

## Effects of Partial Substitution of Wheat Flour with Breadfruit Flour on Quality Attributes of Fried Doughnut

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Received: 12<sup>th</sup> September 2017 / Accepted: 02<sup>nd</sup> December 2017

### ABSTRACT

**Purpose :** Breadfruit is a highly perishable, underutilized fruit and needs more attention because of its nutritional qualities. The study was carried out to investigate the effects of wheat flour substitution with breadfruit flour in doughnut production.

**Research Method :** The breadfruit was washed, peeled, sliced, blanched, cooled, drained at a temperature of 65°C in cabinet dryer and milled into flour and blended with wheat flour at different ratios (100:0, 90:10, 80:20, 70:30, 60:40 and 50:50 respectively). Doughnut was produced from the composite flour using straight dough method and was analyzed for proximate composition (moisture, ash, protein, fat, crude fibre and carbohydrates), physical properties (weight, volume, specific volume, crust and crumb colour) and sensory attributes (colour, aroma, taste, texture and overall acceptability).

**Findings :** Range of values for moisture, ash, protein, fat, crude fibre and carbohydrates were 19.3-30.9%, 2.00-2.28%, 2.98-12.0%, 26.9-35.2%, 1.76-4.79% and 26.4-35.5% respectively. The physical properties of the doughnut decreased with addition of breadfruit flour. The weight, volume and specific volume were within the range of 87.5-120.4g, 35.2-100.6ml and 0.40-0.84cm<sup>3</sup>/g. Range of values for Lightness (L\*), redness (a\*) and yellowness (b\*) of doughnut crust were: 25.3 to 60.3, 10.1 to 20.0 and 26.9 to 39.4 while that of the doughnut crumb were 59.4 to 79.4, 1.41 to 2.54 and 24.4 to 35.3 respectively.

**Originality/Value :** The sensory score for wheat-breadfruit composite doughnut decreased and this suggests that wheat-breadfruit composite flour had a pronounced effect on the doughnut. However, breadfruit flour could be incorporated up to 50% level in the formulation of doughnut without affecting its overall acceptability and this will go a long way in saving the cost of production and improved quality.

**Keywords:** Breadfruit, wheat flour, doughnut, proximate, physical properties

### INTRODUCTION

Snack foods consumption is on the increase due to urbanization and the food based industry can exploit this by developing novel snack foods (Noor aziah and Mohammed, 2012) with locally sourced flours. Doughnuts are fermented and fried sweet snacks made from deep-frying dough that is a mixture of flour, water, egg, oil, sugar and milk (Hatae *et al.*, 2003) and are characterized by a golden brown exterior color,

a crisp crust, and an inner core that resembles a baked product more than a fried food (Tan and Mittal, 2006). Different variations of doughnuts are made all over the world; some are baked instead of deep fried, or made into a variety of shapes. Doughnut is classified into

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two which are the cake type (without yeast) and risen type (with yeast). However, doughnuts are fried foods and they absorb substantial amounts of oil during frying. Traditional doughnuts from wheat flour normally contain 24 to 26% oil. (Prosis, 1990; Tan and Mittal, 2006).

Breadfruit (*Artocarpus altilis*) is widely cultivated to an appreciable extent in south-west states of Nigeria. Present level of breadfruit production in the south-western Nigeria has been estimated to about 10 million tones dry weight per year with potentials for exceeding 100 million tones every year (Adewusi *et al.*, 1995; Ajayi 1997). Breadfruit (*Artocarpus altilis*) is a tree and fruit native to Malaysia and countries of the south pacific and the Caribbean. It is an important food in these areas (Taylor and Tuia 2007). Breadfruit is a fruit tree that is propagated with the root cuttings and the average age of bearing first crop is between 4 to 6 years (Amusa *et al.*, 2002). It produces its fruit up to three times per year and the number of fruits produced is very high. The fruit has been described as an important staple food of a high economic value (Soetjijto and Lubis 1981). The bread fruit pulps are made into various dishes; it can be processed into flour and used in bread and biscuit making (Amusa *et al.*, 2002). Breadfruit has also been reported to be rich in fat, ash, fibre and protein (Ragone 1997). Despite the importance of this fruit, its production is faced with several problems including short shelf life and poor yield due to diseases (Olaoye *et al.*, 2007). The fruits are utilized in Nigeria within 5 days of harvesting because of their short shelf lives. One way to minimize post-harvest losses and increase the utilization of breadfruit is through processing into flour. This is a more stable intermediate product.

