potravinárstvo®

Slovak Journal of Food Sciences

OPEN ACCESS

**Received:** 25.3.2023
**Revised:** 26.4.2023
**Accepted:** 2.5.2023
**Published:** 9.5.2023

*Potravinarstvo Slovak Journal of Food Sciences*
**vol. 17, 2023, p. 419-432**
**https://doi.org/10.5219/1879**
**ISSN: 1337-0960 online**
**www.potravinarstvo.com**


# Effects of using composite flour containing wheat flour with different levels of green banana pulp flour on the quality of saj flatbread

***Khaled Abu-Alruz***

## ABSTRACT

There is an increasing trend in formulating food to contain dietary fibers and particularly resistant starch. Saj bread (a type of flatbread baked on a plate placed directly on fire) is a potential candidate to act as a vehicle for delivering resistant starch. This study aimed to investigate the effects of using composite flour containing wheat flour substituted with different levels (0, 5, 10, 15, and 20%) of green banana pulp flour "GBPF" on some physicochemical properties of flour (moisture, ash, wet and dry gluten content, gluten index, falling number, and farinograph parameters) and the quality of saj bread as measured by CIELAB color space, texture (stretchability and texture profile analysis "TPA"), and sensory properties. The texture of the saj bread was monitored during three days of storage. Composite flour moisture content and falling number were unaffected by wheat flour substitution with GBPF, while dry gluten content decreased significantly for composite flour containing 15% or more GBPF. With increasing wheat flour substitution level with GBPF, dough stability decreased. For saj bread color, the $L*$ and $b*$ values decreased with increasing substitution levels, while $a*$ and $\Delta E*ab$ values increased. With increasing substitution levels, the stretchability of bread decreased, and all tested TPA parameters increased. With increasing saj bread storage time, the stretchability of bread decreased, and all TPA parameters increased except cohesiveness which decreased. Using composite flour improved bread taste and odor scores and decreased color acceptability scores. Texture and overall acceptability scores were not affected. In conclusion, GBPF can potentially substitute up to 20% wheat flour without negatively affecting saj bread quality.

**Keywords:** saj flatbread, green banana pulp flour, texture, color, sensory properties

## INTRODUCTION

Dietary fibers increasingly attract researchers' interest **[1]** due to their believed role in the prevention and treatment of several chronic diseases, particularly obesity **[2]**, diabetes **[3]**, and cardiovascular diseases **[4]**. The effectiveness of fibers in promoting health depends on the type of fiber and the amount consumed **[4]**. Resistance starch received great attention among different dietary fibers **[5]**. Resistant starch is the non-digestible fraction of starch that is fermented and converted into short-chain fatty acids in the colon **[6]**. With the worldwide daily consumption of dietary fibers below the recommended dietary allowances **[7]**, there is an increased demand for food to be formulated to contain high dietary fibers and particularly resistant starch. There are five types of resistant starch: physically inaccessible starch (RS1), crystalline starch (RS2), retrograded starch (RS3), modified starch (RS4), and long amylose chain combined with free fatty acids (RS5) **[6]**.

One of the important sources of resistant starch is green (unripe) bananas, particularly RS2 starch **[8]**. However, the hard texture and astringency of the green banana limit consumption, which makes the utilization of its flour (green banana pulp flour (GBPF)) a better approach to increase its consumption through the addition of it to different foods **[9]**. Depending on the cultivar, the GBPF contains between 80.83-85.5% resistant starch; for instance, the GBPF from Grande Nine cultivar – the primary cultivar in Jordan – contains 80.38% resistant starch **[10]**. Banana is a staple, one of the most cultivated tropical crops **[11]**, **[12]**, **[13]**, which ranked globally fourth after rice, wheat, and corn. The nutraceutical properties of GBPF were recently reviewed in **[14]**. Despite this importance, many bananas are lost as postharvest defects such as miss-shape, off-size, and inappropriate ripening **[5]**, **[12]**. In New Zealand, the waste of bananas represents 3% of total food waste and is ranked second after bread waste **[5]**. A study reported that a third of the produced banana is lost as postharvest waste **[13]**. To solve the waste problem of banana, there is a need to find a processing method to convert this waste into stable food, and this is the third reason after astringency and health properties – that highlight the importance of utilizing the GBPF. The final fourth reason for utilizing GBPF is its functional physicochemical properties, particularly water-holding capacity **[10]**. The addition of GBPF was investigated in different food such as noodles, pasta, cookies, and doughnut **[15]**.

For properly utilizing GBPF, selecting a food product that will serve as a vehicle for delivering it is important. Some researchers highlighted the importance of fortifying high-starch staple food with resistance starch, particularly flatbread **[16]**, **[17]**. The nomination of flatbread comes from its importance; it is the oldest, most consumed stable food worldwide, and its consumption is increasing **[18]**. Flatbread was reported to satisfy the increasing need for increasing food systems sustainability for different reasons discussed in **[19]**, **[20]**. Worldwide, there are 143 types of flatbread, 6 of which are located in Jordan. The classification and processing of flatbreads have been recently reviewed in **[21]**. Saj bread is a type of flatbread baked on a plate placed directly on the fire; this plate may be flat or curved and named "saj," from which the name saj bread is taken **[21]**. Saj flatbread is prepared from simple basic ingredients, using a simple process that does not require ovens, and is popular in Jordan **[21]**, **[22]**. Despite the importance of flatbreads, great attention in literature was given to volume or pan bread in investigating the addition of bioactive ingredients compared to flatbread **[18]**. The addition of GBPF to bread formulation was investigated in pan (sliced) bread **[23]**, **[20]**, **[12]**, **[24]**, **[25]**, **[26]**, **[27]**, **[28]**, chinse steamed bread **[29]**, flatbread **[8]**, and pita flatbread **[30]**. Incorporating GBPF into bread is challenging **[28]** due to the dilution of gluten upon adding it, and from the previous studies, fortifying bread with GBPF will affect its color, flavor, and texture. Therefore, there is a need to investigate the effects of GBPF addition to new types of flatbread. This research aimed to investigate the effects of using composite flour containing wheat flour containing different levels of GBPF on some physical properties, color, texture, and sensory properties of saj flatbread. Additionally, to study the impact of storage for three days on the texture of saj bread.

## Scientific Hypothesis

This research aimed to investigate the effects of using composite flour containing wheat flour with different levels of GBPF (0, 5, 10, 15, and 20%) on some quality aspects of the composite flour and saj flatbread. Additionally, the research aimed to determine the maximum substitution level of wheat flour with GBPF without negatively affecting saj bread quality during storage for up to three days. It is expected that substituting wheat flour with different GBPF will at least not negatively affect flour and bread quality. It is expected to replace 20% of wheat flour with GBPF without compromising saj flatbread quality. It is expected that storage time has a negative impact on saj bread texture.

## MATERIAL AND METHODOLOGY

### Samples

Samples of GBPF were packed in polyethylene plastic bags and kept at room temperature until use. Samples of composite flour were prepared and tested immediately. For the preparation of flat saj bread, composite flour samples were prepared before the preparation process immediately. Samples of flat saj bread were cooled and packed in polyethylene plastic bags and stored at room temperature (25 °C).

### Animals, Plants and Biological Materials

GBPF were obtained from low-grade (small size and miss-shaped) green (stage-1 maturity stage) Grand Nain banana. Wheat flour was obtained from the local market (Mawahad, southern Amman mills, Jordan).

