture, and nutritional value and contribute to the diversification of pasta offerings in the market, providing consumers with a healthier and more flavorful choice.

MATERIALS AND METHODS

Raw materials

Preparation of Unripe banana flour

Unripe banana flesh (*Seeni* banana) flour was prepared using the method described by Castelo-Branco *et al*. (2017) with some modifications. The process of preparing green banana flour involves several sequential steps. Unripe bananas were initially washed with tap water, and then steam-blanching was carried out for 10 min until the bananas became tender. Following this, the banana fingers were cooled under cold water, and the peeling process was undertaken. The peeled bananas were sliced to a thickness of 3-4 mm, and the slices were steeped in a 0.2% (w/v) citric acid solution for 10 minutes. Subsequently, the solution was drained, and the banana slices underwent oven drying at 75 °C for a duration of 6 h. After drying, the banana slices were ground, and the resulting material was sieved with a mesh size of 150 µm to obtain the desired particle size of banana flour. The final step involved storing the unripe banana flesh flour in an air-tight container until further use.

Preparation of Jackfruit Seed powder

Jackfruit seed was prepared using the method used by Akter and Haque (2018) with some modifications. The collected jackfruit seeds were soaked overnight, and the white aril and brown coat layer were removed. Seeds were thoroughly washed with distilled water, thawed at room temperature, and cut into small pieces. Seed pieces were oven-dried at 50°C for 48 h in a hot air oven (GX125B, Faithful Instrument, Hebei, China). The chips were ground into a fine powder using a mixture grinder (SF1365SM, Sanford, Dubai, UAE) and sieved using a 150 µm mesh sieve. The powder was sealed in a labelled glass jar and stored in the refrigerator (4±1 C°) for further use.

Preparation of Instant Pasta incorporating green banana and jackfruit seed flour

Various composite flours were prepared by mixing unripe banana flesh flour and jackfruit byproduct flour with wheat flour using a trial-and-error approach. Four different ratios, as shown in Table 1, were then finalized to produce instant pasta.

Table 1: Different mixing ratios of unripe banana flesh, and jackfruit seed flours with wheat flour (w/w)

Treatment	Wheat flour (%)	Green banana flour (%)	Jackfruit seed flour (%)
T1	80	15	5
T2	70	20	10
T3	60	25	15
C (Control)	100	0	0

The process of preparing instant pasta involved several key steps as shown in Figure 1, beginning with the selection of a flour blend as the primary raw material.

