*Original Research Article*

Effect of Ripe Banana Pulp on the Physical, Chemical and Sensory Properties of White Bread

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ABSTRACT

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| **Aims:** This study focused on incorporating ripe banana pulp into wheat flour at different levels, to determine its effect on the general quality of white bread. This was aimed at minimizing post-harvest losses associated with ripe banana, and for value addition.  **Study design:** The study adopted experimental design.  **Place and Duration of Study:** Department of Food Science and Technology, University of Nigeria, Nsukka, within six months period.  **Methodology:** The ripe banana pulp was incorporated at different levels of 0-30% into wheat flour for bread preparation. Prior to baking, the bread dough samples were evaluated for proofing ability. Physical, proximate and micronutrient properties of the bread were determined using standard analytical methods. The sensory characteristics were evaluated by 20 semi trained panelists using the 9-point Hedonic scale where 1=extremely dislike and 9=extremely like.  **Results:** Results obtained for proofing ability of the dough samples ranged from 3.05 to 4.95 cm. The values for physical properties ranged from 250.25 to 261.75 g, 420.25 to 441.75 cm3, 1.60 to 1.77 cm3/g and 0.75 to 1.05 cm for loaf weight, loaf volume, specific loaf volume and oven spring, respectively. Most of the chemical parameters decreased with increase in banana pulp, probably as a result of dilution effect. However, moisture, Vitamin C and B6 increased with increase in banana pulp incorporation. The bread samples had high sensory attributes.  **Conclusion:** It was observed that up to 30% ripe banana pulp could be substituted with wheat flour in bread making without adversely affecting the general properties of the bread. |

*Keywords: Banana pulp, post-harvest, value-addition, white bread, physical properties, chemical composition, sensory*

1. INTRODUCTION

The word bread is used to describe a staple food prepared from dough of flour and water, usually by baking [1]. White bread characteristically refers to bread made from wheat flour from which the bran and the germ layers have been removed, producing light-colored flour [2]. It is generally considered to be less nutritionally dense as a result of the removal of nutrients such as the B vitamins, micronutrients, iron and some dietary fiber; during the bran- and wheat germ-discarding milling process [3]. White bread has remained the most popular type of bread. It is an important staple food both in the developed and developing world [4]. It is one of the most essential dominant foods and the second most widely consumed non-traditional food products after rice in Nigeria [5]. It is consumed by people in every socioeconomic class and is acceptable to both adults and children.

In the last few years, there has been an increased trend towards healthy eating which has resulted in the development of many novel functional foods including use of other locally available crops for bread production. Partial or total substitution or blending of wheat flour with other crops in non-wheat producing countries is on record [6, 7, 8, 9]. Therefore, white bread can be a vehicle for food fortification using nutrient dense crops such as banana.

Banana is an elongated, edible fruit- botanically a berry- produce by several kind of large herbaceous flowering plants in the genus *Musa*. Banana (*Musa acuminate colla*) fruit belongs to the family of Musaceae. Commercially, banana is among the most cultivated fruit crops in the tropical and subtropical climate countries, being the fourth most important agricultural fruit in the world [10,11]. There are several cultivars of bananas which vary in color (yellow to brown), size (4-9 inches) and weight (70-150g). However, of the total production, approximately 40% is lost only in the post-harvest period [12]. The fruit has an excellent source of nutrients comprising of vitamin B1(3%), vitamin B2 (6%), vitamin B3 (4%), vitamin B5 (7%), vitamin B6 (31%), vitamin B9 (5%), vitamin C (10%), iron (2%), magnesium (8%), manganese (13%), phosphorus (3%), potassium (8%), zinc (2%) and fiber, among others. Banana has some health benefits such as healthy bowels enhancement, protection from strokes and ulcers, improved blood pressure and cardiovascular health. It may also boost mood and reduce water retention because of low sodium [13]. The incorporation of banana pulp into wheat flour for the production of bread would increase the nutrient contents of the bread, reduce post-harvest losses of banana and enhance value addition to the crops and their products. The aim of this study therefore was to produce bread from blends of wheat flour and banana pulp and assess their physical, chemical and sensory properties.