### Instruments

The following instruments were used: halogen moisture analyzer (Mettler-Toledo, USA), Glutomatic system (Perten, Sweden), Falling number apparatus (Perten, Sweden), muffle furnace (Thermo Scientific, USA), texture analyzer (Perten, Sweden), farinograph system (Perten, Sweden), and non-contact spectrophotometer (X-rite 450, UK), saj bread gas oven (locally made in Jordan).

### Laboratory Methods

**Composite flour:** Composite flours made from wheat flour substituted with different proportions of GBPF were evaluated by measuring moisture, gluten (wet and dry gluten and gluten index), falling number, ash, and farinograph parameters. Moisture content was determined using a halogen moisture analyzer according to manufacturer recommendations. Wet gluten, dry gluten, and gluten index were determined according to the American Association of Cereal Chemists (AACC) number 38-12A **[31]**. The falling number was determined according to AACC method number 56-8104 **[32]**. Ash was determined according to AACC method number 08-01.01 **[33]**. Faringraph-tested parameters were determined using the AACC method 54-21.02 **[34]**. According to the manufacturer's recommendation, the color was measured using a non-contact spectrophotometer.

**Saj bread:** Saj bread prepared from different types of composite flour was evaluated by measuring texture (stretchability and TPA), color, and sensory properties. Saj bread stretchability was measured using a texture analyzer using the Perten instruments method 08-05.02 **[35]**. This method uses a stainless steel cylinder probe (18 mm in diameter) and a heavy-duty stand equipped with two 50 mm hole inserts. Using TexCalc software (Perten, Sweden), the texture analyzer was programmed according to the following setting parameters: single-cycle compression, 3.0 mm for sample height, 8.0 mm for starting distance from the sample, 30 mm for compression, 6 mm/s for initial speed, 1.7 mm/s for test speed, and 20 g for trigger force. The texture analyzer was equipped with a 5 kg load cell. After the test initiation, the software drew a curve between the force and distance/time, from which two parameters were determined: breakpoint and stretchability (Figure 1). The breakpoint is the force (g) needed to puncture the sample, while stretchability is the distance (mm) to the maximum force.

Bread Texture Profile Analysis (TPA) was measured using the Perten instruments method 03-04.02 **[36]**. This method used a stainless steel cylinder probe with a 35 mm diameter. The texture analyzer was operated using the following program: double-cycle compression, 3.0 mm for sample height, 50% for compression, 12 s for a pause between cycles, 5 mm/s for initial, test, and retract speed, and 20g for trigger force. The texture analyzer was equipped with a 5 kg load cell. The software (TexCalc, Perten, Sweden) drew a curve between force and distance/time from which the following parameters were determined: hardness, resilience, springiness, cohesiveness, and chewiness. From Figure 2, hardness is force A; resilience is Area $a_2$/ Area $a_1$; springiness distance y/ distance x; cohesiveness is Area B/ Area A; chewiness is calculated by multiplying hardness, springiness, and cohesiveness together.

Sensory analysis of saj flatbread samples was performed using a 9-point hedonic scale, where nine denotes like extremely, and 1 denotes dislike extremely **[23]**. Twenty-five untrained panelists evaluated bread samples.