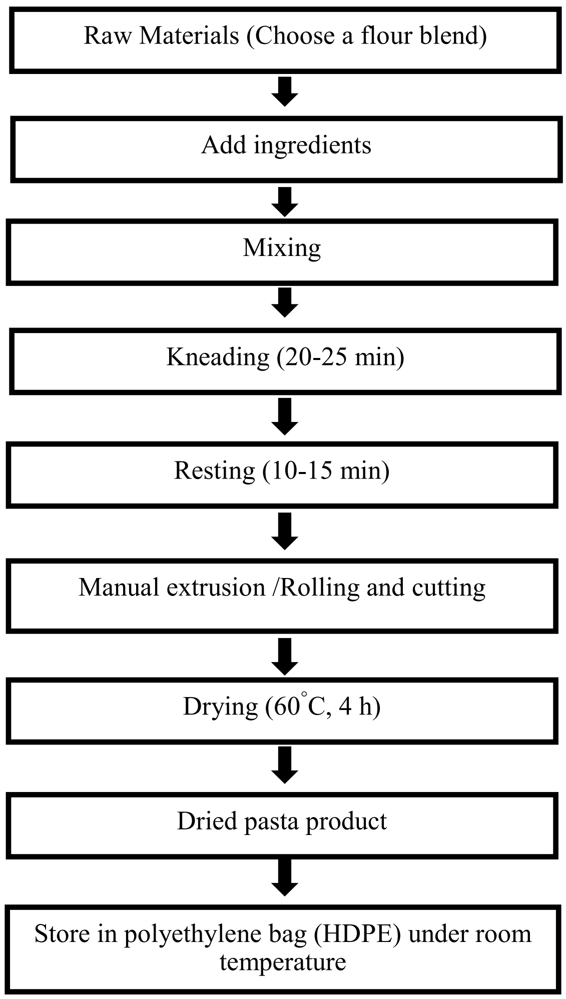

Figure 1: Flow chart for production of instant pasta using composite flours

After adding the necessary ingredients, the mixing phase ensued, followed by a thorough kneading session lasting approximately 20 to 25 min. The dough then underwent a resting period of 10 to 15 min to allow for proper hydration and gluten development. Subsequently, manual extrusion or rolling and cutting of the dough was carried out using a homemade pasta-making machine to achieve the desired pasta shape. The next critical step involved drying the formed pasta at 60°C for a duration of 4 h in a hot air oven. This drying process contributed to the preservation and shelf-stability of the pasta. Once dried, the resulting pasta product was carefully stored in polyethylene bags made of high-density polyethylene (HDPE) and stored at room temperature (30±2 °C) (Figure 2).

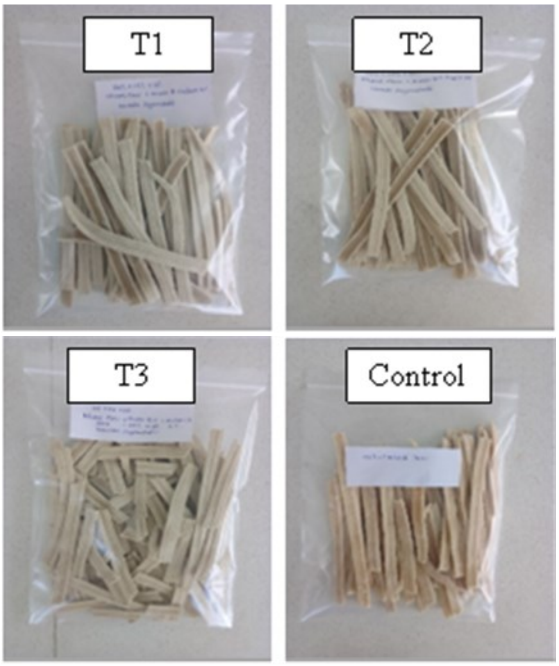

Figure 2: Images of developed instant pasta samples

T1: 80% Wheat flour +15% GB flour+5% JFS, T2: 70% Wheat flour + 20% GB flour + 10% JFS flour, T3: 60% Wheat flour + 25% GB flour +15% JFS flour, Control: Wheat flour 100%.

Sensory Evaluation of Instant Pasta

Sensory evaluation of instant pasta was conducted to evaluate the appearance, texture, aroma, taste, color, chewiness, and overall acceptance of the different treatments using 30 semi-trained panelists. The evaluation was conducted using a 5-point hedonic scale (Like very much – 5, Like moderately – 4, neither like nor dislike – 3, Dislike moderately – 2, Dislike very much –1). Each experimental pasta sample was coded and provided to evaluators after 24 hours of manufacturing. For cooked pasta samples, tomato sauce, ballot paper, and a cup of water were provided for each panelist.

Determination of moisture content

The moisture content of flour samples and instant pasta samples was measured using a moisture analyzer (MA 110. R, Radwag, Radom, Poland).

Determination of Water Absorption Capacity (WAC)

The method described by Anyobodeh *et al*. (2016) was used to measure the WAC of flours with some modifications. Distilled water (10 mL) is used to disperse 1 g of samples in a conical graduated centrifuge tube. Then it was mixed thoroughly in 30 seconds and kept at room temperature for 30 minutes. After that, a tube was centrifuged at 4000 rpm for 20 minutes and the volume of supernatant was measured directly from the graduated centrifuge tube. The amount of the absorbed water was multiplied by the density of water (1 g/mL) and results were expressed as g/100 g.

Determination of Oil Absorption Capacity (OAC)

The oil absorption capacity of the flour was determined using the method described by Islam *et al*. (2015) and Eleazu and Ironua (2013) with some modifications. Each sample (1 g) was taken and mixed with 10 mL of pure soybean oil for 60 seconds and set to stand for 10 minutes at room temperature. Weigh the tube before draining at an angle of 45° for 10 minutes and then re-weigh to record the final data. Oil absorption was expressed as a percentage increase of the sample weight.