2. material and methods

**2.1 Raw Materials and Preparations**

Wheat flour (WF), mature ripe bananas, instant dry yeast, salt, baking fat, sugar, milk, nutmeg, and eggs were purchased from Ogige Market in Nsukka, Enugu State, Nigeria. The ripe bananas were washed thoroughly in potable water, peeled, sliced into small pieces using a kitchen knife, poured into a bowl and mashed. The mashed banana (MB) obtained partially substituted wheat flour (WF) at different levels to give various ratios of WF:MB as 100:0 (control), 95:5, 90:10, 85:15, 80:20,75:25, and 70:30. Straight dough method was used for the bread production. All ingredients were weighed, mixed and kneaded to obtain the dough [14]. The different dough samples were divided, shaped and placed in baking pans smeared with vegetable oil, covered and allowed to proof for 1hour 30 minutes. The dough was baked in an oven at 180°C for 30minutes. The baked loaves were carefully removed from the oven, depanned and allowed to cool at room temperature (28±2°C). After cooling for 30minutes the bread were packaged in high density polyethylene bags for further analysis. The flow diagram for the bread production is shown in Figure 1.

Ingredients

Weighing

Mixing

Kneading

Cutting/scaling

Moulding (shaping)

Panning

Proofing (1h 30 mins)

Baking (180ºC for 30minutes)

De-panning

Cooling

Packaging

Packaged Bread

**Figure 1: Flow diagram for Bread production process**

**2.2** **Determination of physical parameters**

Loaf weight (LW) of each sample was determined using analytical weighing balance. The loaf volume (LV) of each sample was determined using the traditional rapeseed displacement method as described by [15] with slight modification. The loaf was put in a metallic container with known volume (VC). The container was topped with rice grains, then the loaf was removed and the volume of the rice noted (VR). The loaf volume was calculated as follows:

Loaf volume (LV) in cm3= Volume of the container (VC) − Volume of rice (VR)

The specific loaf volume (SLV) of the samples was determined by dividing the loaf volume by the weight of the bread as described by [16].

Proofing ability (PA) was carried out by measuring the difference in the height of each dough in the pan before and after proofing [17].

Oven spring (OS) was determined by measuring the difference in the height of each sample before and after baking [18].

**2.3 Determination of chemical composition of the bread samples**

The samples were evaluated for moisture, ash, protein, crude fiber, and crude fat on a dry weight basis according to the standard procedures recommended by [19] while total carbohydrate was calculated by difference. Percentage available carbohydrates (on dry basis) = 100 – (%Moisture + %Ash + %Fat + %Protein + %Fiber), as described by [19]. Minerals (calcium (Ca), iron (Fe), and Zinc (Zn)) were determined using Flame Atomic Absorption Spectrophotometer (Shimadzu 2010 model) as described by [19]. Vitamins B3, B6 and C contents of the samples were determined according to [19].

**2.4 Sensory evaluation of the bread samples**

The bread samples were subjected to sensory evaluation by 20 semi-trained panelists for color, flavor, texture, mouth feel, taste and overall acceptability. The ratings were done using 9-point Hedonic scale as described by [20].

**2.4 Experimental design and statistical analysis**

The experiment was laid out in a completely randomized design (CRD). Data were subjected to Analysis of Variance (ANOVA) using Statistical Package for Service Solution (SPSS) version 25. Duncan’s New Multiple Range Test (DNMRT) was used to compare the treatment means. Statistical significance was accepted at *P* ˂ 0.05 [21].