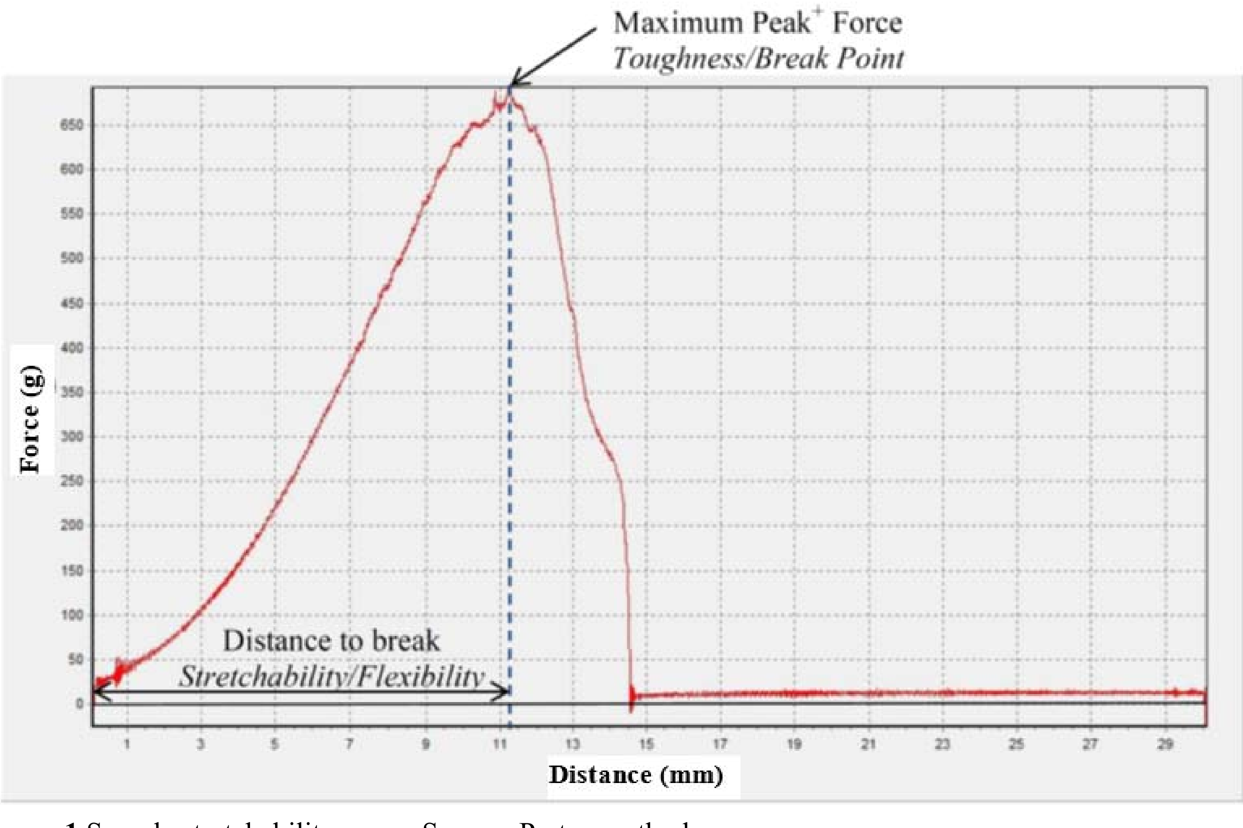


**Figure 1** Sample stretchability curve. Source: Perten methods.

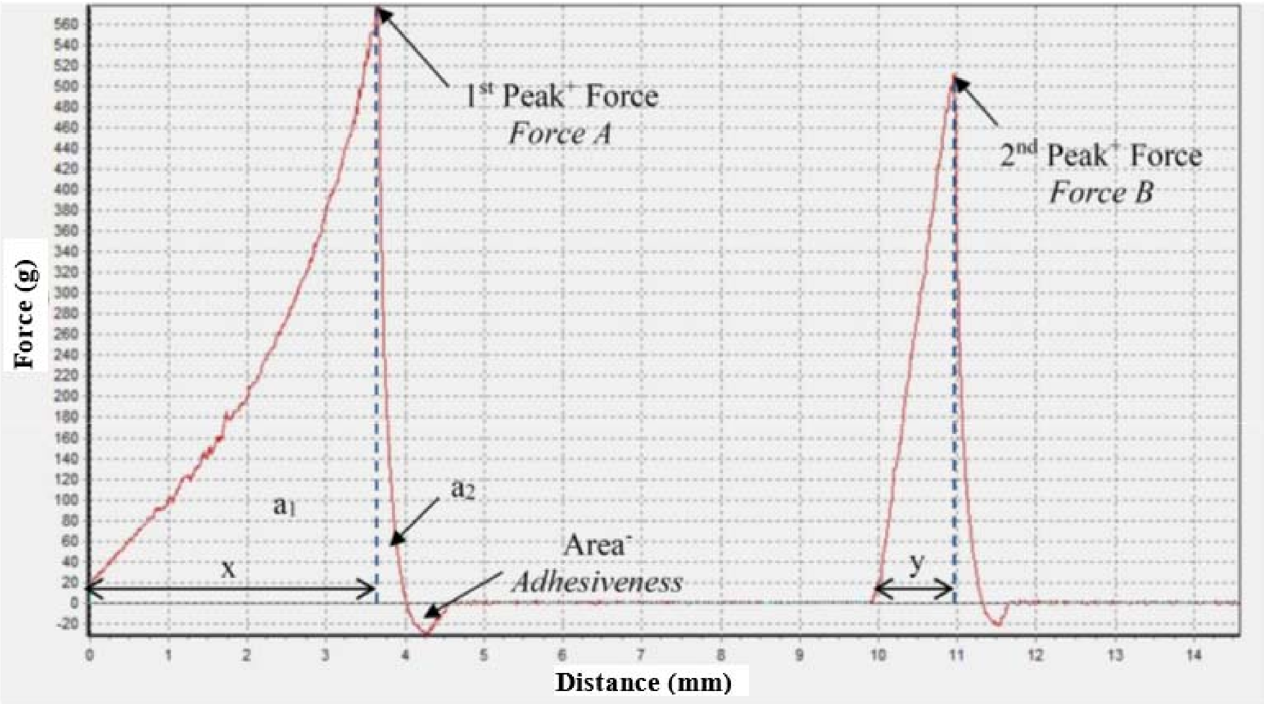


**Figure 2** Sample TPA curve. Source: Perten methods

## Description of the Experiment

**Sample preparation:** No special sample preparation was used for tests to evaluate the composite flour. For bread evaluation, each treatment run gave eight loaves. Four were assigned to measure TBA and color, and the others were assigned to measure stretchability. Each bread loaf was quartered into four equal parts; each part was assigned to be tested at zero, one, two, and three days of storage. A stainless steel cutter was used to cut three circular discs from each bread quart for TPA. The three circular bread discs were stacked together and tested for color first and then for TPA. As a total, four readings were made for stretchability, TPA, and color CIELAB values. These readings were averaged for statical analysis. The whole experiment was repeated three times. The color and sensory evaluation were performed at zero storage time, while texture analysis was performed throughout three days of storage.

**Number of samples analyzed:** The number of samples differed according to the test performed. For composite flour tests, 15 samples (five types of composite flour with three replicates) were analyzed. 60 samples (five composite flour*four storage times*three replicates) were analyzed for bread texture measurement tests. For bread color measurement, 15 samples were analyzed. For sensory analysis. Five samples (five types of composite flour) were analyzed

**Number of repeated analyses:** Sample measurements were duplicated for composite flour tests. For texture and color measurements, each sample was tested four times. For sensory analysis, each sample was tested by 25 panelists.

**Number of experiment replication:** Three.

**Design of the experiment:** The experiment had five main phases. In the first phase, GBPF was prepared according to the steps described in **[30]**. In the second phase, five composite flour were prepared by substituting wheat flour with different levels of GBPF: 0, 5, 10, 50, and 20%. The composite flour was evaluated in the third phase by measuring moisture content, ash, gluten, falling number, and farinograph parameters. In the fourth phase, five types of saj bread were prepared. The formulas used to prepare saj bread are shown in Table 1. All dry ingredients were weighed and mixed together first, then worm water (35 °C) and oil were added. The mixture was kneaded for about 7 mins. The dough was covered with plastic film and proofed for 1 hr at 35 °C. After that, the dough was divided and shaped into balls (125 g each). The dough balls were flattened using a rolling pin to reach the desired diameter (30 cm). The flattened dough was baked using a flat metal plate heated with a gas stove to reach 200 °C. The plate was preheated for 15 mins before baking to equilibrate the temperature. Each side of the dough was heated to about 0.5 min. The backed bread was allowed to cool, then packed in plastic bags and stored at room temperature. In the fifth phase, bread made with different types of composite flour was evaluated; bread color and sensory properties were evaluated directly after preparation, while texture measurements were performed directly after backing and after 1, 2, and 3 days of storage.

## Statistical Analysis

Data were analyzed using Minitab software (19.2020.1, Minitab Inc., USA). A completely randomized design was used to analyze the results of the composite flour evaluation tests and bread color and sensory evaluation results. A factorial design was used to investigate the main effects of different types of composite flour, storage time, and their interaction effect on flatbread texture (stretchability and TPA). Means separation was performed using Tukey's test with $p \leq 0.05$.

**Table 1** Composite flour formula used in the preparation of saj flatbread.

| Ingredients | Weight of ingredients (g) | | | | |
|---|---|---|---|---|---|
| | Wheat flour substitution level with GBPF (%) | | | | |
| | 0 "Control" | 5 | 10 | 15 | 20 |
| **Wheat flour** | 500 | 475 | 450 | 425 | 400 |
| **GBPF** | 0 | 25 | 50 | 75 | 100 |
| **Yeast** | 10 | 10 | 10 | 10 | 10 |
| **Salt** | 9 | 9 | 9 | 9 | 9 |
| **Sugar** | 20 | 20 | 20 | 20 | 20 |
| **Oil** | 20 | 20 | 20 | 20 | 20 |
| **Water** | 330 | 330 | 330 | 330 | 330 |

Note: GBPF means green banana pulp flour.

## RESULTS AND DISCUSSION

**Composite Flour:** Testing the physical properties of composite flour is of great importance because of the role of gluten content, gluten index, and falling number in predicting final product characteristics. Table 2 shows the moisture, ash, gluten, and falling number results. Substitution of wheat flour with different levels of GBPF did not significantly affect moisture content (between 12.11 and 12.39%) and falling number (between 385 and 411.5 sec). These falling numbers are considered high and indicate low α-amylase activity, which will negatively impact bread qualities in terms of volume and dryness due to the increased water-holding capacity of starch **[32]**. In literature, the falling number values of different types of composite flour depend on the material used to substitute wheat flour. Adding buckwheat and millet flour to wheat flour significantly increased the falling number **[37]**. Similarly, adding cassava flour to wheat flour significantly increased the falling number **[38]**. In contrast, substituting wheat flour with millet flour **[39]**, grape seed flour **[40]**, and bamboo shoot and cassava flour **[41]** significantly decreased the falling number. Similar to our results, **[42]** found that substituting wheat flour with barley flour did not affect the falling number. Freen banana flour had falling number values between 1666.8-2376.6 sec, and adding it to wheat flour significantly increased the falling number in values depending on the amount added, which contradicts our result **[43]**. It is worth to be mentioned that the banana used in **[43]** study was pretreated by chemical and physical methods, which may inhibit the α-amylase activity in banana flour, according to the author's interpretation. Ash content significantly increased with every increment of GBPF addition to composite flour, where control wheat flour had the lowest value of 0.7% and composite flour containing 20% GBPF had the highest value of 1.25%; these results are in agreement with the result of **[24]**. Wet gluten and dry gluten significantly decreased with increasing wheat flour substitution levels with GBPF, where the highest values were for control wheat flour, and the lowest values were for composite flour containing 20% GBPF. There were no significant differences in wet and dry gluten content between composite flour containing 5, 10, and 15% GBPF. The gluten content decrease in composite flour was mentioned in **[44]**, who reported that gluten content in composite flours decreased when using flour devoid of gluten in substituting wheat flour, which is the case in GBPF **[43]**. Not only is the decrease in gluten content important, but the rate of reduction corresponding to each substitution level is also essential. The values of dry gluten content decreased significantly when the wheat flour substitution level with GBPF reached 15 and 20%, with a 9.79 and 15.23% reduction in dry gluten content, respectively. Interestingly, the substitution of wheat flour with GBPF significantly increased the gluten index compared to control wheat flour, with no significant differences between different types of composite flour. The small decrease in dry gluten content and the increae in gluten index that ocuured when sustituting wheat flour with GBPF suggested a complex formation between resistant starch in banana flour and wheat gluten proteins **[45]**.

