Dough rheology and physicochemical and sensory properties of wheat–peanut composite flour bread

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Abstract
The effect of inclusion of peanut flour from 0% to 20% on dough rheology and physicochemical and sensory properties of wheat–peanut composite flour bread was studied. Farinograph water absorption, dough development time (DDT), and stability increased from 57.7% to 60.1%, from 2.5 min to 6 min, and from 5.5 min to 8.5 min, respectively, for white bread flour dough with increase in peanut flour proportion from 0% to 20%. Similarly, an increase from 62.7% to 64.9%, from 6 min to 7 min, and from 8.5 to 13 min was observed for farinograph water absorption, dough development time (DDT), and stability, respectively, for brown bread dough. The alveograph dough properties including dough strength, pressure (tenacity), extensibility, and extensibility ratio also increased from 31.0 KJ to 37.4 KJ, from 75.1 mmH2O to 91.3 mmH2O, from 68.3 mm to 83 mm, and from 0.78 to 1.11, respectively. Increase in peanut flour proportion significantly (p < 0.05) increased the loaf weight but decreased loaf volume and specific volume. Moreover, increase in peanut flour proportion resulted in an increase in protein and fat content whereas the moisture content decreased. Bread from all the formulations were found to be acceptable by the consumer panel with an overall hedonic acceptability rate of “like” without much significant difference. The results of the study revealed that it is possible to incorporate peanut flour up to 20% for acceptable bread. Further study on the optimization of the blend proportions and on the possibility of blending peanut with other cereals for bread would reveal more insight to diversify the utilization of peanuts.

KEYWORDS
bread, peanut, rheology, sensory

1 | INTRODUCTION

Bread is one of the most widely consumed food items, and its enrichment would provide an opportunity to enhance the nutrition of the wider consumer. Several studies have been conducted to supplement wheat flour in order to develop nutrient-rich baked products in general and bread in particular by using composite flour (Hasmadi et al., 2020; Noorfarahzilah et al., 2014; Nwankezi, 2013). Often the bakery products produced using composite flours are of good quality though with some relatively inferior attributes particularly texture and specific volume (Dhull et al., 2019; Dhull & Sandhu, 2018). Wheat is the main ingredient in baked products due to the gluten which
predominantly determines the bread structure and texture. However, wheat is deficient in essential amino acids like lysine and threonine (Dhingra & Jood, 2001). Peanuts, however, contain all the amino acids and are nutritionally equivalent to meat and egg for human growth and health (Arya et al., 2016).

The legume *Arachis hypogaea*, commonly known as peanut or groundnut, is very important food crop of tropical and subtropical areas. Peanut is one of the most widely used legumes due to its nutrition and taste. It is a major food crop with its world annual production of about 30 million tons (Akhtar et al., 2014). Peanuts are not only used as a source of edible oil but are also consumed directly or incorporated into different foods such as snacks and confectionary products for nutrition enhancement. It is valued as an important food protein source in the developing and developed countries. Peanut seeds have an important contribution towards human diet being rich in protein (20–28%), lipids (47–50%), and fatty acids (Arya et al., 2016; Davis et al., 2007; Gómez et al., 2008; Venkatachalam & Sathe, 2006; Win et al., 2011) and are potential sources of functional bio-actives and antioxidant components (Arya et al., 2016; Win et al., 2011). The addition of nuts could improve the nutritional quality of bread and bakery products since nuts are rich in proteins, alimentary fiber, fats (unsaturated fats principally), minerals, and vitamins, especially E, A, B₁, and B₂ (Arya et al., 2016; Venkatachalam & Sathe, 2006). Research shows that peanuts and peanut products have tremendous health benefits. The oil is easily digestible, and peanut consumption has been associated with the prevention of cardiovascular diseases (Alper & Mattes, 2003; Arya et al., 2016) and a reduced risk of developing type II diabetes (Arya et al., 2016; Jiang et al., 2002; Win et al., 2011). The health benefits of consuming different peanut products have been reviewed (Akhtar et al., 2014; Arya et al., 2016).