In many developing countries the use of composite flours have the following advantages (a) saving of hard currency, (b) promotion of high yielding, native plant species (c) better supply of protein for human nutrition, and (d) better overall use of domestic agricultural production (Berghofer 2000; Bugusu *et al.*, 2001). Several

information are available on the use of wheat-based composite flour in Nigeria comprising buckwheat (Lin *et al.*, 2009), plantain (Mepba *et al.*, 2007), modified corn starch (Woo and Seib, 2002), waxy corn starch (Lee *et al.*, 2001; Morita *et al.*, 2002), sunflower flour (Biljan and Bojana, 2008), chick pea (Manuel *et al.*, 2008) and bean flour (Alex *et al.*, 2008). Information is however, scanty on the use of composite flour from wheat and breadfruit bakery product- doughnut. Although breadfruit is a highly perishable, it is an underutilized fruit and need more attention because of its nutritional qualities. Thus, this study evaluated the proximate composition, physical properties and sensory characteristics of doughnut made from wheat-breadfruit composite flour.

## **MATERIALS AND METHODS**

### ***Materials***

Matured green ripe and wholesome breadfruit was purchased from a local market in Owode -Yewa, Ogun State. Commercial wheat flour (Golden penny) and other ingredients such as sugar, margarine, non fat dry milk powder, egg, yeast and salt were purchased from Osiele market in Abeokuta, Ogun state, Nigeria.

### ***Production of breadfruit flour***

The modified method of Olaoye *et al.*, (2007) was used for the preparation of breadfruit flour. The breadfruit was thoroughly sorted to remove bad ones from the lot. The sorted fruits were washed to remove adhering soil and dirt. This was followed with peeling. After peeling, the tuber were sliced to facilitate rate of drying and ease milling operation, the sliced tuber were blanched at 60°C, for 15min in order to inactivate enzymes that may cause browning reaction. These were then cooled, drained and followed by drying. After blanching, the chips were spread out uniformly on a stainless steel perforated tray and dried in a cabinet dryer at 65°C for 24hrs. Following drying, the slices chips were milled using the laboratory hammer

mill (Fritsch, D-55743, Idaroberstein- Germany) and the milled sample was sieved (using 250 $\mu$ m screen) to obtain the flour. The breadfruit flour was packed and sealed in polyethylene bags at ambient temperature (26 $\pm$ 2°C) and 760mmHg until further analysis.

### **Blends Formulation**

The blends of wheat and breadfruit were mixed together using a Kenwood mixer (Model HC 750 D, Kenwood, Britain, UK). The flour blends were prepared by substituting wheat flour for breadfruit flour in the percentage proportion of 100:0, 90:10, 80:20, 70:30, 60:40, and 50:50 respectively.

### **Production of Doughnut**

Doughnuts were prepared by the straight-dough method according to the modified formulation by Shih *et al.*, (2001). Ingredients such as egg (12%), sugar (25%), margarine (24%), milk (23%), yeast (12%), salt (0.5%), water (36%) and breadfruit flour were added in appropriate proportion to each of the flour blends and the control flour (wheat). The substitution level of breadfruit flour into wheat flour was 10%, 20%, 30%, 40%, and 50% for making doughnut dough. The composite flour and the margarine were beaten at high speed of 5min in a Kenwood mixer (Model HC 750 D, Kenwood, Britain, UK). Water and all other ingredients were added to the flour and was kneaded for 2mins. The resulting dough was transferred to a cutting board and lightly dusted with flour. It was rolled to a thickness about 1cm and cut into a ring shaped. The dough was subjected to proofing at 35°C and 85% relative humidity for 30mins. After proofing, the doughnuts were fried in a deep-fryer containing vegetable oil at 160°C. The dough was fried for 80s on each side for a total of 160s until it became golden brown on the outside and well cooked on the inside.