**Table 2** Falling number and contents of moisture, ash, and gluten in composite flour containing wheat flour substituted with different levels of GBPF.

| Composite flour | Moisture (%) | Ash (%) | Wet gluten (%) | Dry gluten (%) | Gluten index (%) | Falling number (sec.) |
|---|---|---|---|---|---|---|
| **0% GBPF** | 12.37 ±0.06[a] | 0.70 ±0.00[e] | 27.79 ±0.26[a] | 9.19 ±0.01[a] | 90.05 ±1.48[b] | 385.0 ±14.1[a] |
| **5% GBPF** | 12.39 ±0.01[a] | 0.82 ±0.00[d] | 25.47 ±0.13[b] | 8.73 ±0.06[ab] | 97.4 ±1.13[a] | 392.5 ±3.45[a] |
| **10% GBPF** | 12.29 ±0.10[a] | 0.99 ±0.01[c] | 24.36 ±0.17[bc] | 8.37 ±0.12[abc] | 96.35 ±0.07[a] | 410.0 ±14.1[a] |
| **15% GBPF** | 12.11 ±0.13[a] | 1.15 ±0.00[b] | 24.09 ±0.47[bc] | 8.29 ±0.17[bc] | 97.01 ±0.7[a] | 410.5 ±7.78[a] |
| **20% GBPF** | 12.38 ±0.18[a] | 1.25 ±0.00[a] | 22.90 ±0.98[c] | 7.79 ±0.45[c] | 97.3 ±0.85[a] | 411.50 ±10.61[a] |

Note: GBPF means green banana pulp flour. Values are expressed as means ±standard deviation, and values sharing the same letter in the same column are not significantly different (*p* >0.05) as tested by Tukey's test.

For farinograph-tested parameters (Table 3-A and 3-B), development time (ranging between 95.5-128 sec) and consistency (ranging between 495 and 512 FE) were not significantly affected by wheat flour substitution with GBPF (Table 3-A). However, other tested parameters (water absorption, stability time, degree of softening, and farinograph quality number) were significantly affected (Table 3-A and 3-B). Water absorption (ranging between 58.65 and 59.90%) increased with the substitution of wheat flour with GBPF; however, this increase was significant only at the substitution level of 15% when compared to the control. It is evident that there were no significant differences between control wheat flour and composite flour containing 5% GBPF in terms of stability time, degree of softening, and farinograph quality number, whereas other substitution levels differed significantly. The stability time decreased significantly when substitution levels were above 5%, with no significant differences between those composite flour. The highest stability time was for control wheat flour with a value of 502.0 ±48.1 sec, and the lowest was for flour with a 15% substitution level with a value of 274 sec. The degree of softening increased significantly in composite flour with substitution levels above 5% compared to the control wheat flour. The lowest degree of softening was for control wheat flour (34 ±7.07 FE), and the highest value was for composite flour with a 20% substitution level (96 ±2.83%). The farinograph quality number significantly decreased when using composite flour with substitution levels above 5% compared to the control wheat flour. The highest farinograph quality number was for control wheat flour (94.50 ±9.19 mm), and the lowest was for flour containing 15 and 20% GBPF (46.50 ±3.54 mm). These results are in parallel with the results of **[46]**, who related the increase in water absorption in composite flour to the numerous hydroxy groups in resistant starch that are capable of forming hydrogen bonds with water **[45]**. Mohebbi et al. **[45]** found that adding resistant starch to wheat flour increased water absorption of the composite flour due to the high amount of amylose in resistant starch. There is a direct relationship between dough development time and protein content in different composite flour, which decrease the dough development time due to the decrease in protein content. However, this depends on the material used to substitute flour; adding some types of fibers and RS may improve the farinograph properties **[45]** due to the formation of a complex with wheat gluten. This may explain why the dough development time did not change in composite flours in our results. The decrease in dough stability in composite flour may be related to the dilution of gluten content in composite flour or the interaction between resistant starch and wheat gluten **[45]**. The decrease in the dough stability time and farinograph quality number and the increase in the degree of softening indicated that the composite flours – in this study – could not tolerate extended kneading times **[47]**.

**Table 3-A** Farinograph tested parameters for composite flours containing wheat flour substituted with different levels of GBPF.

| Composite flour | Water absorption (%) | Development time (sec) | Consistency (FE) |
|---|---|---|---|
| **0% GBPF** | 58.65 ±0.21[b] | 128 ±8.49[a] | 506 ±5.66[a] |
| **5% GBPF** | 59.65 ±0.35[ab] | 119 ±15.6[a] | 495 ±17[a] |
| **10% GBPF** | 59.65 ±0.21[ab] | 120 ±4.24[a] | 495.5 ±24.7[a] |
| **15% GBPF** | 59.90 ±0.28[a] | 95.5 ±7.78[a] | 493.5 ±4.95[a] |
| **20% GBPF** | 59.60 ±0.42[ab] | 102.5 ±13.44[a] | 512 ±4.24[a] |

Note: GBPF means green banana pulp flour. Values are expressed as means ±standard deviation, and values sharing the same letter in the same column are not significantly different (*p* >0.05) as tested by Tukey's test.

**Table 3-B** Farinograph tested parameters for composite flours containing wheat flour substituted with different levels of GBPF.

| Composite flour | Stability time (sec) | Degree of softening (FE) | Farinograph quality number (mm) |
|---|---|---|---|
| **0% GBPF** | 502.0 ±48.1$^{a}$ | 34 ±7.07$^{d}$ | 94.50 ±9.19$^{a}$ |
| **5% GBPF** | 475.5 ±46.0$^{a}$ | 41 ±8.49$^{cd}$ | 85.50 ±7.78$^{ab}$ |
| **10% GBPF** | 338.5 ±9.19$^{b}$ | 59 ±5.66$^{bc}$ | 62.00 ±5.66$^{bc}$ |
| **15% GBPF** | 274.0 ±0.00$^{b}$ | 80 ±4.24$^{ab}$ | 49.50 ±0.71$^{c}$ |
| **20% GBPF** | 280.0 ±0.00$^{b}$ | 96 ±2.83$^{a}$ | 46.50 ±3.54$^{c}$ |

Note: GBPF means green banana pulp flour. Values are expressed as means ±standard deviation, and values sharing the same letter in the same column are not significantly different (*p* >0.05) as tested by Tukey's test.

**Saj Bread:** The produced bread was evaluated in color, texture, and sensory properties. For color and sensory properties, only one factor was investigated: wheat substitution with different proportions of GBPF. However, in texture, two factors were investigated: wheat substitution with different proportions of GBPF and storage time.