Peanut flour has been blended with wheat flour to make baked products. Inclusion of up to 15% de-oiled peanut flour has been reported to result in acceptable bread (Yadav et al., 2013). Consumers preferred the taste, aroma, and color of wheat–peanut flour composite flour loaves at 20% peanut flour inclusion (Adeboye et al., 2018). Freshly baked wheat–peanut composite flour bread loaves with 10% level of peanut substitution had higher overall acceptability than 100% wheat flour formulation (Adeboye et al., 2018). Use of hazelnut, walnut, almond, and peanut paste on dough rheology and bread volume has been studied, and the results indicated the possibility of blending peanut with wheat to make baked products (Gómez et al., 2008). Peanut flour has been used to make other products including protein bars, confections, cakes, cookies, snacks, crackers, peanut flour dispersions, pasta, and other baked goods (Adeboye et al., 2018; Akhtar et al., 2014; Badwaik et al., 2014; Chinma et al., 2016; Davis et al., 2007; Kahlon et al., 2021; Yadav et al., 2012, 2013). A dry peanut powder obtained after partial extraction of oil from the roasted peanut kernel is commercially used as an additive to increase the protein content of various food commodities including baked goods, sauces, and dressing (Win et al., 2011).

Despite its contribution to enhance the diet of consumers and its health benefit, there is limited information on the application particularly of whole peanut flour for making baked products. Moreover, information on the dough rheology, physicochemical properties, and sensory attributes of wheat–whole peanut composite flour bread is scanty. Therefore, the objectives of this work were to study the effect of inclusion of peanut flour on dough rheology and physicochemical and the sensory properties of wheat–peanut composite flour bread.

## MATERIAL AND METHOD

### 2.1 Raw material preparation and formulations

The white and brown bread flour was sourced from a commercial mill (Premier Eswatini mill). The peanuts were sourced from local super market and cleaned, and all defective nuts were removed. The nuts were dehulled to remove the skin and then milled in to flour using a heavy duty blender (KM - 1500 MRC, Laboratories, Holon, Israel). The peanuts were not defatted and also not roasted. Three levels of inclusion of peanut flour (10%, 15%, and 20%) to wheat flour and control (100% wheat) were used in the study. The levels of inclusion of peanut flour were based on information in literature (Adeboye et al., 2018; Yadav et al., 2012; Yadav et al., 2013).

### 2.2 Dough rheology

#### 2.2.1 Farinograph

The farinograph characteristics including dough development time, stability, and water absorption were measured using Farinograph (Farinograph AT, Villeneuve, France) according to standard AACC method 54-21 constant dough method (AACC, 2000). At 14% base moisture content, an estimated amount of flour was weighed and placed in the 300 g farinograph mixing bowl. Distilled water from a burette was added to the flour and mixed to form dough. As the dough was mixed, the farinograph consistency (BU) against time (min) was recorded for 30 min.

#### 2.2.2 Alveograph

The alveograph properties including dough strength, pressure (tenacity), extensibility, and extensibility ratio were measured using alveograph (Chopin Technologies, Villeneuve, France) according to standard AACC method 54-30 (AACC, 2000). About 250 g of flour was mixed with dilute sodium chloride solution (50 g salt dissolved in 200 L of distilled water) at an amount as indicated by 14% moisture content base of the flour for 8 min. The dough was extruded to form circular thin sheets and was rested for 5 min. The dough sheet was then blown (inflated) until it burst.
2.3 | Bread baking

The straight dough method was used to produce the bread samples. This method involves the addition of all the ingredients (wheat and peanut flour, salt, water, sugar, yeast, and fats) and mixing and kneading to obtain the dough. The formulation was made of 400 g flour or composite flour, 5 g salt, 25 g sugar, 10 g yeast, and 25 g fat. The different dough samples were placed in baking tins and covered for the dough to ferment resulting in gas production and gluten development for about 45 min. The dough was then kneaded again and then baked in the oven at 180°C for 30 min (Chauhan et al., 1992).

2.4 | Physical properties of bread

The physical properties of bread were evaluated by measuring the loaf weight, loaf volume, specific loaf volume, and loaf density. The loaf volume was measured by rapsseed displacement method (AACC, 2000) whereas the specific volume of the bread was determined as the ratio between the volume of loaf to the bread weight (Yadav et al., 2013). Loaf weight was measured using electronic weighing balances (E.I.M series N17250, Milton Keynes, UK).

2.5 | Determination of proximate composition of composite flour and bread

The proximate composition of the composite flours bread was analyzed in terms of moisture, protein, and fat content. Moisture was determined according to AACC (2000). Total proteins were determined using standard approved methods (AACC, 2000). Fat content was estimated using the Soxhlet method.

2.6 | Sensory evaluation

The consumer acceptance test was carried out to investigate overall acceptance of wheat–peanut composite flour bread. Forty-eight untrained consumers with age range of 19 to 35 evaluated the product in terms of color, taste crumb firmness, crust texture, and overall acceptability. The test was conducted in sensory booth where there is soft white lighting. The test employed a 7-point hedonic scale that determines degree of liking a food product. The hedonic scale assumes that consumer preference exists on a continuum and that preference can be categorized by responses based on likes and dislikes (Lawless & Heymann, 2010). Samples were assigned with randomized codes and were served to panelists in random order.