Determination of Water Activity

The water activity of the flour and pasta samples was measured using a digital water activity meter (LWTM-A10, Labtron Equipment, Surrey, UK).

Determination of color values

The color values of the flour and pasta samples were determined using the method described by Siswantoro (2019). The color of the flour samples was measured using a Hunter lab colorimeter (CS-10, China). Color measurement was expressed as lightness L*, a*, and b* values.

Determination of pH value

The pH values of all the pasta samples were determined using a precise calibrated digital pH meter (MM.42DP model, Japan). The sample preparation was done according to the method described by Dissanayaka *et al.* (2019) with some modifications.

Determination of TSS content

The total soluble solids (TSS) content of all pasta samples was determined utilizing a digital refractometer (model XYZ123, Japan).

Determination of the proximate composition of instant pasta

The proximate composition of instant pasta was assessed using the standard AOAC (2000) methods. It includes the determination of moisture content using a moisture analyzer, crude fat analysis using the Soxhlet method (AOAC 2003.05), crude fiber analysis using the enzymatic gravimetric method (AOAC 978.10), and crude protein analysis using the Kjeldhal method. Additionally, total ash content was determined using a muffle furnace (AOAC 942.05). Carbohydrate content was determined by subtracting the sum of moisture, crude fat, crude protein, crude fiber, and ash content of the sample from 100 (Lakmali and Arampath, 2021).

Texture Profile Analysis of Instant Pasta

The texture of the pasta samples was analyzed using a texture analyzer (CT3, DKSH Technology Limited, Bangkok, Thailand) according to the method described by El-Sohaimy *et al.* (2020) with some modifications. Texture profile analysis was carried out using probe P/50 (50 mm compression platen), in compression mode at a pretest speed of 1.00 mm/sec, test speed of 5.00 mm/sec, and post-test speed of 5.00 mm/sec. Target mode was kept at 40.00% strain and trigger force 5.0 g. The data acquisition rate was kept at 200.00 pps. Three tests for each sample were carried out to obtain the mean value. The hardness, adhesiveness, cohesiveness, springiness, gumminess, and chewiness of the pasta samples were measured as textural parameters.

Data Analysis

All the data are presented as mean±standard deviation of three replicates. The non-parametric Kruskal Wallis test was used to analyze the sensory data using MINITAB software version 17 for Windows. One-way ANOVA with Tukey's test was applied to determine the statistical significance among the different groups at $p<0.05$ using MINITAB software version 17 for Windows.

RESULTS AND DISCUSSION

Evaluation of Flour Properties

The comparative analysis of moisture content, water activity, water absorption, and oil absorption capacities among wheat, unripe banana, and jackfruit seed flours revealed significant variations across all measured parameters (Table 2). Wheat flour exhibited the highest moisture content (12.82±0.01%), water activity (0.50±0.05), water absorption (52.24±1.07%), and oil absorption capacities (134.37±3.41%) among the three flours, highlighting its suitability for products requiring robust dough structure and enhanced moisture retention during baking. Conversely, unripe banana and jackfruit seed flours demonstrated lower moisture content (6.57±0.00%, 5.84±0.00%, respectively), water activity (0.30±0.026, 0.20±0.02, respectively), and absorption capacities (5.08±0.02%, 2.79±0.40%, respectively), suggesting their potential in formulations where reduced moisture levels or water activity are desired, such as in gluten-free or low-carb baked goods. These findings provide valuable insights for food scientists and industry professionals, offering guidance for optimizing ingredient selection and formulation strategies to meet specific product requirements and consumer preferences.

