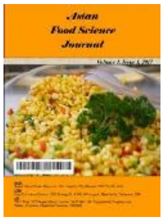

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Evaluation of the Physical, Functional and Microbiological Properties of Composite Bread from Wheat, Tigernut and Defatted Sesame Flour Blends

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Authors' contributions

This work was carried out in collaboration between all authors. Authors SAA and ANS jointly designed the study and wrote the protocols. Author IOA performed the statistical analysis and wrote the first draft of the manuscript. Author ANS managed the analyses of the study and literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The research was carried out to evaluate the effect of addition of tigernut and defatted sesame flours on the physical, functional and microbiological properties of the wheat bread. Tigernut and sesame were processed into flour, which were used in partially substituting the wheat flour. Six blend ratios of 100:0:0 (sample A), 90:10:0 (sample B), 85:10:5 (sample C), 80:10:10 (sample D), 75:10:15 (sample E) and 70:10:20 (sample F) were designed for wheat, tigernut and defatted sesame flours respectively. The physical properties of the bread loaves were evaluated and the results decreased significantly with addition of tigernut flour and increase in the level of substitution wheat flour with defatted sesame flour. The bread weight ranged from 158.23-210.07 g, loaf volume varied from 360-672 cm^3, bread specific volume was in the range of 1.71-4.14 cm^3/g and oven spring lied between 0.43-2.80 cm. The result revealed the following ranges for functional properties of the flour blends: OAC (1.19-1.38 g/g), WAC (1.33-1.63 g/g), BD (0.65-0.69 g/mL), SC (1.13-1.34 cm) and LGC (0.80-1.00%). While the results of the microbiological properties showed

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that the total bacterial count ranged between 2.67 x 10^2 – 2.33 x 10^4 cfu/g and total fungi count ranged from 2.67 x 10^2 – 5.83 x 10^3 respectively. Coliforms were not detected. The study concluded that it is possible to produce composite bread with the incorporation of tigernut and defatted sesame flour. This will go a long way in reducing the over-dependence on wheat, improve the use of more local resources and make bread more affordable especially for the low-income consumers.

Keywords: Bread; wheat flour; tigernut flour; defatted sesame flour.

1. INTRODUCTION

Bread can be described as a fermented confectionary product produced mainly from wheat flour, water, yeast and salt by a series of processes involving mixing, kneading, proofing, shaping and baking [1]. It is one of the fundamental staple foods that are consumed in the world. Its consumption is continuously increasing in countries like Nigeria, as a result of, growing population, rural-urban migration and working conditions [1-3]. Bread has good repository of valuable nutrients such as fibre, carbohydrate, protein, vitamins and minerals. The main ingredients required for bread production are; flour, water, yeast or baking powder and salt. Optional bread enriching ingredients could be sugar/sweeteners, milk, fats, egg, fruits and fruit juices, enzymes, spices and dough conditioners (e.g. malt extract and lemon juice).

Wheat is unique among many other cereal grains, because of its high content of gluten protein, a property that makes bread dough stick together and retain gas [4]. It contains 2-3% germ, 13-17% bran and 80-85% endosperm, which is the source of white flour [5]. Nutritionally, the whole grain contains 78.10% carbohydrates, 14.70% protein, 2.19% fat, 2.10% minerals and considerable proportions of vitamins (thiamine and vitamin-B) [6]. Its flour is used in bread preparation, production of biscuits, confectionary products, noodles as well as the important wheat gluten. Wheat is also used as animal feed, for ethanol production, brewing of wheat beer, wheat base raw material for cosmetics, and wheat protein in meat substitutes to make straw composites [7]. Tigernuts have rich reserve of valuable nutritious starch and dietary fibre. Tigernut is said to have good amount of essential amino acids which is more than the protein standard proposed for meeting adult requirements by FAO/WHO [8], making it a good supplement for sesame and wheat. Tigernut flour (yellow variety) contains 46.99% carbohydrates, 7.15% protein, 32.13% fat, 6.29% crude fibre and 3.97% ash [9]. Its flour is considered to be a good additive for baking as its sugar content is fairly high, avoiding the necessity of adding too much extra sugar [10]. Sesame seed contains 50% oil, 25% protein, 20–25% carbohydrate and are rich sources of iron, magnesium, copper and calcium [11]. The seed also contain phytosterols associated with reduced levels of blood cholesterol [12]. It is reported that defatted sesame flour contains 55.70% protein, 29.10% carbohydrate, 9.83% ash, 1.64% crude fiber and 29.40% total carbohydrate [13], which can be added as an integral part of a blend formulation to provide a better nutritional balance to a food product. Their dietary protein contains fine quality amino acids that are essential for growth especially in children [14]. Sesame seeds are very good source of B-complex vitamins and many essential minerals that have vital role in bone mineralisation and red blood cell production [14]. Sesame increases plasma gamma tocopherol and enhances vitamin E activity which is known to prevent cancer and heart diseases [13].