**CIELAB color values:** Saj bread CIELAB color values were significantly affected by the level of wheat flour substitution with different levels of GBPF (Table 4). The $L^*$ values of bread significantly decreased in samples made from composite flour compared to the control (81.28 ±0.65), with no significant differences between different types of composite flour. Bread made from composite flour $a^*$ values were significantly higher than the control bread made from wheat flour (0.2 ±0.22), with no significant differences between different types of bread made from composite flour containing different levels of GBPF. Bread made from composite flour containing 5% GBPF $b^*$ value (17.34 ±2.54) did not significantly differ from the control bread (19.98 ±0.64); however, other types of bread made from composite flour significantly differed from the control bread. Bread made from composite flour containing 15% GBPF had the highest $\Delta E^*ab$ value (16.66 ±3.09), significantly higher than bread made from composite flour containing 5% GBPF, with no significant differences with other types of bread made from composite flour. The trend in color change found in this study with increased substitution of wheat flour with GBPF was in harmony with the results of steamed Chinese bread fortified with GBPF **[29]** and pita bread made from composite flour containing **[30]**. The changes in composite flour color found in this study are related to the dark color of the GBPF. The dark color of GBPF was reported in previous studies; this dark color negatively affects the utilization of GBPF in different food applications **[26]**. The dark color of GBPF is attributed to the enzymatic browning reactions occurring during the drying process **[23]**. Khoozani et al. **[5]** investigated the effect of different drying conditions on the color and other functional properties of GBPF.

**Table 4** CIELAB color values of saj flatbread made from composite flours containing wheat flour substituted with different levels of GBPF.

| Composite flour | $L^*$ | $a^*$ | $b^*$ | $\Delta E^*ab$ |
|---|---|---|---|---|
| **0% GBPF** | 81.28 ±0.65$^{a}$ | 0.20 ±0.22$^{b}$ | 19.98 ±0.64$^{a}$ | - |
| **5% GBPF** | 73.73 ±1.11$^{b}$ | 1.87 ±0.70$^{a}$ | 17.34 ±2.54$^{ab}$ | 11.88 ±1.84$^{b}$ |
| **10% GBPF** | 72.30 ±1.61$^{b}$ | 2.80 ±0.69$^{a}$ | 15.75 ±0.99$^{bc}$ | 13.33 ±1.42$^{ab}$ |
| **15% GBPF** | 69.95 ±3.17$^{b}$ | 2.43 ±0.31$^{a}$ | 12.80 ±1.26$^{c}$ | 16.66 ±3.09$^{a}$ |
| **20% GBPF** | 73.06 ±2.54$^{b}$ | 2.41 ±0.20$^{a}$ | 13.27 ±0.45$^{c}$ | 13.84 ±1.96$^{ab}$ |

Note: GBPF means green banana pulp flour. Values are expressed as means ±standard deviation, and values sharing the same letter in the same column are not significantly different (*p* >0.05) as tested by Tukey's test.

**Saj bread texture:** Saj bread texture (stretchability and TPA) was only significantly affected by the main effects (levels of wheat flour substitution and storage time), with no significant interaction between them. Therefore, in the following discussion of texture results, only the results of the main effects will be presented and discussed.

The effects of substituting wheat flour with different levels of GBPF on the stretchability test are presented in Table 5. The stretchability of bread was more sensitive to the use of composite flour in bread making than breakpoint. There was a significant difference between the breakpoint value of bread made from composite flour containing 15% GBPF (925.7 ±156.2 g) and control bread (770.5 ±130.4 g), with no significant differences between control bread and other types of bread made from composite flour. For stretchability, using composite flour containing 15% GBPF or more significantly reduced the stretchability compared to the control bread

(13.39 ±3.44 mm). These results did not agree with the results of **[30]** for pita bread made from composite flour containing different proportions of GBPF. **[30]** reported an increase in the breakpoint of pita bread with using the composite flour; there were no significant differences between different GBPF substitution levels. For stretchability, **[30]** reported an increase in the stretchability of bread with increasing GBPF substitution, which contradicts our results, where with increasing GBPF level, the stretchability decreased. The difference in results may be related to the different types of bread used, and the ingredients added. The results of the effects of storage time on the bread stretchability test parameters are presented in Table 6. Only bread stored for three days had a significantly lower breakpoint value of 716.3 ±147.6 g than bread at zero storage time (873.8 ±150.8 g). Bread stretchability decreased significantly with each storage day, with no significant differences between bread stored for 2 and 3 days. These results agreed with pita bread made from composite flour containing GBPF **[30]**.

Table 7 shows the effects of wheat flour substitution with different levels of GBPF on the TPA of bread. It is evident that the hardness, resilience, and chewiness of bread increased significantly when flour substitution levels were 15% or more compared to the control bread. No significant differences were observed in cohesiveness between control bread and bread made from different types of composite flour. The results were in agreement with the results of **[30]** for pita bread prepared using composite flour containing GBPF. Thakaeng et al. **[26]** reported a decrease in springiness values for bread made by adding unripe banana flour to wheat flour. The increase in TPA parameters in our study may be attributed to the low gluten content of gluten in composite flour, which causes a decrease in elasticity due to a decrease in gas holding capacity **[26]**. In contrast to our results, **[8]** reported an increase in hardness and a decrease in other TPA parameters. Table 8 shows the results of the effects of storage time on TPA of bread. Resilience was not affected by the storage time. Hardness, cohesiveness, and chewiness significantly changed with storage time (hardness and chewiness increased, while cohesiveness decreased), with no significant differences between these parameters between bread stored for 2 and 3 days (Table 8). These results agreed with **[30]**, except for resilience which decreased with storage time for pita bread.

**Table 5** Effects of substitution of wheat flour with different levels of GBPF on breakpoint and stretchability of saj flatbread.

| Composite flour | Breakpoint (g) | Stretchability (mm) |
|---|---|---|
| **0% GBPF** | 770.5 ±130.4$^{bc}$ | 13.39 ±3.44$^{a}$ |
| **5% GBPF** | 811.3 ±160.3$^{abc}$ | 12.86 ±3.63$^{ab}$ |
| **10% GBPF** | 699.5 ±117.8$^{c}$ | 12.52 ±3.60$^{bc}$ |
| **15% GBPF** | 925.7 ±156.2$^{a}$ | 11.97 ±3.57$^{c}$ |
| **20% GBPF** | 852.5 ±159.9$^{ab}$ | 11.99 ±3.52$^{c}$ |

Note: GBPF means green banana pulp flour. Values are expressed as means ±standard deviation, and values sharing the same letter in the same column are not significantly different ($p$ >0.05) as tested by Tukey's test.

**Table 6** Effects of storage time on breakpoint and stretchability of saj flatbread.

| Storage time (days) | Breakpoint (g) | Stretchability (mm) |
|---|---|---|
| **0** | 873.8 ±150.8$^{a}$ | 18.20 ±1.05$^{a}$ |
| **1** | 832.6 ±153.0$^{a}$ | 11.77 ±0.97$^{b}$ |
| **2** | 824.9 ±162.0$^{ab}$ | 10.42 ±0.92$^{c}$ |
| **3** | 716.3 ±147.6$^{b}$ | 9.79 ±1.05$^{c}$ |

Note: Values are expressed as means ±standard deviation, and values sharing the same letter in the same column are not significantly different ($p$ >0.05) as tested by Tukey's test.