3. results and discussion

**3.1** **Physical Properties of Bread** **from Blends of Wheat Flour and Banana Pulp**

Table 1 shows the physical properties of the bread samples. The loaf weight increased with increase in banana pulp. The values ranged from 250.25 g of the control sample to 261.75 g at 30% substitution of the banana pulp. The increase in the loaf weight could be attributed to increased moisture content from ripe banana which contains significant amount of moisture, resulting in heavy dough and thus heavy loaf. The loaf volume and the specific loaf volume were observed to decrease as proportions of banana pulp increased from 5%-30%. The values ranged from 420.25 cm3 at 30% substitution of banana pulp to 441.75 cm3 for the control samples; and1.60 cm3/g at 30% substitution of banana pulp to 1.77 cm3/g for the control sample, respectively. This could be due to quantitative reduction of gluten in the dough with addition of banana pulp, resulting to less retention of carbon dioxide gas and dense texture [22]. Gluten causes the dough to extend and trap the carbon dioxide produced by yeast during fermentation making the dough to be elastic and retain high volume. The dough proofing ability of the samples were observed to decrease as the proportion of banana pulp increased from 5%-30%. The values decreased from 4.95 cm for the control sample to 3.05 cm at 30% substitution of banana pulp. This could also be attributed to reduction in the quantity of gluten with addition of banana pulp, resulting to less retention of carbon dioxide. The oven spring results ranged from 0.75 cm at 30% substitution of banana pulp to 1.05cm of the control sample. There was no noticeable change in the values up to 10% substitution. These imply that in the oven, carbon dioxide retention by gluten network was not affected by banana pulp incorporation.

**Table 1:** **Physical properties of bread from blends of wheat flour and banana pulp**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  | **Sample (Wheat Flour: Banana Pulp) (%)** | | |  |  |  |  |
| **Parameter** | **100:0** | **95:5** | **90:10** | **85:15** | **80:20** | | **75:25** | | **70:30** |
| **LW (g)** | 250.25g±0.35 | 251.75f±0.35 | 255.7e ±0.35 | 257.25d±0.35 | 258.75c±0.35 | | 260.25b±0.35 | | 261.75a±0.35 |
| **LV (cm3)** | 441.75a±0.35 | 441.25a ±0.35 | 437.75b ±0.35 | 433.75c±0.35 | 429.75d±0.35 | | 425.25e±0.35 | | 420.25f±0.35 |
| **SLV(cm3/g)** | 1.77a±0.00 | 1.75b±0.00 | 1.71 c ±0.00 | 1.69d ±0.00 | 1.66e±0.00 | | 1.63f±0.00 | | 1.60g±0.00 |
| **PA (cm)** | 4.95a±0.71 | 4.65b±0.71 | 4.25 c ±0.71 | 3.95 d ±0.71 | 3.65e±0.71 | | 3.35f±0.71 | | 3.05g±0.71 |
| **OS (cm)** | 1.05a±0.71 | 1.05a±0.71 | 1.05a±0.71 | 1.00a±0.14 | 0.85a±0.07 | | 0.80a±0.14 | | 0.75a±0.07 |

Values are mean ±SD (n=2). Values in the same row with different superscript were significantly (*P* < 0.05) different

**3.2 Proximate Composition of the Bread Samples from Blends of Wheat Flour and Banana Pulp**

The results of the proximate composition of the bread samples are shown in Table 2. The moisture content of the bread samples increased with increase in substitution of ripe banana pulp from 5%-30%. The moisture content varied from 30.17% to 38.36%. The increased moisture content could be due to high moisture content of ripe banana pulp. The ash, fiber, protein, fat and carbohydrate content decreased significantly with increased ripe banana pulp. This is probably as a result of dilution effect. The decrease in ash, fiber, protein, fat and carbohydrate could be attributed to reduction of wheat flour with addition of ripe banana pulp which is generally low in these parameters [23]. The ash content varied from 0.57% to 1.73%, the fiber varied from 0.68% to1.90%, the protein varied from 7.42% to 9.20%, the fat contents varied from 1.78% to 3.00%, and the carbohydrate varied from 51.19% to 54.00%.