Table 2: Comparison of different flour properties of unripe banana flesh flour, jackfruit seed flour, and wheat flour

Flour type	Moisture (%)	Water activity	Water absorption capacity	Oil absorption capacity
Unripe banana	6.57 ±0.00[b]	0.30 ±0.02[b]	5.08 ±0.01[b]	6.15 ±0.01[b]
Jackfruit seed	5.84 ±0.00[b]	0.20 ±0.02[c]	2.79 ±0.40[c]	2.38 ±0.41[b]
Wheat	12.82 ±0.01[a]	0.50 ±0.05[a]	52.24 ±1.07[a]	134.37 ±3.41[a]

Data are presented in Mean ± SD of three independent measurements. Values with different superscripts along the column are significantly different at p<0.05.

Color values of the different flour samples used in this study are shown in Table 3. Considering the color values, wheat flour, showed the highest L* value of 52.00±0.00, which aligns with its traditional preference in baking due to its lighter color profile. Conversely, unripe banana flour, characterized by a lower L* value of 45.00±0.10, presents a darker alternative, while jackfruit seed flour falls in between with an L* value of 53.00±0.20. The a* (green-red) values of the three different flour types showed no significant difference. Unripe banana and jackfruit seed flours exhibit statistically similar b* values (9.87±0.06, and 7.03±0.06, respectively), reflecting their inherent yellowish tones. In comparison, wheat flour's slightly lower b* value of 9.00±0.005 suggests a marginally less pronounced yellow hue.

Table 3: Color values of different flour samples

Flour type	L* value	a* value	b* value
Unripe banana	45.00±0.10[c]	6.47±0.06[a]	9.87±0.06[a]
Jackfruit seed	53.00±0.20[a]	3.10±0.10[c]	7.03±0.06[c]
Wheat	52.00±0.00[b]	5.00±0.00[b]	9.00±0.00[b]

Data are presented in Mean ± SD of three independent measurements. Values with different superscripts along the column are significantly different at p<0.05.

Sensory Evaluation of Instant Pasta

The sensory evaluation of instant pasta samples reveals significant differences among the various formulations, with sample T1, consisting of 80% wheat flour, 15% GB flour, and 5% JFS flour, consistently outperforming the control sample made exclusively with 100% wheat flour across multiple sensory attributes (Table 4). While direct comparisons with literature values specific to instant pasta formulations are lacking, studies investigating flour blending in similar food products have reported significant improvements in sensory characteristics. For example, Smith *et al.* (2018) found enhanced texture, taste, and overall acceptability in breads made with wheat and alternative flour blends, while Gupta *et al.* (2019) observed similar improvements in gluten-free cookies.

Table 4: Mean values of the different sensory attributes of developed pasta samples

Sensory attribute	Treatments			
	Control	T1	T2	T3
Appearance	3.53 ±0.68[b]	4.60 ±0.56[a]	3.70 ±0.88[b]	3.50 ±0.96[b]
Texture	3.53 ±0.82[b]	4.40 ±0.68[a]	3.33 ±0.84[b]	3.27 ±0.79[b]
Aroma	3.23 ±0.82[b]	4.20 ±0.93[a]	3.33 ±0.88[b]	3.27 ±0.79[b]
Taste	3.30 ±0.92[b]	4.70 ±0.47[a]	3.37 ±1.03[b]	3.03 ±1.13[b]
Color	3.67 ±0.96[b]	4.20 ±0.81[a]	3.43 ±0.90[b]	3.27 ±1.02[b]
Chewiness	2.93 ±1.08[b]	4.37 ±0.67[a]	3.03 ±0.89[b]	3.13 ±0.82[b]
Overall acceptability	3.33 ±0.66[b]	4.90 ±0.31[a]	3.47 ±0.73[b]	3.10 ±0.80[b]

T1: 80% Wheat flour +15% GB flour+5% JFS, T2: 70% Wheat flour + 20% GB flour + 10% JFS flour, T3: 60% Wheat flour + 25% GB flour +15% JFS flour, C: Wheat flour 100% added instant pasta sample. Values with different superscripts along the column is significantly different at p<0.05.

