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Towards the development of peanut–wheat flour composite dough: Influence of reduced-fat peanut flour on bread quality

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Abstract

The effect of partial substitution of wheat flour with reduced-fat peanut flour at different levels (10, 20, 30, 40, and 50%) on physical parameters, proximate composition, sensory profile, and shelf stability of bread were investigated. Loaf volume, specific volume, and crumb density were significantly ($p \leq .05$) reduced with increasing level of substitution with the peanut flour. Peanut flour had significant ($p \leq .05$) improvement on the protein content and reduction in carbohydrate content of loaves. Consumers preferred the taste aroma and color of the peanut–wheat flour composite loaves at ≥20% peanut flour inclusion. Freshly baked composite peanut–wheat bread loaves with 10% level of peanut substitution had higher overall acceptability than 100% wheat flour formulation but less microbial stability during storage. Reduced fat-peanut has potential application for improving the nutritional quality and shelf stability of wheat flour bread.

Practical applications

The demand for convenient alternative to conventional foods is on the increase with the dynamics of the world's social values, lifestyles, and demographic trends. Having peanut incorporated into dough (as one food system) will offer convenience to consumer and therefore add value to bread variety on market shelves. Assessing the influence of the peanut flour on bread quality provides first-hand information that can facilitate optimization of the baking process toward commercial production of peanut–wheat flour bread.

1 | INTRODUCTION

The technology of bread making is one of the oldest technologies known and has been evolving continuously as new materials, equipment, and processes are being developed (Selomulyo & Zhou, 2007). The unique characteristics of wheat flour compared with flours from other cereals in bread making is attributed to the ability of wheat flour dough to retain gas on expansion, due to its gluten content (Gan, Ellis, & Schofield, 1995). Flour obtained from other cereals, legumes and some vegetables are currently being valued for their respective contribution to the quality of baked products (Oghbaei & Prakash, 2016). In the production of biscuits from composite flour, Chandra, Singh, and Kumari (2015) reported that the swelling and water absorption capacity of the composite flour increased with increasing addition of rice, mung bean, and potato flour to the wheat flour used.

Peanut, the third major oil seed of the world next to soybean and cotton is primarily grown for human consumption, but has several uses as whole seed or as basic ingredient in the manufacture of peanut paste/butter, oil, and other similar products (Mieth, 1984). According to Singh, Castell-Perez, and Moreira (2000), the greatest assets of peanut paste are flavor, high protein, and fat content which render it suitable for compositing with carbohydrate foods. There is a general tendency to avoid peanut consumption due to high fat content. However, the oil is easily digestible and peanut consumption has been associated with the prevention of cardiovascular diseases (Alper & Mattes, 2003; Kris-Etherton et al., 1999) and a reduced risk of developing type II diabetes (Jiang et al., 2002).

The demand for convenient alternative to conventional foods reflects the changes in social values, lifestyles, and demographic trends (Lee & Lin, 2013). A myriad of convenience food have been introduced into the food markets over the past decades such as canned mixed fruit juices, pre-mixes, and instant powders. In Nigeria, bread is sometimes consumed with shelled peanut/peanut spread as a combined snack. Having both food stuffs in one system will offer convenience to consumer and therefore add value to bread variety on market shelves.

Gan et al. (1995) reported that reduced-fat peanut paste prepared by the method of Franklin (1994), presented acceptable textural, sensory, and rheological properties. There are large volumes of reported data on different kinds of dough formulations and the quality of their bread loaves (Lazaridou, Duta, Papageorgiou, Belc, & Biliaderis, 2007; Shittu, Raji, & Sanni, 2007; Ziobro, Witczak, Juszczak, & Korus, 2013). However, there is no information on the effect of partial substitution of wheat flour by reduced-fat peanut flour on the quality of the bread loaves. Therefore, this study aimed at developing composite peanut–wheat flour dough with a view to assess the influence of the reduced-fat peanut flour on the physicochemical and textural properties as well as the sensory and microbiological shelf stability of the bread loaves.

2 | MATERIALS AND METHODS

2.1 | Materials

Shelled peanut used for the production of reduced-fat peanut flour, refined granulated sugar and fine edible salt (Dangote refinery, Lagos, Nigeria), white wheat flour (Honeywell flour mills, Lagos, Nigeria), and the baking fat (Pt Intibuca Sejhtera, Jalcarta, Indonesia) were all purchased from Kuto market, Abeokuta, Nigeria.

2.2 | Processing of reduced-fat peanut flour

Reduced-fat peanut flour was prepared by the method described by Franklin (1994) with modifications. Peanut with skin were roasted with sand (ratio 1:4; peanut : sand instead of ceramic beads) until brown. After roasting, peanuts were separated from the sand by sieving. They were then cooled to room temperature, skinned by hand and stored in the refrigerator in zip-lock polythene bags. The roasted peanuts were then grounded into a paste by attrition mill (SK-30-SS, Muson Machinery, NY), using potable water (at about 50 °C) to lubricate the milling process and facilitate subsequent removal of oil. The peanut paste was then tied in a muslin cloth and squeezed between the side plungers of a hydraulic press (IP SRI, Contruzoni Electtromeccaniche, Milano, Italy) and pressure was applied for 1 hr to extract the oil until there was no droplets of oil from the paste. The reduced-fat roasted peanut wet cake was then dried in a hot air tray dryer (NIJI Lucas, Nigeria) at 50 °C for 24 hr to obtain reduced-fat peanut flour. The fat content of the dried flour was then determined using Soxhlet extraction method (Eikani & Golmohammad, 2009).