**Table 2: Proximate composition of bread samples from wheat flour and banana pulp blends**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | |  |  | | **Sample (Wheat Flour: Banana Pulp) (%)** | | | |  |  | |  | |
| **Parameters (%)** | | **100:0** | | | **95:5** | | **90:10** | **85:15** | **80:20** | | | **75:25** | | **70:30** |
| **Moisture** | | 30.17f±0.04 | | | 32.15e±0.04 | | 33.80d±0.06 | 35.29c±0.01 | 35.98c±0.04 | | | 36.72b±0.05 | | 38.36a±0.01 |
| **Ash** | | 1.73a±0.04 | | | 1.69a±0.04 | | 1.45b±0.06 | 1.28c±0.01 | 1.20c±0.04 | | | 1.13c±0.05 | | 0.57d±0.01 |
| **Fiber** | | 1.90a±0.01 | | | 1.77a±0.05 | | 1.58b±0.04 | 1.40c±0.01 | 1.36c±0.06 | | | 1.27c±0.04 | | 0.68d±0.04 |
| **Protein** | | 9.20a±0.04 | | | 8.69b±0.04 | | 8.63b±0.06 | 8.35c±0.01 | 8.02d±0.04 | | | 7.68e±0.05 | | 7.42f±0.01 |
| **Fat** | | 3.00a±0.01 | | | 2.92ab±0.05 | | 2.82b±0.04 | 2.25c±0.01 | 2.06d±0.06 | | | 1.97d±0.04 | | 1.78e±0.04 |
| **Carbohydrate** | | 54.00a±0.04 | | | 52.78b±0.04 | | 51.72c±0.06 | 51.43d±0.01 | 51.38de±0.04 | | | 51.23ef±0.05 | | 51.19f±0.01 |

Values are mean ±SD (n=2). Values in the same row with different superscript were significantly (*P* < 0.05) different

**3.3 Micronutrient Composition of Bread Samples from Wheat Flour and Banana Pulp Blends**

The results of the micronutrients composition of the bread samples are shown in Table 3. The calcium values ranged from 1.47 mg/100g at 30% substitution of the banana pulp to 2.65 mg/100g of the control sample. The decreased could be attributed to decrease in wheat flour with addition of ripe banana pulp which contains lower calcium than wheat flour resulting in less retention of calcium [23]. The iron and zinc content decreased also with increase in ripe banana pulp. The values ranged from 0.10 mg/100g at 30% substitution of banana pulp to 0.44 mg/100g for control sample; and 0.03 mg/100g at 30% substitution of banana pulp to 0.20 mg/100g of the control sample. This could also be as a result of decrease in wheat flour with addition of ripe banana pulp which contains less iron and zinc than wheat flour resulting in low retention of iron and zinc [23]. The vitamin C and vitamin B6 increased significantly with increased banana pulp. The values ranged from 0.17 mg/100g of the control sample to 0.88 mg/100g at 30% substitution of banana pulp and 0.02 mg/100g of the control sample to 0.09 mg/100g of the 30% substitution of banana pulp. The increase could be attributed to increased banana pulp which contains high amount of vitamin C and vitamin B6 [23]. However, vitamin B3 decreased significantly with increased banana pulp. The values decreased from 0.71 mg/100g of the control sample to 0.42 mg/100g of the 30% substitution of banana pulp. The decrease may be attributed to increased banana pulp which contains lower value of vitamin B3 than wheat flour [24].