The continuous utilisation of wheat as a basic ingredient in bread making has led to an increase in the cost of bread production, making it increasingly less affordable for low-income consumers, who constitute the larger population. In order to reverse this trend, the Food and Agricultural Organization (FAO) and the Nigerian government have been encouraging the production of bread made from composite flours with less emphasis on wheat and more attention on locally grown crops. The use of health promoting plant sources such as tigernut and defatted sesame flours as an integral part of the bread making process is a novel approach that could be adopted. The inclusion of tigernut and sesame, not only will it encourage their utilisation, but will add value, improve the socio-economic status of Nigeria's local farmers, minimise complete dependence on imported wheat flour and save foreign exchange for the country.

2. MATERIALS AND METHODS

2.1 Source of Raw Materials

Wheat flour (Golden Penny), sesame seeds (white variety), sugar, dry baker's yeast and fat (Margarine) were purchased from modern market in Makurdi, while dried tigernut tubers (black variety) were obtained from Wadata market also in Makurdi; all in Benue State, North-Central Nigeria. Equipment/materials such as blender, mixer, kneader, knife, digital weighing scale, measuring cylinder, boiler, baking pans, plastic bowls, plastic containers with lids, stirrer, 0.45mm mesh size sieve, Petri dishes, Spoons, Spatula, Portable water and oven were obtained from the Postgraduate Laboratory of Centre for Food Technology and Research, Benue State University, Makurdi. All chemicals used for this study were of analytical grade.

2.2 Preparation of Raw Materials

2.2.1 Preparation of tigernuts flour

The method reported by Ade-Omowaye et al. [15] with slight modification was adopted in the preparation of tigernut flour. Dry tigernuts (black variety) tubers were sorted to remove unwanted materials like stones, pebbles and other foreign seeds, before washing with portable water dried in an oven at 80°C. The dried nuts were milled (Attrition mill) and sieved through 0.45 mm aperture size. The resultant flour was packed in polyethylene bag and stored in a plastic container with air-tight lid at room temperature. The flow chart for the production of tigernut flour is shown in Fig. 1.

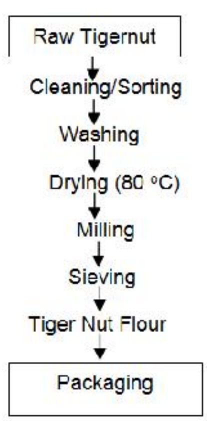

Fig. 1. Flow chart for the production of tigernut flour
Source: Modified method of Ade-Omowaye et al. [15]

2.2.2 Preparation of defatted sesame flour

The method described by Chinma et al. [13] with little modification was adopted in the preparation of defatted sesame flour. The sesame seeds were sorted to remove bad seeds and other foreign materials. The seeds were soaked overnight in cold tap water at ambient temperature and the hulls completely removed by floatation technique through hand rubbing. The dehulled seeds were blanched in water for 5 min, dried at 60°C in an oven and milled into flour using attrition mill to obtain the full fat sesame flour. A 500 g of full fat sesame flour was poured in a white muslin cloth and immersed in aluminum pan containing 1 L of petroleum ether (P.E) for 48 h to extract the oil. The meal was air dried for 1 h and milled using a blender (Binatone, BLG-402). The flour was passed through a 0.45 mm mesh size sieve and stored in plastic containers with lids at 4°C in a refrigerator for future use. The flow chart for the production of defatted sesame flour is shown in Fig. 2.