2.3 | Recipe formulation

Recipe used in previous study (Adeboye, Babajide, Shittu, Omemu, & Oluwatola, 2013) was adopted for dough formulation per loaf; as it produced the bread with the closest physical properties with commercial bread samples among the trial formulations considered for this study. The formulation used for the control bread sample comprises of 300 g white wheat flour, 145 g water, 18 g sugar, 9 g baking fat, 15 g dry bakers' yeast, 0.9 g bread improver, and 4.5 g fine salt. The formulation used for the five treated samples were the same as that of the control except that the composite flour was obtained by mixing 10, 20, 30, 40, and 50 parts of the reduced-fat peanut flour (27.5% fat, db) to 90, 80, 70, 60, and 50 parts of wheat flour on weight per weight (w/w) basis.

2.4 | Bread baking

The procedure described in previous study (Adeboye et al., 2013) was also used to bake the reduced-fat peanut–wheat flour bread loaves. The ingredients (yeast, warm water, and butter) were combined in large liquid measuring cup and stirred until yeast has dissolved and the baking fat has melted. The sugar, composite flour, and salt were dry mixed in a large bowl. The yeast mixture was thoroughly incorporated into the mixture of dry ingredients; dough obtained was then transferred into a lightly floured work surface of the kneading machine (Sanzid, Nigeria) and kneaded for about 15–20 min to form smooth and elastic dough. The dough was then cut into sizes and placed in light greased pan and proofed (at 30 °C and 78–80% RH) for 2 hr, before transferring into the heated oven and baked at 220 °C for 30 min.

3 | ASSESSMENT OF PHYSICAL PROPERTIES OF BAKED LOAVES

3.1 | Loaf weight, volume, and specific volume

After cooling, the weights of the bread samples were determined using digital balance (0.01 g accuracy) (Ignition Manufacturing Pty, Germany). The loaf volume was determined using rapeseed displacement method, Standard 10–05.01 (AACC, 2000). The specific volume of each loaf was then calculated as volume to mass ratio ($cm^3\ g^{-1}$).

3.2 | Crumb moisture, density, and porosity

The moisture content of each bread sample was determined using a moisture analyzer (MAC 210, Radwag Corp., Poland). The density and porosity of the baked loaves were determined as previous described (Shittu et al., 2007). Bread samples were kept in ambient air (25–29 °C, 72–75% RH) for 24 hr to allow slow drying for proper setting of loaf in order to conserve the integrity of crumb porosity during handling. Each bread crumb $4.5 \times 4.5 \times 3.8\ cm^3$ was cut from the central portion of loaves and dried at 50 °C for 12 hr in a hot air oven (Gallemkamp Pty Ltd, City of Manufacturer, England). The moisture content of dried crumb samples used was between 2.5 and 3.5%. The dried crumb slices were then cooled and weighed (W_1) immediately. The crumbs were milled, sieved using a 100 μm mesh size sieve, and the underflow was weighed (W_2). The sample was then poured into a 20 cm^3 measuring cylinder (accuracy = 0.5 cm^3) and tapped 10 times. The volume occupied by the sample was determined (V_2). The data obtained were used to determine the crumb (ρ_c) and solid density (ρ_s) of the samples as follows:

$$\rho_c = \frac{W_1}{W_2}$$

$$\rho_s = \frac{V_1}{W_2}$$

V_2 (volume of rectangular sample) = Length × Breadth × Thickness. The crumb porosity ε_c was calculated as follows:

$$\varepsilon_c = 1 - \rho_c/\rho_s$$

3.3 | Crumb color

The crumb color of the baked reduced-fat peanut–wheat composite bread was determined by measuring the absorbance of the paste (1%, w/vol) of each sample. The pastes were prepared by mixing 50 mg of well ground sample with 5 mL distilled water. The absorbance at 520 nm was determined against a water blank in a UV/VIS Lambda EZ 150 spectrophotometer (Perkinelmer Wallac, USA).

3.4 | Crumb softness (textural analysis)

The crumb hardness/softness of the fresh cooled bread loaves was determine as described in previous study (Shittu et al., 2007). A bench top cone penetrometer with a 35 g probe (Central Ignition Company, UK) was used. Five centimeter (50 mm) thick bread slices were carefully taken to obtain very flat and undistorted surfaces on the slices. The tip of the cone was made to touch the bread surface by adjusting the hanger position. The cone was later released to fall under gravity and penetrate the bread crumb. The extent of penetration (mm) was determined on the radial dial gauge attached to the instrument after 2 s of penetration. Measurement was carried out at three points along a diagonal line within the crumb and the average reported.