2.7 | Statistical analysis

The treatment means were compared by ANOVA using IBM SPSS version 20, and least significant difference (LSD) was used to compare the means at p value of less than 0.05. The experiments were replicated three times.

3 | RESULTS AND DISCUSSION

3.1 | Rheological properties from the Farinograph

3.1.1 | Water absorption

Water absorption (%) for different samples is presented in Table 1. The results indicated that the water absorption increased from 57.7% to 60.1% and from 62.7% to 64.9% for white and brown bread dough, respectively, with increase in peanut proportion from 0% to 20%. The result also indicated that the brown bread dough has higher water absorption compared with white bread dough, which could be attributed to higher fiber content in the brown bread flour (Anil, 2007; Ammar et al., 2016; Gómez et al., 2003; Wang et al., 2002). The fiber content in the brown bread flour has a pronounced effect compared with the fiber in peanut (Table 1). For example, brown bread dough without peanut (100% wheat) has higher water absorption than white bread dough with 20% peanut flour indicating the influence fiber in the brown bread flour. The increase in water absorption with increase in peanut proportion could be attributed to the increase in protein content, which has high water binding capacity (Ammar et al., 2016; Rehman et al., 2007; Ribotta et al., 2005). Moreover, the high fiber content in peanut might have contributed to the increase in the water absorption (Anil, 2007; Arya et al., 2016). Inclusion of protein-rich ingredients in wheat flour has been reported to increase water absorption. Increase in water absorption from 65 to 69% with increase in proportion of soy from 0% to 7% in wheat-soy blend dough (Mashayekh et al., 2008) and increase from 58.8% to 62.5% with increase in chick-pea incorporation from 0% to 30% (Mohammed et al., 2012) has been observed.

3.1.2 | Dough development time (DDT)

The dough development time (DDT) increased with increase in the level of peanut content (Table 1). DDT increased from 2.5 min to 6 min and from 6 to 7 min for white and brown bread dough, respectively, with increase in peanut proportion from 0% to 20%. DDT is the time required for the dough to reach maximum consistency and is an indicator of flour strength. The brown bread dough exhibited higher DDT compared with white bread dough, which could be attributed to the relatively higher fiber content in the brown bread flour (Anil, 2007; Gómez et al., 2003). Increase in DDT from 124 s to 211.5 s with increase in the proportion of peanut from 0% to 15% has been observed (Gómez et al., 2008). Similar trend was noted as a result of inclusion of hazelnut testa in wheat flour due to high fiber in the testa (Anil, 2007). Increase in DDT with increase in chickpea flour content in wheat–chickpea dough
has been attributed to the difference in the physicochemical properties between the constituents of the chickpea and the wheat flours (Mohammed et al., 2012).

### 3.1.3 Stability

The stability time for the different dough formulations of white and brown bread dough is presented in Table 1. Stability is the duration at which the dough consistency is greater than or equal to 500 BU. The stability time increased from 5.5 to 8.5 min and from 8.5 min to 13 min for white and brown bread dough, respectively, with increase in peanut proportion from 0% to 20%. Brown bread dough exhibited higher stability time compared with the white bread dough, which could be attributed to the higher fiber content in the brown bread flour (Gómez et al., 2003; Gómez et al., 2008). The fiber content in the brown bread flour has a more pronounced influence compared with the fiber in the peanut where the stability of 100% brown bread flour has same value of stability as white bread flour dough replaced with 20% peanut. Stability values are indicators of the flour strength where high values suggest stronger dough. An initial increase in stability up to 5% inclusion of peanut followed by a decrease was observed (Gómez et al., 2008). Peanut is a good source of fiber, and fiber increases stability time (Anil, 2007; Arya et al., 2016). Replacement of wheat with 10% chickpea has been reported to increase the stability. However, further increment in replacement to 20% and 30% decreased the stability (Mohammed et al., 2012). The results in this study are opposite to the findings by earlier study that reported a decrease in stability due to increase in the replacement level of wheat by defatted soy flour (Mashayekh et al., 2008).