**Table 3:** **Micronutrient composition of bread samples from wheat flour and banana pulp blends**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | |  |  |  | **Sample (Wheat Flour: Banana Pulp) (%)** | | | | |  |  | |  | |
| **Parameters (mg/100g)** | **100:0** | | | | | **95:5** | **90:10** | **85:15** | **80:20** | | | **75:25** | | **70:30** |
| **Calcium** | 2.65a±0.04 | | | | | 2.64a±0.04 | 2.23b±0.06 | 1.93c±0.00 | 1.85c±0.04 | | | 1.57d±0.05 | | 1.47d±0.00 |
| **Iron** | 0.44a±0.00 | | | | | 0.25b±0.05 | 0.25b±0.04 | 0.24b±0.00 | 0.18b±0.06 | | | 0.15b±0.04 | | 0.10b±0.04 |
| **Zinc** | 0.20a±0.00 | | | | | 0.16ab±0.05 | 0.15ab±0.04 | 0.07bc±0.02 | 0.05c±0.02 | | | 0.05c±0.02 | | 0.03c±0.00 |
| **Vitamin C** | 0.17f±0.02 | | | | | 0.28e±0.04 | 0.35d±0.03 | 0.42cd±0.01 | 0.50bc±0.04 | | | 0.76b±0.02 | | 0.88a±0.01 |
| **Vitamin B3** | 0.71a±0.01 | | | | | 0.57b±0.04 | 0.55b±0.03 | 0.51bc±0.00 | 0.49bcd±0.01 | | | 0.46cd±0.02 | | 0.42d±0.01 |
| **Vitamin B6** | 0.02c±0.01 | | | | | 0.02c±0.01 | 0.03bc±0.01 | 0.04bc±0.01 | 0.07ab±0.01 | | | 0.07ab±0.01 | | 0.09a±0.02 |

Values are mean ±SD (n=2). Values in the same row with different superscript were significantly (p< 0.05) different

**3.4. Sensory Scores of Bread Samples from Wheat Flour and Banana Pulp Blends**

Table 4 shows the sensory scores of the bread samples. The results indicated that all the samples had high ratings for color, flavor, texture, mouth feel, taste and overall acceptability. All the samples compared favorably with the control sample in all the attributes evaluated, however some of the samples showed significant differences. The results show that banana pulp addition in the white bread did not affect consumer acceptability.

**Table 4:** **Sensory scores of bread samples from wheat flour and banana pulp blends**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  | |  | **Sample (Wheat Flour: Banana Pulp) (%)** | | | |  |  | |  | |
| **Parameters (%)** | **100:0** | | **95:5** | | | **90:10** | **85:15** | **80:20** | | | **75:25** | | **70:30** |
| **Color** | 7.90ab±0.74 | | 8.00a±0.94 | | | 7.60ab±1.17 | 7.30ab±1.16 | 7.50ab±0.85 | | | 7.00ab±1.56 | | 6.80b±1.40 |
| **Flavor** | 7.80a±0.79 | | 7.80a±1.14 | | | 7.50a±1.51 | 7.30a±1.34 | 7.10a±1.66 | | | 7.00a±1.49 | | 7.00a±1.63 |
| **Texture** | 7.90a±0.57 | | 7.80a±1.14 | | | 7.70a±1.33 | 6.70ab±1.42 | 6.70ab±1.70 | | | 6.20b±1.75 | | 6.80ab±1.81 |
| **Mouth feel** | 8.10a±0.74 | | 7.60abc±1.26 | | | 8.00ab±1.05 | 7.50abc±1.08 | 6.60c±1.58 | | | 6.70bc±2.00 | | 6.70bc±1.34 |
| **Taste** | 8.00a±0.82 | | 7.60a±1.26 | | | 7.60a±1.78 | 7.40a±1.26 | 7.10a±1.79 | | | 6.90a±1.60 | | 7.20a±1.69 |
| **Overall acceptability** | 8.40a±0.70 | | 7.90ab±1.10 | | | 7.70ab±1.42 | 7.10b±1.29 | 7.40ab±1.26 | | | 6.80b±1.48 | | 6.70b±1.64 |

Values are mean ± SD of 20 panelists. Valuess with different superscript within the same row were significantly (p<0.05) different

4. Conclusion

This study has shown that acceptable bread can be produced from wheat flour and banana pulp blends. Banana pulp showed significant possibility as raw material in the production of white bread for value addition. The physical properties were retained to a great extent and most of the nutrient values were improved. Further studies may be needed to determine the shelf stability of the products.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

Competing interests

Authors have declared that no competing interests exist.

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