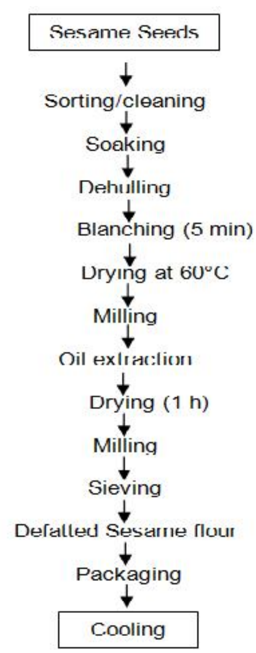

Fig. 2. Flow chart for the production of defatted sesame flour
Source: Modified method of Chinma et al. [13]

2.3 Production of Composite flour from Wheat, Tigernut and Defatted Sesame

Six samples, A-F were designed for this study. Only sample A had 100% wheat flour, while the rest of the samples had 10% tigernut flour incorporated into them. The defatted sesame flour was substituted at 5%, 10%, 15% and 20% into samples, C-F respectively. All blend formulations were thoroughly mixed with the aid of a blender (Binatone, BLG-402) to produce composite flour as shown in details in Table 1.

2.4 Production of the Wheat-Tigernut-Defatted Sesame Composite Bread

Bread was produced using the straight dough method as reported by Chauhan et al. [16]. All the ingredients (flour, sugar, yeast, fat and water) were thoroughly mixed manually for 40 min. The mixture was kneaded properly until the dough became elastic. The kneaded dough was transferred into greased (with margarine) baking pans and covered with aluminum foil. It was allowed to ferment for 55 min at room temperature. The fermented dough was allowed to undergo proofing at room temperature for 90 min. It was transferred to the oven (Century electric oven, model 8320-A20L) for baking at 230°C for 30 min. The loaves were removed from the pans and allowed to cool before packaging in polyethylene bags. The production flow chart is shown in Fig. 3.

2.5 Determination of Physical Properties of the Bread Loaves

2.5.1 Determination of bread weight

The method adopted by Dabels et al. [1] was used. Loaf weight was measured 1 h after the bread was brought out of the oven (Century electric oven, model 8320-A20L), using an electronic weighing balance.

2.5.2 Determination of loaf volume

The volume of the bread was taken by measuring the Length (L), Height (H) and Breath (B), and then using the formula (1) as reported by Eke-Ejiofor et al. [17].

$$\text{Loaf volume } (cm^3/g) = L \times H \times B \quad (1)$$

2.5.3 Determination of specific volume (SV)

Specific volume was calculated using formula (2) as adopted by Dabels et al. [1].

$$SV(cm^3/g) = \frac{V}{W} \quad (2)$$

Where V = volume of loaf sample
W = weight of loaf sample

2.5.4 Determination of oven spring (OS)

The oven spring was calculated by measuring the height of the dough and height of the bread, and then using formula (3) as adopted by Dabels et al. [1].

$$OS = H_2 - H_1 \quad (3)$$

Where H_1 = height of dough
H_2 = height of loaf

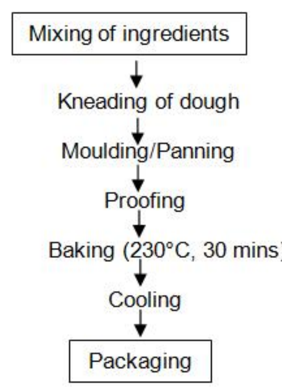

Fig. 3. Flow chart for the production of Bread
Source: Chauhan et al. [16]

Table 1. Recipe formulation of composite flour and other ingredients for bread production

Ingredients	Samples					
	A	**B**	**C**	**D**	**E**	**F**
Wheat flour (g)	100	90	85	80	75	70
Tigernut flour (g)	0	10	10	10	10	10
Defatted Sesame flour (g)	0	0	5	10	15	20
Sugar (g)	12	12	12	12	12	12
Yeast (g)	3	3	3	3	3	3
Fat (g)	16	16	16	16	16	16
Water (mL)	85	85	85	85	85	85

**Key: Sample A=Control I= 100% Wheat flour, Sample B= Control II= 90% Wheat flour: 10% Tigernut flour*

2.6 Determination of the Functional Properties of the Flour Samples

2.6.1 Oil absorption capacity (OAC)

The method of Onwuka [18] was adopted for the determination of OAC. Refined soybean oil with density of 0.92 g/mL was used. 1 g of the sample was mixed with 10 mL of the oil (V_1), for 30 s. The sample was allowed to stand for 30 min at room temperature and then centrifuged (Centurion scientific, Model k241) at 10,000 rpm for 30 min. The amount of oil separated as supernatant (V_2) was measured using 10 mL cylinder. The difference in volume was taken as the oil absorbed by the samples. The result obtained was calculated using equation (4).