| Type of bread | Rheological properties | Treatments |
|---------------|------------------------|------------|
|               |                        | 100% wheat | 10% peanut | 15% peanut | 20% peanut |
| White bread   | Water absorption (%)   | 57.7       | 58.5       | 59.3       | 60.1       |
|               | Development time (min) | 2.5        | 3.0        | 4.5        | 6.0        |
|               | Stability (min)        | 5.5        | 6.5        | 7.0        | 8.5        |
| Brown bread   | Water absorption (%)   | 62.7       | 62.9       | 63.1       | 64.9       |
|               | Development time (min) | 6          | 6.5        | 6.3        | 7.0        |
|               | Stability (min)        | 8.5        | 9.5        | 10.0       | 13.0       |

### 3.2 Rheological properties from the alveograph

#### 3.2.1 Dough strength (KJ)

The dough strength of white bread dough the different dough formulations is presented in Table 2. The result indicated that dough strength increased from 31.0 KJ to 37.4 KJ with increase in peanut flour proportion from 0% to 20%. Dough strength is an indicator of deformation energy (Gómez et al., 2008). Thus, higher proportion of peanut increased the energy required to deform the dough. The findings of this study are in agreement with earlier report where increase in nut inclusion brought about increase in dough strength for nut paste-enriched wheat dough (Gómez et al., 2008) and the increment was attributed to the fiber in the nut paste. Inclusion of fiber in general increases dough strength, and the fiber in the peanut might have contributed to the dough strength (Gómez et al., 2003). Addition of lipids and partially hydrogenated shortening in wheat flour decreased dough strength (Agyare et al., 2005).

#### 3.2.2 Pressure (tenacity)

The pressure (dough tenacity) white bread dough, which is the dough resistance to deformation, increased from 75.1 mm H₂O to 91.3 mm H₂O with increase in the proportion of peanut flour from 0% to 20% (Table 2). Dough tenacity gives information about the dough handling characteristics. Larger quantities of fat, due to addition of peanut flour, increase tenacity since fat is uniformly distributed through the dough and reduce gluten network formation (Agyare et al., 2005; Gómez et al., 2008). Increment in dough tenacity from
68 mmH₂O to 99.46 mmH₂O was reported as a result of increase in nut paste (almond, hazelnut, peanut, and walnut) from 0% to 15% where the increment was attributed to increase in fiber content (Gómez et al., 2008). Increase in dough tenacity in this study could also be due to increase in the fiber content from the peanut flour (Arya et al., 2016; Gómez et al., 2003; Wang et al., 2002).

### 3.2.3 Extensibility

The extensibility for white bread dough increased from 68.3 mm to 83 mm with increase in the proportion of peanut from 0% to 20% (Table 2). Extensibility refers to the ability of the dough to be stretched, extended, or elongated when forces, stress, and pressures are applied to it. The increase in the extensibility could be attributed to the combination of non-gluten protein and fat specially at high fat content (Gómez et al., 2008; Ribotta et al., 2005). Peanut flours when blended with wheat flour exhibited greater extensibility compared with walnuts, hazelnut, and almonds (Gómez et al., 2008). Dough with great extensibility is easy to elongate and not easy to break (Luo et al., 2018). The increase in extensibility could also be associated with increase in water absorption due to increase peanut flour level (Luo et al., 2018). In other studies, opposite trends were noted where replacement of wheat with oil seed flours like fenugreek and flax seed resulted in decrease in extensibility (Indrani et al., 2010; Koca & Anil, 2007). Extensograph extensibility also increased with increase in substitution level of soy in wheat–soy blend dough (Mashayekh et al., 2008). Dough extensibility, however, was observed to decrease with replacement of wheat with protein isolates (Paraskevopoulou et al., 2010).

### 3.2.4 Extensibility ratio

The extensibility ratio of white bread dough increased from 0.78 to 1.11 with increase in the proportion peanut flour from 0% to 20% (Table 2). An increase in the extensibility ratio from 0.5 to 0.74 with increase in level of replacement of wheat flour by nut paste from 0% to 20% was observed in earlier study (Gómez et al., 2008). Increase in extensibility ratio with increase in fiber content was observed, which was attributed to the interaction between dietary fiber and protein (Gómez et al., 2008). The extensibility ratio is indicative of the balance between the resistance to extensibility and extensibility. Greater extensibility is indicated by lower extensibility ratio or high extensibility value (Agyare et al., 2005; Gómez et al., 2008). The fiber in the peanut might have contributed to the extensibility ratio.