3.5 | Microbiological analysis

The total aerobic bacteria and mold counts during storage of the reduced-fat peanut–wheat composite bread samples were determined on Nutrient agar (NA) (Oxoid, Bashingstoke, Hampshire, England) and potatoes dextrose agar (PDA) (Merck, Darmstadt, Germany) (supplemented with 50 mg/L of streptomycin), respectively. Ten grams (10 g) of each of the reduced-fat peanut–wheat composite bread samples were taken at fourth and sixth day of storage and aseptically homogenized with 90 mL sterile 0.1% buffered peptone water (Merck). After serial dilutions of all the bread samples, the appropriate dilution was spread plated and the NA (Oxoid) agar plates were incubated at 37 °C for 24 hr while PDA plates were incubated at 25 °C for 3–5 days.

3.6 | Sensory analysis

Multiple comparison test was applied in the sensory evaluation of the reduced-fat peanut–wheat composite bread. Cooled fresh samples from the experiment were served to 15 man semi-trained panelist. The control sample (0% level of substitution) was marked "*R*" and the test samples (the reduced fat peanut–wheat composite bread slices) were presented in identical containers coded with 3-digit random numbers served simultaneously. The panelist were asked to compare each test sample with the reference sample and tick the expression that best describe their preference using the questionnaire provided. After the evaluation, numerical scores were assigned to the expressions of the panelist with 9 as like extremely than, 5 as equal to "*R*" and 1 as dislike extremely than "*R*." The data obtained were then analyzed for variance and degree of difference (Iwe, 2002). For the overall acceptability test, all samples (including that with 0% level of substitution) were coded differently; panelists were asked to rank the samples according to their degree of likeness.

3.7 | Analyses of data

All experiments were performed three times and the data were analyzed using one-way analysis of variance (ANOVA) to determine whether level of partial substitution of the wheat with reduced-fat peanut flour affected the quality of the reduced-fat peanut–wheat composite bread. Fisher's Least Significant Difference Test (LSD) was used to determine significant differences between the treatments at $p \leq .05$.

4 | RESULTS AND DISCUSSION

4.1 | Loaf weight, volume, and specific volume

The result of size-related parameters of the reduced-fat peanut–wheat bread loaves are shown in Table 1. Loaf weight ranged from 200.13 g in sample with 0% level of reduced-fat peanut substitution to 200.87 g in sample with 50% level of reduced-fat peanut substitution. The loaf volume on the other hand ranged between 9.76 cm^3 in sample with 50% level of reduced-fat peanut substitution to 11.62 cm^3 in sample with 0% level of reduced-fat peanut substitution. The specific volume of the bread loaf decreased gradually from 0.58 in 0% level of reduced-fat peanut substitution to 0.48 in samples with 50% level of reduced-fat peanut substitution. All dough were cut into same weight before

TABLE 1 Loaf weight, loaf volume, and specific volume of reduced fat peanut–wheat composite flour bread loaves

Samples	Loaf weight (g)	Loaf volume (cm^3)	Specific volume
0P: 100W	200.13^a ± 0.60	11.62^e ± 1.50	0.058^e ± 0.00
10P: 90W	200.30^a ± 1.20	11.28^{de} ± 1.10	0.056^{de} ± 0.00
20P: 80W	200.53^c ± 1.00	10.92^{cd} ± 1.30	0.054^{cd} ± 0.00
30P: 70W	200.36^b ± 1.00	10.49^{bc} ± 1.00	0.052^{bc} ± 0.00
40P: 60W	200.63^c ± 1.00	10.33^b ± 1.20	0.051^{ab} ± 0.00
50P: 50W	200.86^d ± 1.20	9.76^a ± 1.00	0.048^a ± 0.00

Values are the means and standard deviations of three replicate experiments (n =3).
Means with different superscript in the same column are significantly different at $p \leq .05$.
0% = Composite bread baked with 0 part peanut:100 parts wheat flour.
10% = Composite bread baked with 10 parts peanut:90 parts wheat flour.
20% = Composite bread baked with 20 partspeanut:80 parts wheat flour.
30% = Composite bread baked with 30 parts peanut:70 parts wheat flour.
40% = Composite bread baked with 40 parts peanut:60 parts wheat flour.
50% = Composite bread baked with 50 parts peanut:50 parts wheat flour.

FIGURE 1 Freshly baked reduced-fat peanut–wheat bread after cooling to room temperature (25 ± 5 °C). A = Composite bread baked with 0 part peanut:100 parts wheat flour. B = Composite bread baked with 10 parts peanut:90 parts wheat flour. C = Composite bread baked with 20 parts peanut:80 parts wheat flour. D = Composite bread baked with 30 parts peanut:70 parts wheat flour. E = Composite bread baked with 40 parts peanut:60 parts wheat flour. F = Composite bread baked with 50 parts peanut:50 parts wheat flour

proofing, higher loaf weight of the sample with 50% level of reduced-fat peanut substitution is not surprising. The significantly ($p \leq .05$) lower loaf volume of the loaves with higher reduced-fat peanut concentration led to the apparent higher weight. Comparative volume of the freshly baked reduced-fat peanut–wheat flour bread after cooling to ambient temperature (25–30 °C) is shown in Figure 1.