**Table 7** Effects of substitution of wheat flour with different levels of GBPF on TPA of saj flatbread.

| Composite flour | Hardness (g) | Resilience | Cohesiveness | Cheweness (g) |
|---|---|---|---|---|
| **0% GBPF** | 5190 ±1749$^{c}$ | 0.47 ±0.03$^{b}$ | 0.81 ±0.05$^{ab}$ | 4077 ±1278$^{b}$ |
| **5% GBPF** | 5952 ±2169$^{bc}$ | 0.48 ±0.03$^{b}$ | 0.79 ±0.05$^{b}$ | 4601 ±1487$^{b}$ |
| **10% GBPF** | 5894 ±2315$^{bc}$ | 0.48 ±0.03$^{b}$ | 0.79 ±0.06$^{b}$ | 4465 ±1570$^{b}$ |
| **15% GBPF** | 6862 ±2170$^{ab}$ | 0.52 ±0.02$^{a}$ | 0.82 ±0.04$^{a}$ | 5496 ±1528$^{a}$ |
| **20% GBPF** | 7084 ±2558$^{a}$ | 0.51 ±0.03$^{a}$ | 0.82 ±0.05$^{a}$ | 5650 ±1819$^{a}$ |

Note: GBPF means green banana pulp flour. Values are expressed as means ±standard deviation, and values sharing the same letter in the same column are not significantly different ($p$ >0.05) as tested by Tukey's test.

**Table 8** Effects of storage time on TPA of saj flatbread.

| Storage time (days) | Hardness (g) | Resilience | Cohesiveness | Cheweness (g) |
|---|---|---|---|---|
| **0** | 3262 ±603[c] | 0.50 ±0.02[a] | 0.88 ±0.02[a] | 2835 ±545[c] |
| **1** | 5800 ±1091[b] | 0.48 ±0.03[a] | 0.79 ±0.03[b] | 4576 ±845[b] |
| **2** | 7943 ±1585[a] | 0.49 ±0.04[a] | 0.77 ±0.02[c] | 6073 ±1261[a] |
| **3** | 7780 ±1456[a] | 0.50 ±0.05[a] | 0.77 ±0.03[c] | 5948 ±1101[a] |

Note: Values are expressed as means ±standard deviation, and values sharing the same letter in the same column are not significantly different (*p* >0.05) as tested by Tukey's test.

**Sensory evaluation:** Figure 3 shows the different types of saj bread prepared, and Table 9 shows the sensory evaluation scores of saj bread made from different types of composite flour containing different proportions of GBPF. The texture and overall acceptability of saj bread were not affected by wheat flour substitution by GBPF, whereas other parameters were significantly affected. Color scores significantly decreased in bread made from composite flour containing 10% GBPF or more, with no significant differences between control bread and bread made from composite flour containing 5% GBPF. Incorporating GBPF improved taste and odor scores significantly, with no significant differences between different substitution levels.

The results indicate that GBPF can be used to substitute up to 20% of wheat flour without negatively affecting the overall acceptability of bread. The perceived improvement in taste and odor of saj bread prepared from composite flour may be related to the increased concentration of Maillard reaction products **[20]**. These results were parallel to previous results. For instance, Viana et al. **[23]** reported that bread formulated with 15 or 20% GBPF had higher than 90% acceptance for all sensory parameters investigated. Khalil et al. **[8]** suggested that GBPF can be used up to 30% in flatbread with acceptable sensory and physical properties. Ebabhamiegbebho et al. **[12]** concluded that GBPF could be used to substitute flour in a ratio of up to 20% for the preparation of bread with good sensory properties. On the other hand, **[24]** found that bread with the highest overall acceptability scores contains 5% GBPF.

**Table 9** Sensory evaluation scores of saj flatbread.

| Composite flour | Color | Texture | Taste | Odor | Overall acceptability |
|---|---|---|---|---|---|
| **0% GBPF** | 7.72 ±0.52[a] | 7.30 ±1.33[a] | 7.01 ±0.78[b] | 6.95 ±0.38[b] | 8.23 ±1.38[a] |
| **5% GBPF** | 7.66 ±1.25[a] | 7.00 ±1.72[a] | 8.10 ±0.98[a] | 8.37 ±0.56[a] | 7.95 ±1.79[a] |
| **10% GBPF** | 6.25 ±0.89[b] | 7.15 ±1.17[a] | 8.44 ±0.77[a] | 8.92 ±0.57[a] | 8.22 ±1.17[a] |
| **15% GBPF** | 6.34 ±1.01[b] | 7.26 ±1.40[a] | 8.21 ±0.57[a] | 8.08 ±0.54[a] | 8.31 ±1.49[a] |
| **20% GBPF** | 6.48 ±1.93[b] | 7.24 ±1.34[a] | 8.32 ±0.55[a] | 8.43 ±0.38[a] | 7.29 ±2.05[a] |
| **0% GBPF** | 6.37 ±1.86[b] | 7.17 ±1.38[a] | 8.40 ±0.64[a] | 8.08 ±0.57[a] | 8.37 ±1.99[a] |

Note: Values are expressed as means ±standard deviation, and values sharing the same letter in the same column are not significantly different (*p* >0.05) as tested by Tukey's test.

**5% GBPF**

**10% GBPF**

**0% GBPF**

**15% GBPF**

**20% GBPF**

**Figure 3** Saj flatbread made from composite flours containing wheat flour with different substitution levels with GBPF.

## CONCLUSION

The possibility of making saj flatbread from composite flour containing wheat flour with different levels of GBPF was investigated. Considering the little scientific work on flatbread, to the best of our knowledge, this is the first research that investigated the potential use of GBPF in saj bread. Saj flatbreads were successfully produced from all types of composite flour used. Results indicated the possibility of using composite flour containing up to 20% GBPF without compromising sensory acceptability, except for the color, which made the bread look like that produced from whole wheat flour. Using composite flour affected the objective physical parameters tested in this study, dependent on the GBPF substitution level and storage period (for texture measurement of saj bread). The results of this research are of great importance to banana producers; it gives them a sustainable solution to reduce the postharvest waste of bananas due to rejects from miss-shape and small sizes. Additionally, the results introduce a new functional food made from saj bread formulated with the incorporation of GBPF in their preparation, which is in line with consumer requirements in providing new functional food by replacing traditional foods with healthier alternatives. Further studies are needed to improve the color of GBPF, and another study with a larger panelist number is needed to confirm the sensory evaluation results.