### 3.3 Proximate composition of bread

#### 3.3.1 Moisture content

The moisture content of the white and brown bread decreased from 14.4% to 13.1% and from 14.5% to 13.1%, respectively, with increase in peanut flour content from 0% to 20% (Table 3). Decrease in moisture content with increase in de-oiled peanut flour (Yadav et al., 2013) and increase in reduced-fat peanut flour (Adeboye et al., 2018) content have been observed for bread made by blending with wheat flour. The reduction in moisture content with increase in peanut flour proportion was attributed to lack of starch for gelatinization, which is responsible for moisture retention. Moreover, higher peanut flour content caused a distorted gluten network. Similar trend was observed for protein-enriched bread made by blending wheat with defatted soy flour (Mashayekh et al., 2008). However, a study by Kahlon et al. (2021) indicated an increase in moisture content with increase in peanut flour content for biscuits.

#### 3.3.2 Protein content

The protein content increased from 11.8 to 12.6 and from 12.0 to 12.7 with increase in peanut flour proportion for white and brown bread, respectively (Table 3). Peanut being a good source of protein, increase in protein content is expected, and similar effect has been also reported for bread and other baked products. The increase in protein would have been substantial if defatted peanut or partially defatted peanut flour had been used. Increase in protein for bread from 10.32 to 15.47 with increment of reduced-fat peanut flour from 0 to 50% (Adeboye et al., 2018) and bread protein increment from 7.67 to 12.75% with increment in de-oiled peanut flour from 0% to 20% (Yadav et al., 2013) have been reported. Similar observation has been found for bread and other baked products with inclusion of peanuts and other nut flours (Chinma et al., 2016; Kahlon et al., 2021).

### TABLE 3 Chemical composition (%) of bread of different formulations

| Treatment  | White bread | | Brown bread |
|------------|-------------|---------------|-------------|
|            | Moisture    | Protein       | Fat         | Moisture    | Protein     | Fat         |
| 100% wheat | 14.4 ± 0.0  | 11.8 ± 0.1    | 1.2 ± 0.0   | 14.5 ± 0.0  | 12.0 ± 0.1  | 1.2 ± 0.0   |
| 10% peanut | 13.5 ± 0.1  | 12.2 ± 0.1    | 3.3 ± 0.1   | 13.4 ± 0.1  | 12.3 ± 0.1  | 3.1 ± 0.1   |
| 15% peanut | 13.2 ± 0.1  | 12.4 ± 0.1    | 4.0 ± 0.1   | 13.2 ± 0.1  | 12.5 ± 0.1  | 4.0 ± 0.1   |
| 20% peanut | 13.1 ± 0.1  | 12.6 ± 0.1    | 5.2 ± 0.1   | 13.1 ± 0.1  | 12.7 ± 0.1  | 4.6 ± 0.1   |

Note: Means followed by the same letter in columns are not significantly different (p > 0.05).
3.3.3 | Fat content

The increase in peanut flour content from 0% to 20% resulted in an increase in fat content from 1.2% to 5.2% and from 1.2% to 4.6% (Table 3). Peanut being a source of oil, the increment in bread fat content with increase in peanut flour proportion is expected. In line with the findings of this study, an increase in crude fat content from 5.46% to 7.43% with an increase in de-oiled peanut flour content from 0% to 20% was reported in wheat–peanut flour composite bread (Yadav et al., 2013). Other studies also reported an increase in fat content of bread made from wheat–reduced fat peanut flour from 3.43% to 17.03% with an increase in peanut flour proportion from 0% to 50% (Adeboye et al., 2018). Similar observation was found for wheat–partially de-oiled peanut flour blend biscuit (Yadav et al., 2012).

3.4 | Bread physical properties

3.4.1 | Weight

The results indicated that the loaf weight of bread was significantly (p < 0.05) influenced by the proportion of peanut. Loaf weight increased from 409.5 to 593.0 g and from 395.0 to 506.5 g for brown and white bread, respectively, as the peanut proportion increased from 0 to 20% (Table 4). The increase in loaf weight could be attributed to the high protein and fat content in peanut, which may have formed a complex with water, thus preventing its removal from the loaf during baking (Chinma et al., 2016; Yadav et al., 2013). An increase in loaf weight from 200.13 to 200.86 g has been reported as a result of an increase in peanut flour proportion from 0% to 50% (Adeboye et al., 2018). Inclusion of bambara nut from 0% to 15% resulted in loaf weight increment from 163.6 to 167.18 g (Chinma et al., 2016). Similar trends have been observed in composite flour bread made by replacing wheat with high protein sources like beans (Manyatsi et al., 2020) and brewer’s spent grain (Stojceska & Ainsworth, 2008).