$$OAC = \frac{(V_1 - V_2)P}{weight\ of\ sample} \quad (4)$$

Where, V_1 = the initial volume of oil used
V_2 = the volume not absorbed
P = the density of oil (0.92 g/mL)

2.6.2 Water absorption capacity (WAC)

The method reported by Ogungbenle et al. [19] was used in the determination of WAC. 1 g of the test sample was weighed into a test tube and mixed with 10 mL of distilled water (V_1). The mixture was left to stand for 30 min at room temperature and shaken every 10 min. At the end, it was centrifuged at 10,000 rpm for 5 min. The supernatant (V_2) was carefully measured using a measuring cylinder. The volume of water absorbed by the sample is the difference between V_1 and V_2.The water absorption capacity was then calculated using equation (5).

$$WAC = \frac{(V_1 - V_2)P}{weight\ of\ sample} \quad (5)$$

Where, V_1 = the initial volume of water used (10 mL).
V_2 = the volume of water not absorbed
P = the density of water (1000 kg/m^3)

2.6.3 Bulk density

The method of Onwuka [18] was adopted for the determination of bulk density. 10 mL capacity graduated measuring cylinder was weighed. The test sample was used to fill the cylinder to the 10 mL mark. The bottom of the cylinder was tapped on a table until the level could fall no further. The weight was taken and noted. The weight of the test sample which occupied the 10 cm^3 was measured and expressed as a ratio of volume. The bulk density (BD) was calculated using equation (6).

$$BD = \frac{W}{V} \quad (6)$$

Where, W = weight of sample
V = volume occupied by the sample

2.6.4 Swelling capacity (SC)

This is the ratio of the swollen volume to the original volume of a unit weight of the flour. The method reported by Oshodi et al. [20] was used. 1 g of the flour sample was weighed into a clean dry measuring cylinder. The height occupied by the sample was recorded (H_1) and then 5 mL of distilled water added to the sample. This was left to stand undisturbed for 1 h, after which the height was observed and recorded again (H_2). The swelling capacity (SC) was then calculated using equation (7).

$$SI = \frac{H_2}{H_1} \quad (7)$$

Where: H_1 = initial height
H_2 = final height

2.6.5 Least gelation concentration (LGC)

The method of Ogungbenle et al. [19] for the determination of least gelation concentration for flour was followed with slight modification. Approximate suspensions of 0.2%, 0.4%, 0.6%, 0.8%, 1.0%, 2.0%, 4.0%, .6.0%, 8.0% (m/v) were each prepared in 5 cm^3 distilled water. The test tubes containing these suspensions were heated for 1 h in boiling water followed by rapid cooling using chilled water at 4°C for 1 h. The tubes were then inverted one after the other. The LGC was taken as the concentration when the sample from the inverted test-tube did not fall or slip.

2.7 Microbial Analysis

The samples were each grounded into powder respectively. 1 g each of the samples were blended with 9 mL of sterile water and shaken very well for 2 min to form a suspension [21]. The microbial load of the samples were determined by performing a ten-fold serial dilution of each of the samples in test tubes containing sterile distilled water up to 10^{-5} dilution factor. The total viable bacteria and fungi count were determined using the pour plate technique culture for each of the sample in triplicates. The plates were incubated at 35°C for 24 h for bacteria, while fungi plates were incubated at 25°C for 48 h. The colonies were counted and expressed as ‘‘colony forming unit per gram (cfu/g)’’ and values were estimated by means of triplicate determination.

2.8 Statistical Analysis

All data obtained were analysed in triplicate determinations. They were subjected to Analysis of Variance (ANOVA) using Statistical Package for Social Sciences (SPSS), version 20.0 to test the level of significant difference at 5% level of probability ($p<0.05$). Duncan Multiple Range Test was used to separate the means where significant differences existed.