The T1 sample scored highest in appearance (4.60±0.56), texture (4.40±0.68), aroma (4.20±0.93), taste (4.70±0.47), color (4.20±0.81), chewiness (4.37±0.67), and overall acceptability (4.90±0.31), indicating superior sensory characteristics. In contrast, T2, featuring 80% wheat flour and 20% GB flour, received slightly lower scores in most attributes compared to T1 but still surpassed the control sample. Specifically, the T2 sample scored lower in appearance (3.70±0.88), texture (3.33±0.84), aroma (3.23±0.82), taste (3.30±0.92), color (3.67±0.96), chewiness (2.93±1.08), and overall acceptability (3.33±0.66) compared to T1. T3, with 80% wheat flour and 10% GB flour, exhibited intermediate scores between T1 and the control across most attributes, suggesting a moderate enhancement in sensory quality. Specifically, T3 scored lower in appearance (3.53±0.68), texture (3.53±0.82), aroma (3.33±0.88), taste (3.37±1.03), color (3.43±0.90), chewiness (3.03±0.89), and overall acceptability (3.47±0.73) compared to T1 samples. The present study emphasizes that flour blending can improve the sensory attributes and overall quality of instant pasta, with T1 sample showing the highest level of sensory acceptability (Figure 3), providing valuable guidance for product development and formulation to enhance consumer satisfaction in the instant pasta market.

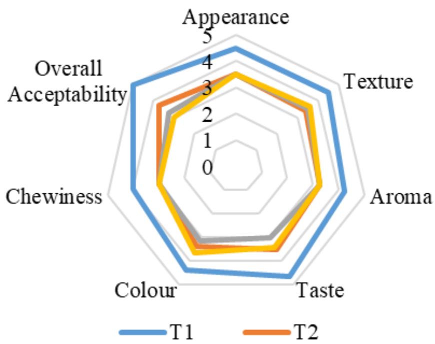

Figure 3: Radar chart for sensory analysis values of pasta samples

T1: 80% Wheat flour +15% GB flour+5% JFS, T2: 70% Wheat flour + 20% GB flour + 10% JFS flour, T3: 60% Wheat flour + 25% GB flour +15% JFS flour, C: Wheat flour 100% added instant pasta sample.

Determination of the proximate composition of instant pasta

The assessment of proximate composition reveals notable discrepancies among the various pasta samples, providing insights into their nutritional profiles and the results of the different pasta samples are shown in Table 5.

Considering the moisture content the control pasta sample showed the highest value at 8.32±0.02, followed by T2 (6.83%), T1 (5.77%), and the lowest value by T3 (2.80±0.01%). Controlling moisture content is critical in pasta production to achieve desired product quality, processing efficiency, and shelf-life. By carefully managing moisture levels throughout the production process, pasta manufacturers can ensure consistent texture, cooking properties, and sensory attributes, meeting consumer expectations and market demands. Ash content of the samples also followed the same changing pattern shown by moisture. Ash content in food is crucial for assessing its purity and nutritional value. It indicates the mineral content and can help in ensuring compliance with regulatory standards for food quality and safety. A significantly higher fat content was observed in T2 (2.73%), followed by T1 (1.49%), control (0.77%), and T3 (0.87%) samples. Fat content in raw pasta contributes to the texture, flavor, and cooking properties of the final product. Additionally, fat enhances the mouthfeel and tenderness of cooked pasta, providing a more satisfying eating experience for consumers. The sample T1 exhibits the highest protein content, while the control sample had the highest ash content. There were significant differences ($p<0.05$) between the T1, T2, and T3 samples compared to the control sample for most of the parameters.

Table 5: Comparison of proximate composition for different pasta samples

Treatment	Moisture (%)	Total ash (%)	Crude fiber (%)	Crude fat (%)	Crude protein (%)	Total carbohydrate (%)
T1	5.77±0.00^{c}	1.68±0.00^{d}	1.49±0.00^{b}	16.07±0.00^{c}	7.56±0.01^{a}	67.44±0.01^{b}
T2	6.83±0.00^{b}	3.09±0.00^{c}	2.73±0.03^{a}	25.94±0.00^{a}	6.47±0.06^{c}	54.98±0.07^{d}
T3	2.80±0.01^{d}	3.23±0.00^{b}	0.87±0.00^{c}	11.31±0.00^{d}	5.81±0.01^{d}	75.98±0.01^{a}
Control	8.32±0.02^{a}	3.87±0.00^{a}	0.77±0.00^{d}	16.88±0.00^{b}	7.36±0.01^{b}	62.80±0.02^{c}

T1: 80% Wheat flour +15% GB flour+5% JFS, T2: 70% Wheat flour + 20% GB flour + 10% JFS flour, T3: 60% Wheat flour + 25% GB flour +15% JFS flour, C: Wheat flour 100% added instant pasta sample. Values with different superscripts along the column is significantly different at $p<0.05$.