3.4.2 | Volume and specific volume

Inclusion of peanut flour significantly (p < 0.05) affected the bread volume. The bread volume decreased from 1297.0 cm$^3$ to 962.25 cm$^3$ and from 1107.75 to 928.5 for brown and white bread, respectively, with an increase in peanut flour from 0% to 20% (Table 4). A volume reduction from 540 cm$^3$ to 490 cm$^3$ has been reported with an increase in peanut flour from 0% to 20% (Yadav et al., 2013). Similar trend has been observed for wheat–peanut flour bread with different levels of inclusion of peanut flour (Adeboye et al., 2018). The reduction in volume with an increase in peanut flour has been attributed to poor gas retention and moisture diffusion ability. The reduction in volume is also attributed to the relative reduction in gluten, which is responsible for increase in bread volume, with an increase in wheat replacement (Adeboye et al., 2018; Yadav et al., 2013). A decrease in bread volume was noted with an increase in the inclusion of bambara nut (Chinma et al., 2016) and other protein sources like legumes (Manyatsi et al., 2020; Mohammed et al., 2012).

The level of peanut flour significantly (p < 0.05) affected the specific volume. The specific volume decreased from 3.18 g/cm$^3$ to

| TABLE 4 | Physical properties of bread of different composition |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Treatments | Weight (g) | Volume (cm$^3$) | Sp. volume (cm$^3$/g) | Density (g/cm$^3$) | Weight (g) | Volume (cm$^3$) | Sp. volume (cm$^3$/g) | Density (g/cm$^3$) |
| 100% wheat | 409.5 ± 0.71d | 1297.0 ± 1.41a | 3.18 ± 0.01a | 0.330 ± 0.01c | 395.0 ± 0.00d | 1107.8 ± 1.06a | 2.81 ± 0.01a | 0.36 ± 0.02d |
| 10% peanut | 436.0 ± 0.1c | 986.0 ± 0.00c | 2.27 ± 0.01b | 0.440 ± 0.00b | 457.0 ± 0.00c | 1098.0 ± 0.00b | 2.40 ± 0.00b | 0.41 ± 0.00c |
| 15% peanut | 439.0 ± 0.1b | 989.5 ± 0.71b | 2.23 ± 0.00c | 0.435 ± 0.01c | 489.3 ± 1.06b | 1042.0 ± 1.41c | 2.13 ± 0.00c | 0.46 ± 0.01b |
| 20% peanut | 593.0 ± 0.00a | 962.3 ± 0.35d | 1.62 ± 0.00d | 0.62 ± 0.00a | 506.5 ± 0.71a | 928.5 ± 0.71d | 1.84 ± 0.01d | 0.54 ± 0.00b |

Note: Means followed by the same letter in columns are not significantly different (p > 0.05).

| TABLE 5 | Sensory evaluation scores of different bread formulations |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Treatment | Color | Taste | Crumb firmness | Texture/crust | OAC | Color | Taste | Crumb firmness | Texture/crust | OAC |
| 100% wheat | 5.4 ± 1.3a | 5.2 ± 1.7ab | 5.2 ± 1.5ab | 5.1 ± 1.3a | 5.4 ± 1.3ab | 5.2 ± 1.0ab | 4.9 ± 1.1ab | 5.2 ± 1.3a | 5.3 ± 1.2a | 5.3 ± 1.0a |
| 10% peanut | 5.1 ± 1.2bc | 4.8 ± 1.5bc | 4.9 ± 1.4c | 4.9 ± 1.2ab | 5.1 ± 1.3c | 5.2 ± 1.2bc | 4.8 ± 1.3bc | 5.0 ± 1.3ab | 5.3 ± 1.1a | 5.1 ± 1.1bc |
| 15% peanut | 5.3 ± 1.1bc | 5.2 ± 1.2ab | 5.3 ± 1.4c | 4.7 ± 1.2bc | 5.2 ± 1.2abc | 5.4 ± 1.0c | 5.0 ± 1.3a | 5.0 ± 1.2ab | 5.2 ± 1.3ab | 5.3 ± 1.0a |
| 20% peanut | 5.4 ± 1.2a | 5.5 ± 1.4a | 5.1 ± 1.4bc | 5.1 ± 1.3a | 5.5 ± 1.2a | 5.2 ± 1.0abc | 4.8 ± 1.4bc | 4.8 ± 1.3bc | 5.1 ± 1.3bc | 5.2 ± 1.0abc |