Bread samples studied here have been produced from the same formulation, dough size, proofing time, and baking temperature and time; the perceived variation in size related properties studied here can be attributed mainly to the effect of reduced-fat peanut flour on the interaction of the water–starch mix systems and by extension the starch gelatinization and extensibility of the dough. The only factor that could possibly have led to the differences observed in the volume and specific volume of the bread samples is poor gas retention and moisture diffusion abilities of the dough with progressive reduced-fat peanut concentration.

Higher loaf weight is a desirable economic quality at the consumer end, as this suggests more substance for the same price. However, the specific volume which is the ratio of the loaf volume and weight is a reliable measure of loaf size (Shittu et al., 2007).

4.2 | Crumb porosity, crumb density, and moisture content

The crumb moisture, density, and porosity of samples are presented in Table 2. Crumb moisture ranged from 29.18% in sample containing 50% reduced-fat peanut flour to 36.84% in 0% reduced-fat peanut samples. Crumb moisture was significantly ($p \leq .05$) lower in bread loaves with reduced-fat peanut flour compared with the 100% wheat flour bread. According to Babajide, Adeboye, and Shittu (2014), water absorption of a composite flour dough is not exactly simple; the influence of the implicit physicochemical properties of the composite solids together with the other minor components on water uptake during mixing, and its diffusion during proving soon become apparent at baking. Although a reduced-fat peanut flour was used in the composite flour, nonetheless, this is not likely to mix readily with water leading to reduced water absorption capacity of composite dough.

The crumb density significantly ($p \leq .05$) reduced from 1.07 g/cm^3 in the 100% wheat flour bread loaf to 1.00 g/cm^3 in the 40 and 50% reduced-fat peanut flour substituted samples, and then increased slightly in the 30% reduced-fat peanut flour substituted samples. Mathematically, density is expressed as mass per unit volume, the observation above suggest intricate effect of mass transfer during baking of the composite bread. As noted in the earlier study, Babajide et al. (2014), the effect of composite flour interaction with minor components together with water and amylase activity at different substitution level become significantly ($p \leq .05$) apparent in physical properties of product but in an irregular pattern.

The crumb porosity of the samples ranged between 0.60 in the samples with 50% level of reduced-fat peanut substitution and 0.77 in the sample with 10% level of reduced-fat peanut substitution. It is observed that just like the crumb density, there was no direct pattern on the influence of reduced-fat peanut flour on the crumb porosity of the bread loaves. The mechanical properties of cellular solids have been reported to depend on both their structural properties and the

TABLE 2 Crumb porosity, crumb density, and moisture content of peanut–wheat composite bread loaves

Samples	Crumb porosity	Crumb density (g/cm^3)	Crumb moisture content (%)
0P:100W	$0.65^{ab} \pm 0.00$	$1.07^{c} \pm 0.05$	$36.84^{f} \pm 1.00$
10P:90W	$0.77^{ab} \pm 0.01$	$1.01^{ab} \pm 0.00$	$36.77^{e} \pm 1.30$
20P:80W	$0.63^{ab} \pm 0.00$	$1.01^{ab} \pm 0.02$	$33.49^{c} \pm 1.10$
30P:70W	$0.61^{a} \pm 0.00$	$1.03^{b} \pm 0.01$	$33.69^{d} \pm 1.10$
40P:60W	$0.64^{ab} \pm 0.01$	$1.00^{a} \pm 0.01$	$29.78^{b} \pm 1.10$
50P:50W	$0.60^{a} \pm 0.00$	$1.00^{a} \pm 0.06$	$29.18^{a} \pm 1.10$

Values are the means and standard deviations of three replicate experiments ($n = 3$).
Means with different superscript in the same column are significantly different at $p \leq .05$.
0% = Composite bread baked with 0 part peanut:100 parts wheat flour.
10% = Composite bread baked with 10 parts peanut:90 parts wheat flour.
20% = Composite bread baked with 20 partspeanut:80 parts wheat flour.
30% = Composite bread baked with 30 parts peanut:70 parts wheat flour.
40% = Composite bread baked with 40 parts peanut:60 parts wheat flour.
50% = Composite bread baked with 50 parts peanut:50 parts wheat flour.

TABLE 3 Pasting characteristics of reduced fat peanut–wheat composite bread loaves