## REFERENCES


1. He, Y., Wang, B., Wen, L., Wang, F., Yu, H., Chen, D., Su, X., & Zhang, C. (2022). Effects of dietary fiber on human health. In Food Science and Human Wellness (Vol. 11, Issue 1, pp. 1–10). Elsevier BV. https://doi.org/10.1016/j.fshw.2021.07.001
2. Waddell, I. S., & Orfila, C. (2022). Dietary fiber in the prevention of obesity and obesity-related chronic diseases: From epidemiological evidence to potential molecular mechanisms. In Critical Reviews in Food Science and Nutrition (pp. 1–16). Informa UK Limited. https://doi.org/10.1080/10408398.2022.2061909
3. Zhang, L., Wang, X., He, Y., Cao, J., Wang, K., Lin, H., Qu, C., & Miao, J. (2022). Regulatory Effects of Functional Soluble Dietary Fiber from Saccharina japonica Byproduct on the Liver of Obese Mice with Type 2 Diabetes Mellitus. In Marine Drugs (Vol. 20, Issue 2, p. 91). MDPI AG. https://doi.org/10.3390/md20020091
4. Salgado-Cruz, M. de la P., Ramírez-Miranda, M., Díaz-Ramírez, M., Alamilla-Beltran, L., & Calderón-Domínguez, G. (2017). Microstructural characterisation and glycemic index evaluation of pita bread enriched with chia mucilage. In Food Hydrocolloids (Vol. 69, pp. 141–149). Elsevier BV. https://doi.org/10.1016/j.foodhyd.2017.01.027
5. Khoozani, A. A., Bekhit, A. E.-D. A., & Birch, J. (2019). Effects of different drying conditions on the starch content, thermal properties and some of the physicochemical parameters of whole green banana flour. In International Journal of Biological Macromolecules (Vol. 130, pp. 938–946). Elsevier BV. https://doi.org/10.1016/j.ijbiomac.2019.03.010
6. Bojarczuk, A., Skąpska, S., Mousavi Khaneghah, A., & Marszałek, K. (2022). Health benefits of resistant starch: A review of the literature. In Journal of Functional Foods (Vol. 93, p. 105094). Elsevier BV. https://doi.org/10.1016/j.jff.2022.105094
7. Alrawashdeh, H., & Abu-Alruz, K. (2022). Development of High-Fiber, Low Fat Chicken Nuggets. In International Journal of Food Studies (Issue 2, pp. 354–373). ISEKI Food Association. https://doi.org/10.7455/ijfs/11.2.2022.a8
8. Khalil, M., Tabikha, M., Hosny, M., & Kortam, A. (2017). Physiochemical and Sensory Evalution of some Bakery Products Supplemented with Unripe Banana Flour as a Source of Resistant Starch. In Journal of Food and Dairy Sciences (Vol. 8, Issue 10, pp. 411–417). Egypts Presidential Specialized Council for Education and Scientific Research. https://doi.org/10.21608/jfds.2017.38925
9. Silva, A. dos A., Barbosa Junior, J. L., & Barbosa, M. I. M. J. (2015). Farinha de banana verde como ingrediente funcional em produtos alimentícios. In Ciência Rural (Vol. 45, Issue 12, pp. 2252–2258). FapUNIFESP (SciELO). https://doi.org/10.1590/0103-8478cr20140332
10. Khoza, M., Kayitesi, E., & Dlamini, B. C. (2021). Physicochemical Characteristics, Microstructure and Health Promoting Properties of Green Banana Flour. In Foods (Vol. 10, Issue 12, p. 2894). MDPI AG. https://doi.org/10.3390/foods10122894
11. Vishala, J., & Singh, G. (2021). A review on product development through pulp and peel of banana. In Plant Archives (Vol. 21, Issue Suppliment-1, pp. 693–698). Plant Archives. https://doi.org/10.51470/plantarchives.2021.v21.s1.104
12. Ebabhamiegbebho, P. A., Abel, E. S., & Willie, S. T. (2020). Composition and sensory quality of wheat-banana flour blend bread. In Fuw Trends in Science & Technology Journal (Vol. 5, Issue 2, pp. 529–532). Federal University Wukari.

13. Falcomer, A. L., Riquette, R. F. R., de Lima, B. R., Ginani, V. C., & Zandonadi, R. P. (2019). Health Benefits of Green Banana Consumption: A Systematic Review. In Nutrients (Vol. 11, Issue 6, p. 1222). MDPI AG. https://doi.org/10.3390/nu11061222
14. Tadesse, T. F., Nigusse, G., & Kurabachew, H. (2015). Nutritional, Microbial and Sensory Properties of Flatbread (kitta) Prepared from Blends of Maize (Zea mays L.) and Orange-fleshed Sweet Potato (Ipomoea batatas L.) Flours. In International Journal of Food Science and Nutrition Engineering (Vol. 5, Issue 1, pp. 33–39). Scientific And Academic Publishing.
15. Ayo-Omogie, H., & Odekunle, O. Y. (2019). Substituting Wheat Flour with Banana Flour: Effects on the Quality Attributes of Doughnut and Cookies. In Applied Tropical Aggriculture (pp. 134–142). School of Agriculture and Agricultural Technology.
16. Boers, H. M., van Dijk, T. H., Hiemstra, H., Hoogenraad, A.-R., Mela, D. J., Peters, H. P. F., Vonk, R. J., & Priebe, M. G. (2017). Effect of fibre additions to flatbread flour mixes on glucose kinetics: a randomised controlled trial. In British Journal of Nutrition (Vol. 118, Issue 10, pp. 777–787). Cambridge University Press (CUP). https://doi.org/10.1017/s0007114517002781
17. Amini Khoozani, A., Kebede, B., & El-Din Ahmed Bekhit, A. (2020). Rheological, textural and structural changes in dough and bread partially substituted with whole green banana flour. In LWT (Vol. 126, p. 109252). Elsevier BV. https://doi.org/10.1016/j.lwt.2020.109252
18. Boukid, F. (2022). Flatbread - A canvas for innovation: A review. In Applied Food Research (Vol. 2, Issue 1, p. 100071). Elsevier BV. https://doi.org/10.1016/j.afres.2022.100071
19. Pasqualone, A. (2018). Traditional flat breads spread from the Fertile Crescent: Production process and history of baking systems. In Journal of Ethnic Foods (Vol. 5, Issue 1, pp. 10–19). Springer Science and Business Media LLC. https://doi.org/10.1016/j.jef.2018.02.002
20. Khoozani, A. A., Kebede, B., & Bekhit, A. E.-D. A. (2022). The effects of green banana flour fortification on volatiles compounds of bread: A fingerprinting approach. In Applied Food Research (Vol. 2, Issue 2, p. 100202). Elsevier BV. https://doi.org/10.1016/j.afres.2022.100202
21. Pasqualone, A., Vurro, F., Summo, C., Abd-El-Khalek, M. H., Al-Dmoor, H. H., Grgic, T., Ruiz, M., Magro, C., Deligeorgakis, C., Helou, C., & Le-Bail, P. (2022). The Large and Diverse Family of Mediterranean Flat Breads: A Database. In Foods (Vol. 11, Issue 15, p. 2326). MDPI AG. https://doi.org/10.3390/foods11152326
22. Aljanada, R., & Alfaisal, A. (2020). Metaphorical Conceptualization of Food in Jordanian Arabic. In International Journal of Language and Literary Studies (Vol. 2, Issue 3, pp. 94–107). Tawasul International Centre for Publishing, Research and Dialogue. https://doi.org/10.36892/ijlls.v2i3.347
23. Viana, E. D. S., Souza, A. D. S., Reis, R. C., & Oliveira, V. J. dos S. de. (2018). Aplicação de farinha de banana verde na substituição parcial da farinha de trigo em pão de forma. In Semina: Ciências Agrárias (Vol. 39, Issue 6, p. 2399). Universidade Estadual de Londrina. https://doi.org/10.5433/1679-0359.2018v39n6p2399
24. Rahman, T., Akter, S., Sabuz, A. A., & Rana, R. (2021). Characterization of Wheat Flour Bread Fortified with Banana Flour. In International Journal of Food Science and Agriculture (Vol. 5, Issue 1, pp. 7–11). Hill Publishing Group Inc. https://doi.org/10.26855/ijfsa.2021.03.002
25. Oliveira, D. A. S. B. D., Müller, P. S., Franco, T. S., Kotovicz, V., & Waszczynskyj, N. (2015). Avaliação da qualidade de pão com adição de farinha e purê da banana verde. In Revista Brasileira de Fruticultura (Vol. 37, Issue 3, pp. 699–707). FapUNIFESP (SciELO). https://doi.org/10.1590/0100-2945-176/14
26. Thakaeng, P., Boonloom, T., & Rawdkuen, S. (2021). Physicochemical Properties of Bread Partially Substituted with Unripe Green Banana (Cavendish spp.) Flour. In Molecules (Vol. 26, Issue 7, p. 2070). MDPI AG. https://doi.org/10.3390/molecules26072070
27. Akter, A. (2019). Qualitative and quantitative evaluation of bread, cake and jam prepared with the addition of banana peel flour [Master thesis, Chittagong Veterinary and Animal Sciences University].
28. Zuwariah, I., & Aziah, A. A. N. (2009). Physicochemical properties of wheat breads substituted with banana flour and modified banana flour. In J Trop Agric and Fd Sc (Vol. 37, Issue 1, pp. 33–42). Malaysian Agricultural Research and Development Institute.
29. Loong, C. Y. L., & Wong, C. Y. H. (2018). Chinese steamed bread fortified with green banana flour. In Food Research (Vol. 2, Issue 4, pp. 320–330). Rynnye Lyan Resources. https://doi.org/10.26656/fr.2017.2(4).058
30. Dala'in, M. N. (2022). Using Green Banana Pulp Flour as a Functional Ingredient in Pita Bread Processing [Master thesis, Mutah University].
31. AACC Approved Methods of Analysis, 11th Ed. Method 38-12.02. Wet Gluten, Dry Gluten, Water-Binding Capacity, and Gluten Index. Cereals & Grains Association, St. Paul, MN, U.S.A. http://dx.doi.org/10.1094/AACCIntMethod-38-12.02