3. RESULTS AND DISCUSSION

3.1 Physical Properties of Bread Loaves

Result of the physical properties of bread made from wheat, tigernut and defatted sesame flour blends are presented in Table 2. The volumes of the bread from composite flour blends were lower than those made from 100% wheat flour. Bread specific volume decreased with increase in the proportion of defatted sesame flour. The highest bread specific volume was 4.14±0.03 cm^3/g obtained with 100% wheat flour (sample A), while the lowest (1.71 ±0.00 cm^3/g) was the one made from 70% wheat flour, 10% tiger nut flour and 20% defatted sesame flour (sample F). However, sample C was not significantly different from sample B (control II). This is in agreement with the result of [1,2] where they found lower bread volumes associated with composite flour as opposed to 100% wheat flour. The decrease in the volume and specific volume may be attributable to the corresponding decrease in the gluten content of the flours due to dilution of wheat with tigernut and defatted sesame flour blends, thereby reducing the ability of the dough to rise during the proofing process. The loaf weight of sample B was lower than that of bread samples with tigernut and defatted sesame flour substitutions, with sample F producing the heaviest loaf (210.07±0.12 g). Similar trend was reported by [22,23]. It maybe suggested that the lower specific volume of composite bread samples may be responsible for their heavy weight. There seems to be a correlation between high weight and the increase in water absorption capacity of the substituted flours. This weight increase could be desired by consumers, since they may consider going for food products that offer better fill. The oven spring also decreased significantly with the inclusion of the tigernut flour and increasing substitution of defatted sesame flour. This could be attributable to the poor gluten frame work in the composite flour samples. The same trend was also observed by Dabels et al. [1].

3.2 Functional Properties of the Flour Samples

Result of the functional properties of wheat, tigernut and defatted sesame flour samples are shown in Table 3. The OAC was highest in sample A (1.38 ±0.33 g/g) and lowest in sample F (1.19±0.24 g/g). There was no significant difference between samples. Values obtained from the study were higher than the range of 0.51 to 0.68 g/g reported by Ndife et al. [24]. Low OAC means that the food material has less hydrophobic proteins; the more hydrophobic proteins demonstrate superior binding of lipids [25]. The water absorption capacities (WAC) of the flour blends were significantly different. The WAC was highest in sample F (1.63±0.01 g/g) and lowest in sample B (1.33±0.00 g/g). The values obtained in the study were higher than those reported by Ezeocha and Onwuneme [26]. High WAC means that the food material may have more hydrophilic parts (polar amino acids) [25]. This could also be attributed to presence of higher amount of fibre; this is because fibre has good ability to associate with water under limited water conditions [27]. High water absorption capacity of composite flours suggests that the flours can be used in formulation of some foods such as sausage, dough, and processed cheese [28]. The bulk densities (BD) of the flour blends were not significantly different from one another. Sample F had the highest (0.68±0.01 g/mL) BD while the least was sample A (0.65 ±0.09 g/mL). The BD in this study was slightly below the values reported by Ohizua et al. [29] for unripe banana, pigeon pea and sweet potato flours. Bulk density is generally affected by the particle size of the flour [30] and initial moisture contents [31], which play a crucial role in the determination of requirements for packaging, material handling and wet processing application in the food industrial sector. Generally, high BD is desirable for its great ease of dispensability and reduction of paste thickness which is an important factor in convalescent child feeding, while in contrast, low BD would be an advantage in the formation of complementary foods [27]. The swelling capacity (SC) of the flour blends decreased. There was no significant difference between samples A, B and C, but they were significantly different from samples D, E and F. The values of SC ranged from 1.13 ±0.01 to 1.34±0.00 cm, with sample A having the highest value and sample F with the least value. The swelling capacities were lower compared to that of plantain and tigernut flour blends reported by Adebayo-Oyetoro et al. [32]. The swelling capacity of flours depends on size of particles, variety and type of processing method or unit operation [33]. The high swelling capacity observed in wheat may be as a result of gluten which is a protein found in wheat which contributes to the viscoelastic properties of wheat flour dough [26]. Least gelation concentration (LGC) measures the minimum amount of flour needed to form a gel in a measured volume of water [28]. It varies from flour to flour depending on the relative ratios of their structural constituents like protein, carbohydrates and lipids [28]. The LGC ranged from 0.8±0.00 - 1.0±0.00%. No significant difference existed between samples. The extent of gelation of the flour was lower compared to the value reported for unripe banana, pigeon pea and sweet potato flour blends by Ohizua et al. [29]. The greater the LGC, the greater will be the flour quantity required to form a gel. On the contrary, an LGC that is lesser leads to a better ability of the flour to form a gel. This simply means that the blend formulations from flour could be applied in food systems such as sauce, pudding as well as other foods which need thickening and gelling.