Sample	Peak (RVU)	Trough (RVU)	Breakdown (RVU)	Final viscosity (RVU)	Setback (RVU)	Peak time (min)	Pasting temp (°C)
0P:100W	$22.34^{d} \pm 1.36$	$17.58^{d} \pm 1.25$	$4.75^{b} \pm 0.51$	$21.42^{d} \pm 0.13$	$2.96^{b} \pm 2.79$	$5.27^{b} \pm 0.13$	$79.55^{a} \pm 0.05$
10P:90W	$22.29^{d} \pm 0.49$	$17.33^{d} \pm 0.25$	$4.96^{b} \pm 0.03$	$22.84^{e} \pm 0.13$	$5.50^{c} \pm 0.13$	$5.84^{c} \pm 0.13$	$85.18^{b} \pm 0.11$
20P:80W	$21.14^{d} \pm 0.11$	$15.92^{cd} \pm 0.16$	$5.23^{c} \pm 0.27$	$21.95^{d} \pm 1.18$	$5.93^{cd} \pm 0.23$	$5.35^{b} \pm 0.04$	$85.88^{b} \pm 0.23$
30P:70W	$12.43^{a} \pm 0.42$	$7.13^{a} \pm 0.05$	$5.28^{c} \pm 0.00$	$13.26^{a} \pm 0.21$	$6.04^{d} \pm 0.17$	$5.14^{a} \pm 0.01$	$85.33^{b} \pm 0.12$
40P:60W	$18.55^{c} \pm 0.14$	$15.08^{c} \pm 0.25$	$3.48^{a} \pm 0.19$	$18.24^{b} \pm 0.03$	$3.16^{a} \pm 0.05$	$6.73^{d} \pm 0.13$	$85.88^{b} \pm 0.11$
50P:50W	$15.43^{b} \pm 0.06$	$9.34^{b} \pm 0.6$	$6.09^{d} \pm 0.35$	$15.00^{c} \pm 0.11$	$5.66^{cd} \pm 1.23$	$5.38^{b} \pm 0.12$	$87.63^{c} \pm 0.01$

Values are the means and standard deviations of three replicate experiments ($n = 3$).
Means with different superscript in the same column are significantly different at $p \leq .05$.
0P:100W = Composite bread baked with 0 part peanut:100 parts wheat flour.
10P:90W = Composite bread baked with 10 parts peanut:90 parts wheat flour.
20P:80W = Composite bread baked with 20 parts peanut:80 parts wheat flour.
30P:70W = Composite bread baked with 30 parts peanut:70 parts wheat flour.
40P:60W = Composite bread baked with 40 parts peanut:60 parts wheat flour.
50P:50W = Composite bread baked with 50 parts peanut:50 parts wheat flour.

physical properties of the solid materials (Keetels, van Vliet, & Walstra, 1996). Gas (CO_2) retention and moisture diffusivity greatly determine porosity of bread samples (Zghal, Scanlon, & Sapirstein, 2002). The observed variation in moisture content, density and porosity of samples could be attributed mainly to varied gas retention and moisture diffusion abilities of the different dough formulations in this study. It is noteworthy, however, that the observed variation in the crumb porosity of the samples was not significant ($p \leq .05$).

4.3 | Rheological indices of crumb

Data on pasting properties of the bread crumb is presented in Table 3. Pasting viscosity parameters (peak, breakdown, and final viscosity) of the dried bread crumb generally decreased with increasing inclusion of reduced-fat peanut flour in the bread formulation. This may be due to reduced ability of reduced-fat peanut flour granules to swell before physical breakdown. Lower peak viscosity directly indicates poor swelling capacity, which can be attributed to the fat content of the reduced-fat peanut flour hindering diffusion of water into the starch matrix during heating. Plasticization of starch-protein structure lowered final viscosity in similar composite bread formulation study (Shittu et al., 2007). Higher breakdown viscosity generally accompanies a high peak viscosity due to a greater loss of granule integrity of the constituent starch. It is observed that the samples with lower peak viscosity seem to be having higher breakdown viscosity; these are mostly samples with higher level of reduced-fat peanut substitution. Although, a low breakdown is expected to accompany a low peak viscosity, the contrast observed from the table is of interest. According to Savita, Bajwa, and Nagi (1999), amylographic viscosity maximum depends on concentration of starch in the flour. Considering the reduced concentration of starch in the loaves with higher concentration of reduced-fat peanut flour, the explanation for the observation is not farfetched. Furthermore, the observation may suggest that cohesive force between starch granules and other constituents in the formulations with high percentage of reduced-fat peanut paste is not as high as those with lesser amount. This may have led to the collapse of the mixture leading to progressive fall in the holding strength of the paste not necessarily as a result of starch granule collapse. The rheological implication of this on the bread loaves with higher reduced-fat peanut flour concentration is that the loaves will be more brittle rather than elastic, and this is common to nongluten bread loaves (Mohammed, Ahmed, & Senge, 2012; Savita et al., 1999).

The softness index measured as the distance travelled into the bread slice by the penetrometer probe decreases with increasing reduced-fat peanut flour substitution level (Table 4). As observed earlier, varied density and porosity of samples in this study could be attributed mainly to varied gas retention and moisture diffusion abilities of the different dough formulations. Crumb structure plays a critical role in the textural properties of bread crumb (Scanlon, Sapirstein, & Fahloul, 2000) especially softness index. The unique position of wheat

TABLE 4 Solid density and texture of reduced fat peanut–wheat composite bread loaves

