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Nutritional and consumers acceptance of biscuit made from wheat flour fortified with partially defatted groundnut paste

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ABSTRACT

Biscuit is a nutritive snack eaten by everyone and often produced from unpalatable batter transformed into appetizing product through oven heat. Wheat, the major raw material used, is deficient in essential amino acid, lysine, while groundnuts lack methionine found in wheat. Blended wheat flour and partially defatted-groundnut paste was used for production in order to replace lost nutrients. Partially defatted-groundnut paste was used to substitute wheat flour at the ratios: A (100:0); B (95:5); C (90: 10); D (85: 15); E (80: 20); F (75: 25); G (70: 30), which were mixed with other ingredients to produce biscuit at 155–180 °C for 15–20 min, cooled and packaged for analyses. The functional properties of the flour, proximate composition, colour, and sensory evaluation of the biscuit were determined using standard methods. Proximate composition revealed that Protein, Moisture-Content, Ash, Crude-Fat, Crude-Fibre and Carbohydrate respectively ranged thus: (17.14–24.90%), (8.28–13.05%), (1.07–2.76%), (25.38–28.12%), (0.84–2.34%), and (46.35–33.68%). The swelling, water and oil absorption capacities of the flour: (1.10–1.27 ml/g), (1.40–1.754 ml/g), (0.82–1.99 ml/g) respectively. Sensory evaluation shows than sample B (95% wheat flour, 5% partially defatted-groundnut paste) was the most preferred. Concluding, incorporation of partially defatted-groundnut paste into wheat flour to produce biscuits could improve nutritional content and prevent malnutrition among consumers.

1. Introduction

Biscuit is the original British word used for small baked products that are sometimes flat shaped and usually made from wheat flour blended with some other ingredients. Biscuits are popular food or snack products consumed by many people, as a result of their varied taste, long shelf life and relatively low cost (Duncan, 2001). In Nigeria, biscuits are one of the most consumed cereal foods apart from bread, because they are readily available in local shops as ready to eat, cheap, convenient and appetizing food products (Iwegbue, 2012; Kulkarni, 1997). Biscuits are produced as nutritive snacks from unpalatable dough transformed into appetizing products through the application of oven heat (Onabanjo & Ighere, 2014). They are flat crisp that may be sweetened or unsweetened according to preferences. Biscuits can be made from either hard dough, hard sweet dough, short or soft dough. The main ingredient used for biscuit production is wheat flour, while other ingredients include margarine, sugar, milk, egg, salt and flavour (Oluwamukomi, Oluwalana, & Akinbowale, 2010). Biscuits are divided into two groups of hard and soft dough. Soft dough biscuits are rich in fat and sugar and include short cakes, short bread and melted biscuits etc., while hard dough includes Maries and morning coffee. Other types of biscuits are cream cracker, soda crackers, savory, water biscuits, digestive etc. (Okoli, Okolo, Moneke, & Ire, 2010). In many parts of Sub-Saharan Africa and most especially Nigeria, advancing prosperity and urbanization coupled with tremendous increase in population in recent years have led to an increase in the consumption of wheat-based products, especially biscuits and breads. However, production of wheat in Nigeria is extremely low and far below domestic requirements. Also, the wheat flour produced lacked some essential amino acids. As a result of this, fortification of wheat protein has been on the front burner of research studies, most especially the use of plant sources that are high in protein (legumes and oil seeds in particular) (Enujiugha, 2003). While one is deficient in lysine, the other, methionine. Blending the two would definitely bring about balancing of the amino acids, a process known as protein complementation (Potter & Hotchkiss, 2006), and would definitely lead to biscuit with better nutritional, healthy, natural and good functional characteristics. Compositing wheat flour with other locally available cereals and root crops have been reported to be equally desirable (Oyarekua & Adeyeye, 2009). Groundnut, also known as peanut and taxonomically classified as *Arachis hypogaea*, is a legume crop grown mainly for its edible seeds. It is widely grown in the tropics and subtropics, as it is important to both small and large commercial