3.3 Microbiological Analysis

Result of the microbiological quality of wheat-tigernut-defatted sesame composite bread samples are presented in Table 4. The total bacterial counts of the bread samples ranged from 2.67×10^{2}±0.06 − 2.33×10^{4}±0.58 cfu/g with samples, B and A having the lowest and highest values respectively. Fungi counts ranged from 2.67×10^{2}±0.12 − 5.83×10^{3}±0.46 cfu/g with the lowest and highest counts recorded for sample A

Table 2. Physical properties of wheat-tigernut-defatted sesame composite bread loaves

Sample	Weight(g)	Volume(cm^3)	Specific volume(cm^3/g)	Oven spring(cm)
A	161.87^{c}±0.68	672.00^{f}±5.2	4.14^{d}±0.03	2.80^{f}±0.00
B	158.23^{a}±0.46	588.00^{e}±5.2	3.71^{c}±0.03	2.23^{e}±0.12
C	160.90^{b}±0.10	537.00^{d}±5.2	3.36^{c}±0.00	1.57^{d}±0.11
D	167.53^{d}±0.06	492.00^{c}±5.2	2.95^{b}±0.32	0.83^{c}±0.06
E	169.13^{e}±0.06	450.00^{b}±0.00	2.66^{b}±0.00	0.60^{b}±0.00
F	210.07^{f}±0.12	360.00^{a}±0.00	1.71^{a}±0.00	0.43^{a}±0.06

** Means with same superscript within the column do not differ significantly at 5% level of confidence, ± = standard deviation of triplicate determinations.*

A=100% wheat flour; B=90% wheat flour, 10% tigernut flour and 0% defatted sesame flour; C=85% wheat flour, 10% tigernut flour and 5% defatted sesame flour; D=80% wheat flour, 10% tigernut flour and 10% defatted sesame flour; E=75% wheat flour, 10% tigernut flour and 15% defatted sesame flour and F=70% wheat flour, 10% tigernut flour and 20% defatted sesame flour

Table 3. Functional properties of wheat-tigernut-defatted sesame composite flour samples

Sample	OAC(g/g)	WAC(g/g)	BD(g/mL)	SC(cm)	LGC%
A	1.38^{a}± 0.33	1.40^{c}±0.05	0.65^{a}± 0.09	1.34^{c}± 0.00	0.80^{a}± 0.00
B	1.26^{a}± 0.19	1.33^{a}± 0.00	0.69^{a}± 0.06	1.32^{c}± 0.01	1.00^{a}± 0.00
C	1.20^{a}± 0.28	1.37^{b}± 0.05	0.66^{a}± 0.06	1.28^{c}± 0.01	1.00^{a}± 0.00
D	1.22^{a}± 0.21	1.48^{d}± 0.01	0.67^{a}± 0.01	1.18^{a}± 0.00	1.00^{a}± 0.00
E	1.23^{a}± 0.28	1.55^{e}±0.00	0.68^{a}±0.11	1.22^{ab}±0.06	0.80^{a}±0.00
F	1.19^{a}± 0.24	1.63^{f}± 0.01	0.68^{a}± 0.01	1.13^{a}± 0.01	0.80^{a}± 0.00

** Means with same superscript within the column do not differ significantly at 5% level of confidence, ± = standard deviation of triplicate determinations.*

A=100% wheat flour; B=90% wheat flour, 10% tigernut flour and 0% defatted sesame flour; C=85% wheat flour, 10% tigernut flour and 5% defatted sesame flour; D=80% wheat flour, 10% tigernut flour and 10% defatted sesame flour; E=75% wheat flour, 10% tigernut flour and 15% defatted sesame flour and F=70% wheat flour, 10% tigernut flour and 20% defatted sesame flour.

OAC=oil absorption capacity, WAC=water absorption capacity, BD=bulk density, SC=swelling capacity and LGC=least gelation concentration

Table 4. Microbiological properties of wheat-tigernut-defatted sesame composite bread samples (cfu/g)

Sample	Total bacterial count	Total fungi count	Total coliform count
A	$2.33x10^4±0.58^b$	$2.67x10^2±0.12^b$	NG
B	$2.67x10^2±0.06^a$	$3.33x10^2±0.06^a$	NG
C	$2.07x10^4±0.12^b$	$1.43x10^3±0.06^a$	NG
D	$3.37x10^2±0.01^a$	$3.83x10^2±0.03^a$	NG
E	$1.33x10^3±0.01^a$	$4.93x10^2±0.01^a$	NG
F	$2.67x10^3±0.58^b$	$5.83x10^3±0.46^c$	NG

** Means with same superscript within the column do not differ significantly at 5% level of confidence, ± = standard deviation of triplicate determinations.*