### **Proximate composition of Doughnut**

The moisture, crude protein, fat, ash crude fibre of bread samples were analyzed using the method described by AOAC (2000) methods.

Carbohydrate content of doughnut samples was calculated by difference.

### **Physical properties of the doughnut**

The weight of the doughnut was determined using the modified method of Shittu *et al.*, (2006). The weights of the doughnuts were determined with the aid of weighing balance (AD, EK-4100i, JAPAN) after cooling and the weight values were recorded for each sample. The volume was measured using the method described by Rheman *et al.*, (2007). The volume was determined using sorghum seed displacement method. The sorghum seeds were poured in a container to measure the volume and were then measured in a graduated cylinder and marked as  $V_1$ . Thereafter, the sample was placed in the same container and seeds were poured till the test of the doughnut was covered. Again the sorghum seeds were measured in a graduated cylinder and marked as  $V_2$ . The volume of sample was then calculated based on the following equation.

$$Volume (ml) = V_1 - V_2$$

Where  $V_1$  represents the volume of the sorghum seeds in the empty container (ml),  $V_2$  represents volume of the sorghum seeds in the container containing sample (ml).

The specific volume was also calculated as shown in the following equation

$$Specific\ volume(cm^3/g) = \frac{(Volume\ of\ doughnut)}{(weight\ of\ doughnut)}$$

Crust and crumb colour measurement was measured by using Minolta chroma meter (CR- 410, Japan) based on (CIE) L\*a\*b\* scale. After calibrating the instrument by covering a zero calibration mask it was followed by white calibration plate. Crust and crumb were analyzed by placing them on the petri dish, and then the image was captured on the samples. The colour attributes such as lightness (L\*), redness (a\*) and yellowness (b\*) were recorded.

### ***Sensory attributes of doughnuts***

A 9 point Hedonic scale rating was used in evaluating the sensory attributes of doughnuts, where 1 = dislike extremely and 9 = like extremely. All doughnut samples were evaluated for colour, aroma, taste, texture and overall acceptability of the samples by 50 untrained panelists consisting of staff from National Biotechnology Development Agency, Owode Yewa, Ogun State, Nigeria who were asked to score the wheat-breadfruit doughnut. Data obtained were subjected to statistical analysis. Means, Analysis of variance (ANOVA) was determined using SPSS Version 21.0 and the differences between the mean values were evaluated at  $p \leq 0.05$  using Duncan's multiple range test.

## **RESULTS AND DISCUSSION**

### ***Proximate composition of doughnut***

The proximate compositions; moisture content, ash, protein, crude fat and crude fiber of fried doughnut with added breadfruit flour and control doughnut are shown in Table 01. There were significant ( $p < 0.05$ ) differences in the proximate compositions. There was a decrease in the moisture content of the doughnut ranging from 30.9 to 19.3%. Doughnut without breadfruit flour had the highest moisture content, while doughnut with 50% breadfruit flour had the least value. The moisture content wheat-breadfruit doughnut was in agreement with the findings of Shih *et al.*, (2001) who reported that the moisture content of doughnut replaced with long grain rice flour had lower than the controlled doughnut. The ash content of the doughnut ranged between 2.00 and 2.28%. Ash content is an indication of the level of minerals present in a food material. Increased levels of minerals with increase in breadfruit flour levels could be due to the amount of minerals in breadfruit flour. This suggests that breadfruit