Samples	Solid density (g/cm^3)	Softness (mm)
0P:100W	$3.14^{e} \pm 0.10$	$1.48^{a} \pm 1.01$
10P:90W	$3.07^{d} \pm 0.11$	$1.45^{a} \pm 0.14$
20P:80W	$2.79^{c} \pm 0.12$	$1.17^{a} \pm 0.01$
30P:70W	$2.70^{b} \pm 0.16$	$1.10^{a} \pm 0.00$
40P:60W	$2.66^{b} \pm 0.04$	$0.95^{a} \pm 0.00$
50P:50W	$2.50^{a} \pm 0.37$	$0.90^{a} \pm 0.00$

Values are the means and standard deviations of three replicate experiments ($n = 3$).
Means with different superscript in the same column are significantly different at $p \leq .05$.
0% = Composite bread baked with 0 part peanut:100 parts wheat flour.
10% = Composite bread baked with 10 parts peanut:90 parts wheat flour.
20% = Composite bread baked with 20 partspeanut:80 parts wheat flour.
30% = Composite bread baked with 30 parts peanut:70 parts wheat flour.
40% = Composite bread baked with 40 parts peanut:60 parts wheat flour.
50% = Composite bread baked with 50 parts peanut:50 parts wheat flour.

TABLE 5 Crumb color of reduced fat peanut–wheat composite bread loaves

Samples	Color @ 520 nm
0P:100W	$0.53^{a} \pm 0.12$
10P:90W	$0.65^{a} \pm 0.01$
20P:80W	$0.69^{b} \pm 0.00$
30P:70W	$0.70^{bc} \pm 0.01$
40P:60W	$0.73^{c} \pm 0.00$
50P:50W	$0.75^{c} \pm 0.01$

Values are the means and standard deviations of three replicate experiments ($n = 3$).
Means with different superscript in the same column are significantly different at $p \leq .05$.
0P:100W = Composite bread baked with 0 part peanut:100 parts wheat flour.
10P:90W = Composite bread baked with 10 parts peanut:90 parts wheat flour.
20P:80W = Composite bread baked with 20 parts peanut:80 parts wheat flour.
30P:70W = Composite bread baked with 30 parts peanut:70 parts wheat flour.
40P:60W = Composite bread baked with 40 parts peanut:60 parts wheat flour.
50P:50W = Composite bread baked with 50 parts peanut:50 parts wheat flour.

flour compared with flours from other cereals, in bread making is attributed to the ability of wheat flour dough to retain gas on expansion. The decreasing softness of the crumb as the substitution level with reduced-fat peanut flour increases again typifies the uniqueness of wheat flour in extensibility and gas retention ability.

4.4 | Color of bread crumb

The crumb color of the reduced-fat peanut–wheat composite bread loaves is presented in Table 5. The absorbance of the paste prepared from each of the crumbs measured at 520 nm (Table 5) indicates that the bread loaves became progressively darker as the level of substitution with reduced-fat peanut flour increased. Maillard reaction and caramelization are the major phenomena contributing to color development during baking of bread. The reduced-fat peanut flour used was very chocolaty in color; the objective of color measurement in this study was to examine the influence of reduced-fat peanut paste on the browning of the bread crumb, over and/or above the effect of Maillard and caramelization reactions. Color is an important physical and sensory property of concern to consumers. Darker crust/crumb color generally discourages acceptability of bread, because it often suggests the bread is "burnt." Peanut–wheat flour composite bread formulations will therefore require considerable attention in this regard.

4.5 | Proximate composition of bread loaves

The proximate composition (protein, fat, crude fiber, ash, and total carbohydrate) of the bread loaves varied significantly ($p \leq .05$). It is evident from Table 6 that protein and fat content of the bread increased with increasing concentration of the reduced-fat peanut flour while the total carbohydrate and ash content decreased with increasing concentration of the reduced-fat peanut flour. The crude of the composite bread loves ranged from 2.88 to 5.31% with samples baked with 50% level of reduced-fat peanut substitution having the highest value. The fat content of the reduced-fat peanut flour used in this study was reduced to 25%. Atasie, Akinhanmi, and Ojiodu (2009) reported the proximate composition of reduced-fat peanut flour as fat: 47%, crude protein: 38.6%, crude fiber: 3.7%, ash: 3.8%, and total carbohydrate: 1.8%. This explains the influence of the reduced-fat peanut flour on the proximate composition of the bread loaves in this study. Generally, peanut flour inclusion in bread formulations increased the protein content of the loaves. This is not expected to compromise calorie nonetheless, because the short fall in the carbohydrate content can be complimented by the lipid calorie supply. The increasing crude fiber with increasing addition of reduced-fat peanut flour could also be viewed as a nutritional advantage considering the effect of fiber in digestion of food.