A=100% wheat flour; B=90% wheat flour, 10% tigernut flour and 0% defatted sesame flour; C=85% wheat flour, 10% tigernut flour and 5% defatted sesame flour; D=80% wheat flour, 10% tigernut flour and 10% defatted sesame flour; E=75% wheat flour, 10% tigernut flour and 15% defatted sesame flour and F=70% wheat flour, 10% tigernut flour and 20% defatted sesame flour. NG=No Growth

and sample F respectively. There was no detection of Coliforms in the bread samples evaluated. The microbial counts were within the permissible limit set by the Standard Organization of Nigeria, which states that the counts of aerobic bacterial must not exceed 100 cfu/g and coliform growth must not be detected in bread samples [34]. Results from this study suggest that the bread samples are safe for human consumption as they do not pose any serious health concern. The microbial growth observed in the samples may have evolved during processing probably from the raw materials (e.g. flour, sugar and yeast) or perhaps from the environment. Talaro and Talaro [35] reported that microbes are widely distributed in the environment and occur on the skin and nostrils of humans, where they can contaminate food. Results of total bacteria and fungi counts were in close range to that reported by Bhatt and Gupta [23] on wheat and sweet potato breads.

4. CONCLUSION

The physical properties of the bread loaves and the functional properties of the flour samples were affected by the increased substitution of wheat flour with defatted sesame flour and the constant addition of tigernut flour. The microbial counts of the bread loaves fell within the minimum specification set by Standard Organization of Nigeria (SON). The production of bread from these flours will go a long way in improving the socio-economic status of Nigeria's local farmers, reduce the over-dependence on the wheat flour for the production of bread, make it affordable for low income groups and ultimately, reduce the amount of money usually spent on wheat importation and thus, save the nation's foreign reserve.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Dabels N, Igbabul B, Shar F, Iorliam B, Abu J. Physicochemical, nutritional and sensory properties of bread from wheat, Acha and Mung bean composite flours. Journal of Food Science and Quality Management. 2016;56:21-6.
2. Igbabul B, Grace NG, Amove J. Quality evaluation of composite bread produced from wheat, maize and orange fleshed sweet potato flours. American Journal of Food Science and Technology. 2014;2(4): 109-15.
3. Alozie YE, Iyam MA, Lawal O, Udofia U, Ani IF. Utilization of Bambara groundnut flour blends in bread production. Journal of Food Technology. 2009;7(4):111-4.
4. David O, Arthur E, Kwadwo SO, Badu E, Sakyi P. Proximate composition and some functional properties of soft wheat flour. Int J Inn Res Sci Eng Technol. 2015;4:753-8.
5. Šramková Z, Gregová E, Šturdík E. Chemical composition and nutritional quality of wheat grain. Acta Chimica Slovaca. 2009;2(1):115-38.
6. Kumar P, Yadava R, Gollen B, Kumar S, Verma R, Yadav S. Nutritional contents and medicinal properties of wheat: A review. Life Sciences and Medicine Research. 2011;22:1-10.
7. Shewry P. The HEALTHGRAIN programme opens new opportunities for improving wheat for nutrition and health. Nutrition Bulletin. 2009;34(2):225-31.