Evaluation of pH, TSS, Water Activity and colour values of Instant Pasta sample

The pH, Total Soluble Solids (TSS), and water activity among the four types of instant pasta samples (T1, T2, T3, and Control) were measured (Table 6).

Table 6: pH, TSS, and water activity of developed pasta sample

Treatment	pH	TSS	Water activity
T1	5.86±0.01^{b}	0.13±0.06^{a}	0.78±0.01^{ab}
T2	5.73±0.01^{c}	0.27±0.21^{a}	0.76±0.01^{b}
T3	5.80±0.03^{bc}	0.47±0.21^{a}	0.73±0.01^{c}
C	6.10±0.05^{a}	0.23±0.12^{a}	0.80±0.01^{a}

T1: 80% Wheat flour +15% GB flour+5% JFS, T2: 70% Wheat flour + 20% GB flour + 10% JFS flour, T3: 60% Wheat flour + 25% GB flour +15% JFS flour, C: Wheat flour 100% added instant pasta sample. Values with different superscripts along the column are significantly different at $p<0.05$.

Notably, T1 and T3 exhibit pH values of 5.86±0.01 and 5.80±0.03, respectively, closely resembling each other and differing slightly from the Control's pH of 6.10±0.05, while T2 displays the lowest pH at 5.73±0.01. In terms of TSS, all samples demonstrate similar levels ranging from 0.13 to 0.47. However, in water activity, the Control stands out with the highest value of 0.80, contrasting with progressively lower values in T1, T2, and T3. The significant differences underscore the treatment-specific impact on pH and water activity, though TSS values remain relatively consistent across samples. It's imperative to consider the significance levels ($p<0.05$) indicated by the letters (a-c) accompanying the values, highlighting the statistical significance within columns.

The comparison of colorimetric values between T1 and control instant pasta samples reveals notable distinctions (Table 7). Firstly, T1 exhibits a lower lightness (L*) value of 38.67±0.32 compared to the control (42.03±0.06), indicating a darker appearance for T1. This aligns with prior research indicating that ingredient composition and processing techniques can influence lightness in food products (Sun-Waterhouse *et al.*, 2011; Li *et al.*, 2018). Secondly, regarding redness/greenness (a* value), T1 demonstrates a slightly higher value of 9.67±0.06 compared to the control sample (9.17±0.06) suggesting a tendency towards a redder hue in T1. This may be attributed to differences in grain types and thermal processing affecting pigment presence (Ktenioudaki *et al.*, 2008; Marti *et al.*, 2019). Lastly, the yellowness/blueness (b*) value is lower in T1 than in the control sample indicating the reduced yellowness is possibly due to ingredient composition or processing conditions (Turhan *et al.*, 2002; Dowling *et al.*, 2019).

Table 7: Colour values of selected and control pasta sample

Treat-	L* value	a* value	b* value
T1	38.67±0.32^{b}	9.67±0.06^{a}	9.80±0.10^{b}
C	42.03±0.06^{a}	9.17±0.06^{b}	12.50±0.10^{a}

T1: 80% Wheat flour +15% GB flour+5% JFS, C: Wheat flour 100% added instant pasta sample. Values with different superscripts along the column are significantly different at $p<0.05$.