TABLE 6 Proximate composition of reduced fat peanut–wheat composite bread loaves

Samples	Moisture (%)	Protein (%, db)	Fat (%, db)	Crude (%, db)	Ash (%, db)	CHO (% db)
0P:100W	$10.78^{a} \pm 0.25$	$10.32^{a} \pm 0.02$	$3.43^{a} \pm 0.41$	$2.88^{a} \pm 0.22$	$5.52^{a} \pm 0.05$	$77.88^{e} \pm 1.25$
10P:90W	$10.87^{a} \pm 0.05$	$11.55^{b} \pm 0.22$	$3.71^{a} \pm 0.13$	$3.84^{b} \pm 0.13$	$5.49^{a} \pm 0.25$	$64.54^{d} \pm 0.25$
20P:80W	$11.16^{a} \pm 0.35$	$13.62^{c} \pm 0.11$	$6.03^{b} \pm 0.52$	$3.90^{b} \pm 0.00$	$5.70^{a} \pm 0.00$	$59.59^{d} \pm 1.15$
30P:70W	$11.40^{ab} \pm 0.05$	$14.46^{d} \pm 0.03$	$9.67^{c} \pm 0.50$	$4.34^{c} \pm 0.05$	$6.42^{b} \pm 0.15$	$53.71^{c} \pm 0.05$
40P:60W	$12.17^{b} \pm 0.00$	$14.92^{de} \pm 0.05$	$14.64^{d} \pm 0.15$	$4.45^{c} \pm 0.25$	$6.83^{c} \pm 0.31$	$46.99^{b} \pm 0.03$
50P:50W	$12.17^{b} \pm 0.21$	$15.47^{e} \pm 0.12$	$17.03^{e} \pm 0.06$	$5.31^{d} \pm 0.00$	$6.45^{b} \pm 0.11$	$43.57^{b} \pm 0.45$

Values are the means and standard deviations of three replicate experiments ($n = 3$).
Means with different superscript in the same column are significantly different at $p \leq .05$.
0P:100W = Composite bread baked with 0 part peanut:100 parts wheat flour.
10P:90W = Composite bread baked with 10 parts peanut:90 parts wheat flour.
20P:80W = Composite bread baked with 20 parts peanut:80 parts wheat flour.
30P:70W = Composite bread baked with 30 parts peanut:70 parts wheat flour.
40P:60W = Composite bread baked with 40 parts peanut:60 parts wheat flour.
50P:50W = Composite bread baked with 50 parts peanut:50 parts wheat flour.

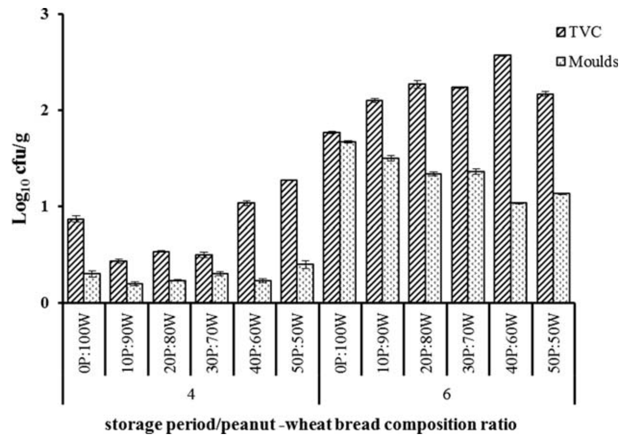

FIGURE 2 The total viable and mold counts of peanut–wheat composite bread during 6 day storage at room temperature (25 ± 5 °C). Values are the means and error bars represents standard deviations of three replicate experiments ($n = 3$). TVC – Total Viable Counts. 0P:100W = Composite bread baked with 0 part peanut:100 parts wheat flour. 10P:90W = Composite bread baked with 10 parts peanut:90 parts wheat flour. 20P:80W = Composite bread baked with 20 parts peanut:80 parts wheat flour. 30P:70W = Composite bread baked with 30 parts peanut:70 parts wheat flour. 40P:60W = Composite bread baked with 40 parts peanut:60 parts wheat flour. 50P:50W = Composite bread baked with 50 parts peanut:50 parts wheat flour

4.6 | Microbial shelf stability

The total viable counts and mold population of reduced-fat peanut–wheat composite bread during 6 days storage is presented in Figure 2. Microbiological analysis of total viable count revealed that all the bread samples were free of microorganisms for up to 3 days after production. However, bacterial growth was observed on the fourth day of storage and these might be the microorganisms which survived the baking process and were able to grow under favorable conditions during storage. Furthermore, the gradual increase in the TVC from day 4 to day 6 of storage is consistent with our previous study on cassava-wheat bread substituted with honey (Adeboye et al., 2013). The first mold growth was observed on day four of storage which could be due to the presence of reduced-fat peanut in the composite bread loaf which delayed the microbial growth. It has been predicted that the use of reduced-fat peanuts could increase the shelf life and improve the microbial stability of reduced-fat peanut products due to the high level of oleic acid (Isleib, Pattee, Sanders, Hendrix, & Dean, 2006). However, microbial growth increased gradually from day 4 to day 6 of storage with lower mold growth in the bread loaves with 40 and 50% reduced-fat peanut substitution compared with samples with 10, 20, and 30% reduced-fat peanut substitution. This indicates that mold reduction seems to be associated with increased level of reduced-fat peanut flour substitution in the composite bread loaf. It can, therefore, be proposed at this stage of the study that high level of reduced-fat peanut flour substitution in reduced-fat peanut–wheat composite bread could have possible commercial application in improving microbial shelf stability of bread loaf.