Note: Means followed by the same letter in columns are not significantly different (p > 0.05).
1.62 g/cm³ and from 2.81 g/cm³ to 1.84 g/cm³ for brown and white bread, respectively, with increase in peanut flour proportion from 0% to 20% (Table 4). Since volume and specific volume are related, such a trend was expected. Similar trend has been found in earlier studies where de-oiled peanut was used to replace wheat up to 20% (Yadav et al., 2013) and reduced fat peanut flour with replacement up to 50% (Adeboye et al., 2018). The fiber content in peanut flour might have contributed for the decrease in the specific volume (Arya et al., 2016). Replacement of wheat with other protein-rich flour like brewer’s spend grain (Aprodu et al., 2017; Ktenioudaki et al., 2015), soy flour (Fenn et al., 2010), chickpea (Mohammed et al., 2012), and beans (Manyatsi et al., 2020) also resulted in decreased specific volume. Density increased significantly (p < 0.05) from 0.330 to 0.62 g/cc and from 0.36 to 0.54 g/cc for brown and white bread, respectively, with increase in peanut flour from 0% to 20%. Density reflects the size and ratio of air cells to solid product. This trend was consistent with other studies (Yadav et al., 2013).

3.5 | Sensory evaluation

The sensory scores for the quality attributes of the different formulations of white and brown bread are presented in Table 5. Accordingly, all the formulations were found to be acceptable with an overall hedonic acceptability rate of “like” without much significant difference. For the peanut–white flour blend bread, inclusion of peanut flour at 20% brought about a notable reduction in taste and firmness score. For brown bread formulation, however, inclusion of peanut flour up to 20% appears a possibility where the panelists accept the product with a comparable acceptability score with the control sample. The results also indicate that there is a possibility to increase the peanut flour proportion over 20% where the product may still be acceptable. Inclusion of de-oiled peanut meal flour of up to 20% resulted in an acceptable bread (Yadav et al., 2013) whereas up to 15% inclusion of de-oiled peanut meal flour resulted in acceptable biscuits (Yadav et al., 2012). Consumers also liked the taste, aroma, and color of peanut–wheat flour bread at 20% or more peanut flour proportion (Adeboye et al., 2018).

4 | CONCLUSION

The farinograph rheological properties including Farinograph water absorption, dough development time (DDT), and stability increased with increase in the proportion of peanut flour. The alveograph properties dough strength, pressure (tenacity), extensibility, and extensibility ratio increased with increase in proportion of peanut flour. Increase in peanut flour proportion significantly (p < 0.05) increased the loaf weight but decreased volume and specific volume. The sensory evaluation revealed that it is possible to include peanut flour up to 20% for an acceptable bread. Further work to optimize the blend proportions needs to be conducted.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

ETHICS STATEMENT

This article does not contain any studies with human subjects.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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REFERENCES

AACC. (2000). Approved methods of the American Association of Cereal Chemists (10th ed.). The American Association of Cereal Chemist Press.

Adeboye, A. S., Fayemi, O. E., Bambose, A., Adewunmi, A., & Sobowale, S. S. (2018). Towards the development of peanut–wheat flour composite dough: Influence of reduced-fat peanut flour on bread quality. Journal of Food Processing and Preservation, 42(1), e13385.

Agare, K. K., Addo, K., Xiong, Y. L., & Akoh, C. C. (2005). Effect of structured lipid on alveograph characteristics, baking and textural qualities of soft wheat flour. Cereal Science, 42(3), 309–316. https://doi.org/10.1016/j.csc.2005.03.008

Akhbar, S., Khalid, N., Ahmed, I., Shahzad, A., & Suleria, H. A. (2014). Physicochemical characteristics, functional properties, and nutritional benefits of Peanut oil: A review. Critical Reviews in Food Science and Nutrition, 54(12), 1562–1575. https://doi.org/10.1080/10408398.2011.644353

Alper, C., & Mattes, R. (2003). Peanut consumption improves indices of cardiovascular disease risk in healthy adults. Journal of the American College of Nutrition, 22(2), 133–141. https://doi.org/10.1080/07315724.2003.10719286

Ammar, A. F., Zhang, H., Siddeeg, A., Chamba, M. V. M., Kimani, B. G., Hassanin, H., Obadi, M., & Alhejj, N. (2016). Effect of the addition of alhydwan seed flour on the dough rheology, bread quality, texture profile and microstructure of wheat bread. Journal of Texture Studies, 47(2), 484–495. https://doi.org/10.1111/jtxs.12187

Anil, M. (2007). Using of hazelnut testa as a source of dietary fiber in breadmaking. Journal of Food Engineering, 80, 61–67. https://doi.org/10.1016/j.jfoodeng.2006.05.003

Aprodu, I., Simion, A. B. & Banu, I. (2017). Valorisation of the Brewers Spent Grain Through Sourdough Bread Making. International Journal of Food Engineering, 13(10), 20170195. https://doi.org/10.1515/ijfe-2017-0195