flour can help in boosting mineral content of wheat doughnut. The protein content of wheat-breadfruit doughnut ranged from 2.98 to 12.0%. The protein content of wheat-breadfruit doughnuts was significantly lower ( $p < 0.05$ ) than the control and an inverse relationship with the amount of breadfruit added. This might be due to the relatively low percentage of protein in breadfruit flour as compared to wheat flour (Chong and Noor, 2008). Increase in the level of breadfruit flour in the doughnut lead to a significant ( $p < 0.05$ ) increase in the fat contents of the doughnut, this could be attributed to the increase in fat with increased in level of breadfruit flour due to the oil absorbed to replace the pores. The fat content of wheat-breadfruit doughnut was not in agreement with the findings of Supatchalee *et al.*, (2016). The crude fibre of wheat-breadfruit doughnut ranged from 1.76 to 4.79%. The increase in the crude fibre content might be attributed to the high fibre content in the breadfruit flour (Ajani *et al.*, 2012). The result obtained for this study was also similar to the report of Olaoye *et al.*, (2008) for crude fibre content of blends of wheat and breadfruit flour used for the production of baked products. Studies have shown that fibre plays a significant role in the prevention of several pathological diseases such as cardiovascular diseases, diverticulosis, constipation, irritable colon, cancer and diabetes (Slavin 2005; Elleuch *et al.*, 2011). The carbohydrate content in wheat-breadfruit doughnut ranged from 26.4% to 35.5%. Doughnut without breadfruit flour had the lowest carbohydrate content, while doughnut with 50% breadfruit flour had the highest value for carbohydrate content. Carbohydrate supplies energy to cells such as brains, muscles and blood. It contributes to fat mechanism and spares proteins as an energy source and acts as a mild natural laxative for human beings and generally adds to the bulk of the diet (Gaman and Sherrington, 1996; Gordon, 2000).

**Table 01: Proximate composition of wheat-breadfruit doughnut**

WF:BF	Moisture	Ash	Protein	Fat	Fibre	Carbohydrate
100:0	30.9±0.52 <sup>f</sup>	2.00±0.05 <sup>a</sup>	12.0±0.06 <sup>f</sup>	26.9±0.64 <sup>a</sup>	1.76±0.18 <sup>a</sup>	26.4±0.99 <sup>a</sup>
90:10	28.2±0.04 <sup>e</sup>	2.05±0.03 <sup>ab</sup>	10.0±0.04 <sup>e</sup>	28.4±0.23 <sup>b</sup>	2.05±0.07 <sup>b</sup>	29.3±0.33 <sup>b</sup>
80:20	27.5±0.14 <sup>d</sup>	2.11±0.004 <sup>ab</sup>	8.04±0.04 <sup>d</sup>	29.2±0.33 <sup>c</sup>	2.40±0.07 <sup>c</sup>	30.8±0.45 <sup>b</sup>
70:30	25.3±0.04 <sup>c</sup>	2.15±0.08 <sup>bc</sup>	7.27±0.09 <sup>c</sup>	32.5±0.18 <sup>d</sup>	3.33±0.13 <sup>d</sup>	29.4±0.11 <sup>d</sup>
60:40	22.6±0.21 <sup>b</sup>	2.28±0.04 <sup>c</sup>	5.37±0.07 <sup>b</sup>	33.1±0.19 <sup>d</sup>	4.03±0.04 <sup>e</sup>	32.6±0.48 <sup>d</sup>
50:50	19.3±0.14 <sup>a</sup>	2.25±0.07 <sup>c</sup>	2.98±0.03 <sup>a</sup>	35.2±0.07 <sup>e</sup>	4.79±0.04 <sup>f</sup>	35.5±0.15 <sup>e</sup>

Mean values with different superscripts within the same column are significantly different ( $p < 0.05$ ); WF- Wheat flour, BF- breadfruit flour; CHO-Carbohydrate

### *Physical properties of doughnut*

The physical properties of doughnut are presented in Table 02 and 03. The weight of wheat-breadfruit doughnut ranged from 87.5 to 120.4 g. Doughnut produced from wheat flour had the highest weight while doughnut produced from breadfruit flour at 50% had the lowest weight. It was observed that the weight decrease as breadfruit flour substitution increased; this can be attributed to lower level of gluten network in the composite flour dough and consequently decreased ability for the dough to rise (Aluko and Olugbemi, 1989). The volume of the wheat doughnut (control sample) was higher and significantly different ( $p < 0.05$ ) from doughnuts incorporated with breadfruit flour. The volume decreased with increase in breadfruit flour as shown in Table 2. This decrease is due to the lower gluten content in breadfruit flour compared to wheat flour. Gluten is an important component in protein which gives firmer dough matrix and manages to trap air cells to produce doughnuts with greater volume.