Texture Profile Analysis of before and after cooking instant pasta

Texture profile analysis in food is essential for evaluating the sensory properties that influence consumer perception and acceptance. It helps food producers understand and optimize product characteristics such as crispiness, chewiness, and overall mouthfeel to meet consumer preferences and ensure product quality. Therefore, the investigation of textural properties of both selected samples through sensory analysis (T1) and control pasta samples before and after cooking is important to get an idea about the alterations brought by the cooking process. Initially, the T1 sample demonstrated notably higher hardness (9781.0 g vs. 2140.7 g), adhesiveness (0.07 mJ vs. 0.10 mJ), cohesiveness (33.64 vs. 3.40), and gumminess (6474.0 g vs. 6560.7 g) compared to the control sample (Table 8). However, after cooking, both samples exhibited a substantial decrease in hardness (T1: 1728.0 g vs. Control: 379.30 g), cohesiveness (T1: 0.34 vs. Control: 0.53), springiness (T1: 1.37 mm vs. Control: 1.58 mm), gumminess (T1: 897.3

g vs. Control: 2016.0 g), and chewiness (T1: 12.07 mJ vs. Control: 31.43 mJ).

Table 8: Texture profile analysis of pasta sample (Before and After cooking)

Textural property	Samples			
	Before cooking		After cooking	
	T1	C	T1	C
Hardness (g)	9781.0 ±02.7[a]	2140.7 ±16.2[c]	1728.0 ±110.9[c]	379.30± 358.0[b]
Adhesiveness (mJ)	0.07 ±0.06[b]	0.10 ±0.00[b]	3.03±0.65[a]	3.20 ±0.76[a]
Cohesiveness	33.64 ±0.99[a]	3.40 ±0.57[b]	0.34 ±0.30[c]	0.53 ±0.01[c]
Springiness (mm)	1.66 ±0.90[b]	4.81 ±2.03[a]	1.37±0.23[b]	1.58 ±0.10[b]
Gumminess (g)	6474.0 ±4.0[a]	6560.7 ±2.1[a]	897.3± 065.4[c]	2016.0± 238.0[b]
Chewiness (mJ)	114.43 ±3.74[b]	163.00 ±2.26[a]	12.07± 2.97[d]	31.43 ±5.34[c]

T1: 80% Wheat flour +15% GB flour+5% JFS, T2: 70% Wheat flour + 20% GB flour + 10% JFS flour, T3: 60% Wheat flour + 25% GB flour +15% JFS flour, C: Wheat flour 100% added instant pasta sample. Values with different superscripts along the column is significantly different at p<0.05.

Moreover, the T1 sample maintained a higher adhesiveness (3.03 mJ vs. 3.20 mJ) after cooking compared to the control sample. These changes are indicative of starch gelatinization, protein denaturation, and moisture loss during the cooking process, which softens the pasta and alters its texture. Despite initial differences, the converging textural properties post-cooking suggest a homogenizing effect of the cooking process on pasta samples, with certain distinctions, such as adhesiveness, persisting.

CONCLUSIONS

The present study discussed the potential use of a composite flour blend of unripe banana flesh powder and jackfruit seed flour in the development of instant pasta. This approach effectively valorizes food waste and incorporates underutilized food products into value-added product development. These findings suggest promising avenues for leveraging these unconventional ingredients to not only transform pasta manufacturing but also revolutionize the wider food industry. Our study concludes that treatment T1 exhibits promising potential as a nutritional supplement in the cereal industry. The superior sensory attributes, including elevated protein (7.56±0.01%) and carbohydrate (67.44±0.01%) content, alongside lower fat (16.07±0.00%) and moisture (5.77±0.00%) levels compared to the control ($p<0.05$), highlight the efficacy of T1 in enhancing the nutritional profile of pasta products without compromising texture. These findings underscore the potential utility of incorporating green banana and jackfruit seed flour as nutritional supplements within the cereal industry, while simultaneously maintaining desirable sensory attributes and textural qualities in pasta products. Consequently, such research endeavors could significantly contribute to enhancing the nutritional value and sensory appeal of various food products, effectively addressing broader dietary and nutritional needs.

AUTHOR CONTRIBUTION

MMK, HGNJ, and GSNF designed the study, HGNJ conducted the experiments, MMK and HGNJ analyzed the data and wrote the original draft, and MMK and GSNF edited the manuscript.

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