Arya, S. S., Salve, A. R., & Chauhan, S. (2016). Peanuts as functional food: A review. Journal of Food Science and Technology, 53(1), 31–41. https://doi.org/10.1007/s13197-015-2007-9

Badwaik, L. S., Prasad, K., & Seth, D. (2014). Optimization of ingredient levels for the development of peanut-based fiber rich pasta. Journal of Food Science and Technology, 51(10), 2713–2719. https://doi.org/10.1007/s13197-012-0779-8

Chauhan, G., Zillman, P. R., & Eskin, N. (1992). Dough mixing and bread making properties of Quionion-wheat flour blends. Journal of Food Science, 27(6), 701–705.

Chinma, C. E., Anuonye, J. C., Ocheme, O. B., Abdullahi, S., Oni, S., Yakubu, C. M., & Azeez, S. O. (2016). Effect of acha and bambara nut...
Indrani, D., Rajiv, J., & Rao, G. V. (2010). Influence of fenugreek seed powder on dough rheology and bread quality. LWT - Food Science and Technology, 43, 1693–1698. https://doi.org/10.1016/j.lwt.2008.01.075.x

Mohammed, I., Ahmed, A. R., & Sengea, B. (2012). Dough rheology and bread quality of wheat–chickpea flour blends. Industrial Crops and Products, 38(3), 196–202. https://doi.org/10.1016/j.indcrop.2011.09.006

Noorfarahzilah, M., Lee, J. S., Sharifuddin, M. S., Mohd Fadzelly, A. B., & Hasmadi, M. (2014). Applications of composite flour in development of food products. International Food Research Journal, 21(6), 2061–2074.

Nwanzeke, E. C. (2013). Composite flours for baked products and possible challenges—A review. Nigerian Journal Food, 31(2), 8–17. https://doi.org/10.1016/S0189-7241(15)30071-0

Paraskevopoulos, E., Provatiolou, D., & Tsotsiou, V. K. (2010). Dough rheology and baking performance of wheat flour-lupin protein isolate blends. Food Research International, 43(4), 1009–1016. https://doi.org/10.1016/j.foodres.2010.01.010

Rehman, S., Paterson, A., Hussain, S., Murtaza, M. A., & Mehmoond, S. (2007). Influence of partial substitution of wheat flour with vetch (Lathyrus sativus L) flour on quality characteristics of doughnuts. Lebensmittel Wissenschaft Und Technologie, 40(1), 73–82. https://doi.org/10.1016/j.lwt.2005.09.015

Ribotta, P. D., Armulphi, S. A., Leon, A. E., & Anon, M. C. (2005). Effect of soybean addition on the rheological properties and baking quality of wheat flour. Journal of the Science of Food and Agriculture, 85(11), 1889–1896. https://doi.org/10.1002/jsfa.2191

Stojceska, M., & Ainsworth, P. (2008). The effect of different enzymes on the quality of high fibre enriched brewer's spent grain breads. Food Chemistry, 110(4), 865–872. https://doi.org/10.1016/j.foodchem.2008.02.074

Venkatachalam, M., & Sathe, S. K. (2006). Chemical composition of selected edible nut seeds. Journal of Agricultural and Food Chemistry, 54, 4705–4714. https://doi.org/10.1021/jf0606959

Wang, J., Rosell, C. M., & Benedicto de Barber, C. (2002). Effect of the addition of different fibres on wheat dough performance and bread quality. Food Chemistry, 79, 221–226. https://doi.org/10.1016/S0308-8146(02)00135-8

Win, M. M., Abdul-Hamid, A., Baharin, B. S., Anwar, F., & Saari, N. (2011). Effects of roasting on phenolics composition and antioxidative activity of peanut (Arachis hypogaeae L) kernel flour. European Food Research and Technology, 233, 599–608. https://doi.org/10.1007/s00217-011-1544-3

Yadav, D. N., Thakur, N., & Sunooj, K. V. (2012). Effect of partially de-oiled peanut meal flour (dpmf) on the nutritional, textural, organoleptic and physico chemical properties of biscuits. Food and Nutrition Sciences, 3, 471–476. https://doi.org/10.4236/fns.2012.34067

Yadav, D. N., Thakur, N., Sunooj, K. V., & Singh, K. K. (2013). Effect of de-oiled peanut meal flour (DPMF) on the textural, organoleptic and physico-chemical properties of bread. International Food Research Journal, 20(3), 1307–1312.