The crust and crumb colour results in terms of Lightness ( $L^*$ ), redness ( $a^*$ ) and yellowness ( $b^*$ ). Significant ( $p < 0.05$ ) differences existed in lightness ( $L^*$ ), redness ( $a^*$ ) and yellowness ( $b^*$ ) of the crust colour of wheat-breadfruit

doughnut. Lightness ranges from 25.3 to 60.3 and decreased with increase in breadfruit flour substitution. Redness ranged from 10.1 to 20.1 and decreased as breadfruit flour was increased. Yellowness values ranged from 26.9 to 39.4 and increased with increase in breadfruit flour substitution. A significant ( $p < 0.05$ ) difference existed in the crumb colour of the wheat-breadfruit doughnut. Lightness ranges from 59.4 to 79.4. There was a decrease in the lightness of the wheat-breadfruit composite doughnut. Redness ranged from 1.41 to 2.54 and increased with increase in breadfruit flour substitution, Yellowness ranged from 24.4 to 35.3 and increased with breadfruit flour substitution. The crust color of samples was affected by the replacement of wheat flour with breadfruit flour. In general, as breadfruit flour level increased, the crust color of the doughnut became dark brown. The crust of the control was lighter and less yellow than any of the other samples. For crumb color, as the level of breadfruit flour increased, the crumb was lighter and decreased, the ( $a^*$ ) indicating more red, and ( $b^*$ ) increased indicating more yellow crumb as measured by the chroma meter. The dark brown colour of doughnut could be attributed to Maillard browning between protein and inverse sugar in the presence of heat (Chong and Noor, 2008).

**Table 02: Quality of wheat-breadfruit composite doughnut**

WF:BF	Weight (g)	Volume (ml)	Specific volume (cm <sup>3</sup> /g)
100:0	120.4±0.35 <sup>f</sup>	100.6±0.35 <sup>f</sup>	0.84±0.00 <sup>e</sup>
90:10	115.9±0.42 <sup>e</sup>	95.6±0.42 <sup>e</sup>	0.83±0.01 <sup>e</sup>
80:20	114.1±0.28 <sup>d</sup>	70.5±0.35 <sup>d</sup>	0.62±0.00 <sup>d</sup>
70:30	105.1±0.21 <sup>c</sup>	60.6±0.42 <sup>c</sup>	0.58±0.01 <sup>c</sup>
60:40	90.5±0.21 <sup>b</sup>	40.6±0.42 <sup>b</sup>	0.45±0.00 <sup>b</sup>
50:50	87.5±0.28 <sup>a</sup>	35.2±0.71 <sup>a</sup>	0.40±0.01 <sup>a</sup>

Mean values with different superscripts within the same column are significantly different (p<0.05); WF- Wheat flour, BF- breadfruit flour

**Table 03: Crust and crumb colour of wheat-breadfruit composite doughnut**

WF:BF	Crust			Crumb		
	L*	a*	b*	L*	a*	b*
100:0	60.3±0.07 <sup>f</sup>	20.0±0.26 <sup>f</sup>	26.9±0.49 <sup>a</sup>	79.4±0.26 <sup>e</sup>	1.41±0.02 <sup>a</sup>	24.4±0.48 <sup>a</sup>
90:10	53.9±0.62 <sup>e</sup>	19.1±0.17 <sup>e</sup>	30.6±0.91 <sup>b</sup>	77.2±0.23 <sup>de</sup>	1.69±0.05 <sup>ab</sup>	25.5±0.31 <sup>a</sup>
80:20	47.3±1.34 <sup>d</sup>	16.3±0.11 <sup>d</sup>	32.2±0.32 <sup>c</sup>	74.7±0.09 <sup>d</sup>	1.81±0.13 <sup>b</sup>	29.4±0.08 <sup>b</sup>
70:30	42.6±0.53 <sup>c</sup>	14.3±0.04 <sup>c</sup>	35.4±0.31 <sup>d</sup>	70.6±0.21 <sup>c</sup>	1.88±0.06 <sup>bc</sup>	31.7±1.04 <sup>c</sup>
60:40	36.3±0.03 <sup>b</sup>	13.0±0.13 <sup>b</sup>	36.4±0.09 <sup>d</sup>	64.9±2.28 <sup>b</sup>	2.22±0.30 <sup>cd</sup>	32.6±0.21 <sup>d</sup>
50:50	25.3±0.46 <sup>a</sup>	10.1±0.08 <sup>a</sup>	39.4±0.30 <sup>e</sup>	59.4±1.12 <sup>a</sup>	2.54±0.11 <sup>d</sup>	35.3±0.16 <sup>d</sup>