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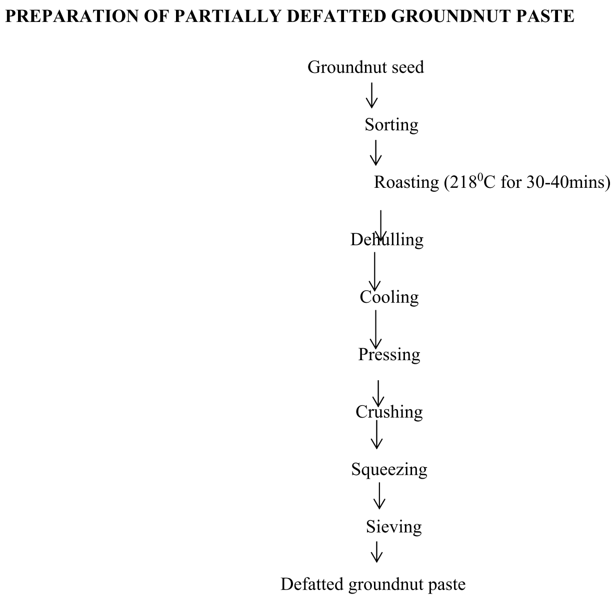

Fig. 1. Flowchart for the production of defatted groundnut paste.

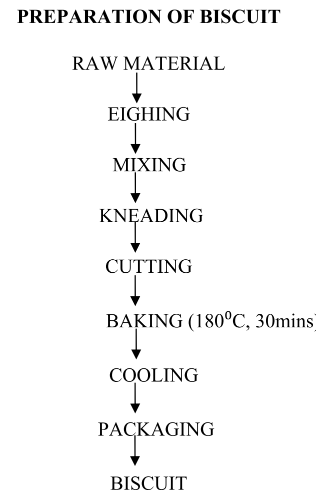

Fig. 2. Flowchart for the production of Biscuit.

producers (USDA, 2016). Groundnut has the highest oil content of all food crops and second only to soybean in term of protein content (20–30%) among the food legumes (Khan, Ashari, & Siraj, 2004). Groundnuts are low in saturated fat and cholesterol, and as result, could beneficial in reducing the risk of heart disease (Moretzsohn, Gouvea, Inglis, & Bertioli, 2013). As a result of these, this research work hopes to evaluate the nutritional and overall acceptance of biscuit made from wheat flour fortified with partially-defatted groundnut paste.

2. Materials and methods

2.1. Procedure for defatted groundnut paste production

Groundnut seeds used for the research work were obtained from a research institute in Ilorin, Kwara State. The groundnut seeds were properly cleaned, sorted to remove dirt, bad ones and sand. They were roasted at 425 °F (218 °C) for 40–60 min, dehulled and allowed to cool. The roasted groundnuts were later crushed using a mechanical screw press. The nuts were ground into paste and with the aid of a muslin cloth; oil was squeezed out (see Fig. 1). The pressed cakes obtained were again crushed using mortar and pestle, dried and sieved using 750 cm mesh screen.

Partially-defatted groundnut paste was incorporated into refined wheat flour at different ratios (0:100, 5:95, 10:90, 15:85, 20:80, 25:75 and 30:70). All the ingredients (pre-weighed flour, sugar, salt and baking powder) were weighed accurately, mixed thoroughly with shortening and eggs added to form batter/dough. The batter was rolled to a sheet of uniform thickness, cut to the desired shape and size of biscuits with a cutter and baked in the oven, using the method of Gbadamosi, Enujiugha, & Odepidan, 2011 (see Fig. 2). The baked biscuits, after cooling, were stored in airtight plastic container before further analysis. The biscuit samples were produced in the food processing laboratory of the department of Home Economics and Food Science, University of Ilorin. There were three (3) trials of biscuit production in all, and on each occasion, the readings of the parameters measured were taken in triplicate. The various blends are as given below:

A = 100% Wheat flour for biscuits (Control sample).
B = 95%: 5% Ratio of wheat and partially defatted groundnut paste in the biscuit product.
C = 90%: 10% Ratio of wheat and partially defatted groundnut paste in the biscuit product.
D = 85%: 15% Ratio of wheat and partially defatted groundnut paste in the biscuit product.
E = 80%: 20% Ratio of wheat and partially defatted groundnut paste in the biscuit product.
F = 75%: 25% Ratio of wheat and partially defatted groundnut paste in the biscuit product.
G = 70%: 30% Ratio of wheat and partially defatted groundnut paste in the biscuit product.