32. AACC Approved Methods of Analysis, 11th Ed. Method 56-81.04. Determination of Falling Number. Cereals & Grains Association, St. Paul, MN, U.S.A. http://dx.doi.org/10.1094/AACCIntMethod-56-81.04
33. AACC Approved Methods of Analysis, 11th Ed. Method 08-01.01. Total Ash Methods. Cereals & Grains Association, St. Paul, MN, U.S.A. http://dx.doi.org/10.1094/AACCIntMethod-08-01.01
34. AACC Approved Methods of Analysis, 11th Ed. Method 45-21.02. Total Ash Methods. Cereals & Grains Association, St. Paul, MN, U.S.A. http://dx.doi.org/10.1094/AACCIntMethod-45-21.02
35. Perten Instrument Method. TVT method 08-05.02. Flour Tortilla Stretchability/ Flexibility AIB Standard Procedure. Retrieved from https://www.perten.com/Global/Application%20notes/TVT/08-05.02%20Flour%20Tortilla%20Stretchability-Flexibility,%20AIB%20Standard%20Procedure%20-%20Penetration.pdf.
36. Perten Instrument methods. TVT method 03-04.2. Bread Dough Properties by Double Cycle compression.
37. Gavurníková, S., Havrlentová, M., Mendel, Ľ., Čičová, I., Bieliková, M., & Kraic, J. (2011). Parameters of Wheat Flour, Dough, and Bread Fortified by Buckwheat and Millet Flours. In Agriculture (Polnohospodárstvo) (Vol. 57, Issue 4, pp. 144–153). Walter de Gruyter GmbH. https://doi.org/10.2478/v10207-011-0015-y
38. Khalil, A. H., Mansour, E. H., & Dawoud, F. M. (2000). Influence of Malt on Rheological and Baking Properties of Wheat–cassava Composite Flours. In LWT - Food Science and Technology (Vol. 33, Issue 3, pp. 159–164). Elsevier BV. https://doi.org/10.1006/fstl.1999.0629
39. Vijayakumar T, P., & Beryl Mohankumar, J. (2009). Formulation and characterization of Millet flour blend incorporated composite flour. In International Journal of Agriculture Sciences (Vol. 1, Issue 2, pp. 46–54). Bioinfo Publications. https://doi.org/10.9735/0975-3710.1.2.46-54
40. Mironeasa, S., Codină, G. G., & Mironeasa, C. (2015). Optimization of Wheat-Grape Seed Composite Flour to Improve Alpha-Amylase Activity and Dough Rheological Behavior. In International Journal of Food Properties (Vol. 19, Issue 4, pp. 859–872). Informa UK Limited. https://doi.org/10.1080/10942912.2015.1045516
41. Nyamayi, D., Anyango, J., & Omwamba, M. (2022). Functional and physicochemical properties of wheat, cassava, and bamboo shoot composite flours and bread. In African Journal of Food, Agriculture, Nutrition and Development (Vol. 22, Issue 114, pp. 21418–21436). African Journal of Food, Agriculture, Nutrition and Development. https://doi.org/10.18697/ajfand.114.22315
42. El-Taib, H., Rizk, I., Yousif, E., & Hassan, A. (2018). Effect of barley flour on wheat bread quality. In Arab Universities Journal of Agricultural Sciences (Vol. 26, Issue 3, pp. 1109–1119). Egypts Presidential Specialized Council for Education and Scientific Research. https://doi.org/10.21608/ajs.2018.28364
43. Bakare, A. H., Ogunbowale, O. D., Adegunwa, M. O., & Olusanya, J. O. (2016). Effects of pretreatments of banana (Musa AAA,Omini) on the composition, rheological properties, and baking quality of its flour and composite blends with wheat flour. In Food Science & Nutrition (Vol. 5, Issue 2, pp. 182–196). Wiley. https://doi.org/10.1002/fsn3.378
44. Noorfarahzilah, M., Lee, J. S., Sharifudin, M. S., Mohd Fadzelly, A. B., & Hasmadi, M. (2014). Applications of composite flour in development of food products. In International Food Research Journal (Vol. 21, Issue 6, pp. 2061–2074). Universiti Putra Malaysia.
45. Mohebbi, Z., Homayouni, A., Azizi, M. H., & Hosseini, S. J. (2017). Effects of beta-glucan and resistant starch on wheat dough and prebiotic bread properties. In Journal of Food Science and Technology (Vol. 55, Issue 1, pp. 101–110). Springer Science and Business Media LLC. https://doi.org/10.1007/s13197-017-2836-9
46. Li, P.-H., Wang, C.-W., Lu, W.-C., Chan, Y.-J., & Wang, C.-C. R. (2022). Effect of Resistant Starch Sources on the Physical Properties of Dough and on the Eating Quality and Glycemic Index of Salted Noodles. In Foods (Vol. 11, Issue 6, p. 814). MDPI AG. https://doi.org/10.3390/foods11060814
47. Sibanda, T., Ncube, T., & Ngoromani, N. (2015). Rheological Properties and Bread Making Quality of White Grain Sorghum-Wheat Flour Composites. In International Journal of Food Science and Nutrition Engineering (Vol. 5, Issue 4, pp. 176–182). Scientific And Academic Publishing. https://doi.org/10.5923/j.food.20150504.03



## Funds:
This research received no external funding.

## Acknowledgments:
I would like to thank Mr. Mu'ath Dala'in for providing the green banana flour used in this research.


## Conflict of Interest:
The author declares no conflict of interest.

## Ethical Statement:

This article does not contain any studies that would require an ethical statement.

## Contact Address:

***Khaled Abu-Alruz**, Mutah University, Faculty of Agriculture, Department of Nutrition and Food Technology, 61710, Al-Karak, Jordan,
E-mail: kabu_ruz@mutah.edu.jo or khaledabualruz@yahoo.com
ORCID: https://orcid.org/0000-0001-7788-9723

Corresponding author: *