Mean values with different superscripts within the same column are significantly different (p<0.05); WF- Wheat flour, BF- breadfruit flour, L\*- lightness, a\*- redness, b\*- yellowness

### **Sensory attributes of doughnut**

The sensory score of wheat-breadfruit doughnut is presented in Table 04. There were significant differences (p<0.05) in all the attributes measured. The values of the sensory score decrease as the substitution of breadfruit flour increases. The values of colour and aroma attributes ranged from 6.24 to 8.20 and 6.12 to 8.10 respectively. Doughnut without breadfruit flour had the highest likeness for colour and aroma while doughnut with 50% breadfruit flour had the lowest likeness. There were significant differences (p<0.05) in both taste and texture attributes. Doughnut without breadfruit flour had the highest likeness in terms of taste and

texture with values of 8.38 and 8.10 respectively, while doughnut with 50% breadfruit flour had the lowest values of 6.09 and 6.03 in terms of taste and texture respectively. The overall acceptability expresses how the consumers or panelist accept the product generally. The overall acceptability ranges from 6.26 to 8.22. Doughnut with 100% wheat flour was most preferred while doughnut with 50% breadfruit flour addition was the least preferred by the panelist. It is observed that up to 50% wheat replacement was accepted. So, the addition of breadfruit flour up to 50% could be accepted for production of doughnut.

**Table 04: Sensory score of wheat-breadfruit composite doughnut**

WF:BF	Colour	Aroma	Taste	Texture	Overall acceptability
100:0	8.20±0.28 <sup>d</sup>	8.10±0.14 <sup>d</sup>	8.38±0.04 <sup>e</sup>	8.10±0.71 <sup>e</sup>	8.22±0.10 <sup>d</sup>
90:10	7.26±0.08 <sup>c</sup>	7.24±0.25 <sup>c</sup>	7.36±0.09 <sup>d</sup>	7.29±0.09 <sup>d</sup>	7.32±0.12 <sup>c</sup>
80:20	7.23±0.11 <sup>c</sup>	7.04±0.06 <sup>c</sup>	7.07±0.11 <sup>c</sup>	7.02±0.08 <sup>c</sup>	7.04±0.08 <sup>bc</sup>
70:30	7.17±0.23 <sup>c</sup>	7.02±0.06 <sup>c</sup>	7.03±0.12 <sup>c</sup>	7.01±0.03 <sup>c</sup>	7.10±0.07 <sup>c</sup>
60:40	6.68±0.04 <sup>b</sup>	6.51±0.11 <sup>b</sup>	6.38±0.06 <sup>b</sup>	6.34±0.14 <sup>b</sup>	6.76±0.12 <sup>b</sup>
50:50	6.24±0.12 <sup>a</sup>	6.12±0.08 <sup>a</sup>	6.09±0.08 <sup>a</sup>	6.03±0.04 <sup>a</sup>	6.26±0.19 <sup>a</sup>

Mean values with different superscripts within the same column are significantly different ( $p < 0.05$ ); WF- Wheat flour, BF- breadfruit flour

## CONCLUSION

The study shows that doughnut can be produced from wheat-breadfruit composite flour. The proximate composition of the doughnut had improved, depending on the substitution level. This is true for ash, fat, fibre and carbohydrate content of the doughnut. The physical properties such as weight, volume and specific

volume of the doughnut decreased; however, there were significant differences in lightness, redness and yellowness among different levels of substitution. The crust and crumb colour was directly related to the level of substitution. Doughnut produced from all the blends was preferred by the panelist. However, further studies can be carried out on the storage stability of wheat-breadfruit composite doughnut.

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