4.7 | Sensory properties of reduced-fat peanut–wheat bread

The mean preference scores for the sensory evaluation of the reduced-fat peanut–wheat composite bread are presented in Table 7 (with addendum chat in Supporting Information). In terms of texture, bread prepared from 10% level of reduced-fat peanut flour had the highest score of 3.60, while the composite bread with 20% reduced-fat peanut flour substitution had the least score of 2.27. The bread prepared from 10% reduced-fat peanut flour level is most preferred in terms of texture. This may be attributed to the low concentration of peanut flour in the dough.

In terms of taste, the bread prepared with 50% reduced-fat peanut flour had the highest score of 6.53 while the loaf prepared with 10% reduced-fat peanut flour had the least score of 3.47. This suggests that consumers relish the intricate taste of reduced-fat peanut–wheat flour bread. This further underscores the relevance of the objective of this study to create a convenient form of having this intricate taste in such

TABLE 7 Mean sensory score of reduced fat peanut–wheat composite bread loaves

Sample	Texture	Taste	Aroma	Color	Overall acceptability
0P:100W	$3.66^{b} \pm 0.04$	$3.52^{a} \pm 0.01$	$3.34^{a} \pm 0.11$	$3.90^{a} \pm 0.32$	$1.80^{a} \pm 0.20$
10P:90W	$3.60^{b} \pm 0.01$	$3.47^{a} \pm 0.01$	$3.33^{a} \pm 0.01$	$3.80^{a} \pm 0.21$	$1.60^{a} \pm 0.00$
20P:80W	$2.27^{a} \pm 0.00$	$3.60^{bc} \pm 0.01$	$4.87^{b} \pm 0.21$	$5.57^{a} \pm 0.11$	$2.40^{b} \pm 0.04$
30P:70W	$2.60^{ab} \pm 0.10$	$4.53^{ab} \pm 0.21$	$5.27^{b} \pm 0.01$	$4.20^{ab} \pm 0.01$	$2.80^{b} \pm 0.01$
40P:60W	$3.00^{ab} \pm 0.21$	$5.00^{abc} \pm 0.01$	$5.53^{b} \pm 0.41$	$4.87^{ab} \pm 0.12$	$4.07^{c} \pm 0.03$
50P:50W	$2.40^{a} \pm 0.03$	$6.53^{c} \pm 0.01$	$5.40^{b} \pm 0.01$	$5.40^{b} \pm 0.01$	$4.13^{c} \pm 0.23$

Values are the means and standard deviations of panelist score ($n = 15$).
Means with different superscript in the same column are significantly different at $p \leq .05$.
0P:100W = Composite bread baked with 0 part peanut:100 parts wheat flour.
10P:90W = Composite bread baked with 10 parts peanut:90 parts wheat flour.
20P:80W = Composite bread baked with 20 parts peanut:80 parts wheat flour.
30P:70W = Composite bread baked with 30 parts peanut:70 parts wheat flour.
40P:60W = Composite bread baked with 40 parts peanut:60 parts wheat flour.
50P:50W = Composite bread baked with 50 parts peanut:50 parts wheat flour.

a composite formulation. Equal amount of reduced-fat peanut flour and wheat flour appear to be an optimum formulation in this regard.

There was no significant ($p \leq .05$) difference in the aroma of the composite loaf at 10% level of substitution with reduced-fat peanut flour. However, above this level, the reduced-fat peanut aroma perhaps became more intense and noticeably different from that of the 100% wheat flour.

The panelists mean sensory scores for color suggests there was no significant ($p \leq .05$) difference in the composite samples up to 40% level of substitution with reduced-fat peanut flour. These subjective scores may appear a contrast to the objective data of the spectrophotometric determination of color intensity (Table 5). Two facts are worthy of note here, one is that the panelists may not be able to pick the differences in the color of the crumb slice served; the other is that irrespective of apparent difference in crumb color intensity, the consumer seems to like them equally as the 100% wheat loaf.

It is intriguing that the bread prepared with 10% reduced-fat peanut flour substitution was most acceptable in terms of overall acceptability with the lowest score of 1.60. Texture is one of the most significant quality parameter of bread that determines consumer acceptability. The closeness of the texture, taste and aroma of this sample to those of the 100% wheat flour loaf may have influenced consumer choice in this regard.

5 | CONCLUSIONS AND RECOMMENDATION

The effects of substitution of wheat flour with reduced-fat peanut flour on the physical properties of bread do not have a uniform trend. Laboratory and technical information suggest that higher level of reduced-fat peanut flour inclusion compromises crumb density, color, texture, and porosity. Consumer perception nevertheless agrees that it is quite possible to produce acceptable bread from reduced-fat peanut–wheat composite flour that would compare favorably well with 100% whole wheat formulation. Bread produced with high level of reduced-fat peanut flour inclusions is more shelf stable than other bread produced from lower level of substitution. Research focus on the farignograph study, viscoelastic properties of the reduced-fat peanut–wheat composite dough and the role of rancidity on the physical, sensory, and microbial test results obtained in this study will be far reaching in complimenting the report presented.

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SUPPORTING INFORMATION

Additional Supporting Information may be found online in the Supporting Information tab for this article.

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