8. Acham IO, Kundam DN, Girgih AT. A review on potential of some Nigerian local food as source of functional food and their health promoting benefits. Asian Food Science Journal. 2018;2(4):1-15.
9. Adejuyitan JA. Tigernut processing: Its food uses and health benefits. American Journal of Food Technology. 2011;6(3): 197-201.
10. Sánchez-Zapata E, Fernández-López J, Pérez-Alvarez JA. Tiger nut (*Cyperus esculentus*) commercialization: Health aspects, composition, properties, and food applications. Comprehensive Reviews in Food Science and Food Safety. 2012; 11(4):366-77.
11. Gebremichael ZG. Assessment of sesame *Sesamum indicum* grain storage loss due to Indian Meal Moth Plodia interpunctella (Lepidoptera) for small scale-farmers in western zone of Tigray, North Ethiopia. Journal of Stored Products and Postharvest Research. 2017;8(2):11-5.
12. Zerihun J. Sesame (*Sesame indicum* L.) crop production in Ethiopia: Trends, challenges and future prospects. Science, Technology and Arts Research Journal. 2012;1(3):01-7.
13. Chinma CE, Igbabul BD, Omotayo OO. Quality characteristics of cookies prepared from unripe plantain and defatted sesame flour blends. American Journal of Food Technology. 2012;7(7):398-408.
14. Tunde-Akintunde TY, Oke MO, Akintunde BO. Sesame Seed, Oilseeds, Uduak G. Akpan(Ed.); 2012. ISBN: 978-953-51-0665-4, InTech.
15. Ade-Omowaye BIO, Akinwade BA, Bolarinwa IF, Adebiyi AO. Evaluation of Tigernut-wheat composite flour bread. African Journal of Food Science. 2008;2: 087-91.
16. Chauhan GS, Zillman RR, Eskin NAM. Dough mixing and breadmaking properties of quinoa-wheat flour blends. International Journal of Food Science & Technology. 1992;27(6):701-5.
17. Eke-Ejiofor J, Deedam JN, Beleya EA. Effect of addition of three leaf yam flour on dough properties and sensory qualities of bread. Journal of Food Research. 2015; 4(6):133.
18. Onwuka GI. Food analysis and instrumentation: Theory and practice. Surulere, Lagos, Nigeria: Naphthalic Prints. 2005;219-30.
19. Ogungbenle HN, Oshodi AA, Oladimeji MO. Effect of salts on the functional properties of benniseed (*Sesamum radiatum*) seed flour. International Journal of Food Sciences and Nutrition. 2002; 53(1):5-14.
20. Oshodi AA, Pinmoroti KO, Addeyege I, Hall GM. Amino and fatty acid composition of African yam bean (*Spenostylis stenocarpa*) flour. Food Chemistry. 1995; 53:1-6.
21. Fawole MO, Oso BA. Biochemical test. Laboratory Manual of Microbiology. Ibadan: Spectrum Books Limited; 2004.
22. Makinde FM, Akinoso R. Physical, nutritional and sensory qualities of bread samples made with wheat and black sesame (*Sesamum indicum* Linn) flours. International Food Research Journal. 2014;21(4):1635.
23. Bhatt SM, Gupta RK. Bread (composite flour) formulation and study of its nutritive, phytochemicals and functional properties. Journal of Pharmacognosy and Phytochemistry. 2015;4(2):254-68.
24. Ndife J, Kida F, Fagbemi S. Production and quality assessment of enriched cookies from whole wheat and full fat soya. European Journal of Food Science and Technology. 2014;2(1):19-28.
25. Lawal OS, Adebowale KO. Effect of acetylation and succinylation on solubility profile, water absorption capacity, oil absorption capacity and emulsifying properties of mucuna bean (*Mucuna pruriens*) protein concentrate. Food / Nahrung. 2004;48(2):129-36.
26. Ezeocha CV, Onwuneme NA. Evaluation of suitability of substituting wheat flour with sweet potato and tiger nut flours in bread making. Open Agriculture. 2016;1(1).
27. Adegunwa MO, Adelekan EO, Adebowale AA, Bakare HA, Alamu EO. Evaluation of nutritional and functional properties of plantain and tigernut flour blends for food formulations. Cogent Chemistry. 2017;13: 1-15.
28. Amandikwa C, Iwe MO, Uzomah A, Olawuni A. Physico-chemical properties of wheat-yam flour composite bread. Nigerian Food Journal. 2015;33(1):12-7.
29. Ohizua ER, Adeola AA, Idowu MA, Sobukola OP, Afolabi TA, Ishola RO, Ayansina SO, Oyekale TO, Faloma A. Nutrient composition, functional, and pasting properties of unripe cooking banana, pigeon pea, and sweetpotato flour

blends. Food Science & Nutrition. 2017; 5(3):750-62.
30. Adebowale AA, Sanni SA, Oladapo FO. Chemical, functional and sensory properties of instant yam-breadfruit flour. Nigerian Food Journal. 2008;26(1).
31. FAO/WHO. Codex Alimentarius. Foods for Special Dietary Uses (including foods for infants and children). Rome: FAO; 1994.
32. Adebayo-Oyetoro AO, Ogundipe OO, Adeeko KN. Quality assessment and consumer acceptability of bread from wheat and fermented banana flour. Food Science & Nutrition. 2016;4(3):364-9.
33. Suresh C. Assessment of functional properties of different flours. African Journal of Agricultural Research. 2013; 8(38):4849-52.
34. Ijah UJJ, Auta HS, Aduloju MO, Aransiola SA. Microbiological, nutritional, and sensory quality of bread produced from wheat and potato flour blends. International Journal of Food Science; 2014.
35. Talaro K, Talaro A. Foundations in microbiology. Dubuque, Iowa: W.C. Brown, USA; 1993.

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