2.2. Laboratory analysis

2.2.1. Proximate analysis

The proximate composition (protein, moisture, crude fibre, fat, ash and carbohydrate) of the biscuit samples was determined using the standard method of AOAC (2005).

2.2.2. Colour determination of biscuit samples

The L* a* b* colour parameter of the samples was determined using a colorimeter (Chromameter CR-400/410). The following colour traits were determined: **L*-** a measure of lightness from black (0) to white (100); **a*** measures redness and; **b*,** yellowness or blueness (Chen, Zhu, Zhang, Niu, & Du, 2010). The instrument was standardized based on the manufacturer's instructions.

2.2.3. Functional properties

2.2.3.1. Determination of water absorption capacity (WAC) and oil absorption capacity (OAC). These were done by the method of Onwuka, 2005, pp. 133–137.

2.2.3.2. Determination of swelling capacity (SC). This was done by the method of Narayana & Narasinga, 2002.

2.2.4. Sensory evaluation

The organoleptic properties of the biscuit including taste, appearance, aroma, crunchiness and overall acceptability were assessed by 35 untrained panelists who were regular biscuit consumers. They were randomly selected and requested to assess the biscuits using a nine point Hedonic scale (1 and 9 representing “extremely disliked” and “extremely liked” respectively), while the data were analyzed using Analysis of Variance (ANOVA) (Wright & Kader, 1997).

2.2.5. Data analysis

Statistical analysis of all the data was done. All the analyses were carried out in three replicates and duplicated. Statistically, significant differences ($p < .05$) in all the data were determined by analysis of

Table 1
Proximate composition of wheat and partially defatted groundnut paste biscuits.

Samples	MC (%)	Protein (%)	Fat (%)	Ash (%)	CF (%)	CHO (%)
A	8.28[c] ± 0.11	17.14[c] ± 0.15	25.38[c] ± 0.75	1.07[d] ± 0.11	2.34[a] ± 0.32	46.35[a] ± 2.35
B	8.54[c] ± 0.04	18.34[c] ± 0.56	25.64[bc] ± 0.68	1.32[cd] ± 0.30	1.99[b] ± 0.51	45.12[b] ± 1.53
C	13.05[a] ± 0.48	18.65[b] ± 0.72	25.94[bc] ± 1.39	2.15[c] ± 0.28	1.86[b] ± 0.32	38.19[d] ± 2.12
D	7.86[d] ± 0.18	20.21[b] ± 0.88	26.47[b] ± 1.08	1.66[c] ± 0.31	1.54[bc] ± 0.04	42.20[c] ± 0.38
E	10.32[b] ± 0.05	20.64[b] ± 0.41	26.83[b] ± 1.62	2.34[b] ± 0.32	1.02[c] ± 0.16	38.82[d] ± 2.75
F	10.29[b] ± 1.70	22.03[a] ± 1.09	27.64[a] ± 1.43	2.76[a] ± 0.67	1.01[c] ± 0.16	35.24[e] ± 0.27
G	10.09[b] ± 0.55	24.90[a] ± 0.56	28.12[a] ± 1.10	2.42[b] ± 0.10	0.84[d] ± 0.31	33.68[f] ± 0.61

Mean ± SD of three replicates.* Mean values within a column with different letters are significantly different ($p < .05$).
KEY:
A = 100% Wheat flour for biscuits (Control sample).
B = 95%: 5% Ratio of wheat and defatted groundnut paste in the biscuits respectively.
C = 90%: 10% Ratio of wheat anddefatted groundnut paste in the biscuits respectively.
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variance (ANOVA) method and difference separated using Duncan multiple range test.

3. Results and discussion

Proximate composition of the biscuit samples is as shown in Table 1, with significant differences (at $p < .05$) among some of the samples. From the table, it could be seen that protein content ranged from 17.14% to 24.90%; crude fat (25.38% and 28.12%); moisture content (8.28%–13.05%); ash (1.07% and 2.76%); crude fibre (0.84%–2.34%); while the carbohydrate values ranged between 33.68% and 46.35%. The protein content increased by 7–45% based on the quantities of the added partially-defatted groundnut paste. Crude fat increased by about 1–11%, ash (23–126%), while the crude fibre and carbohydrate contents respectively reduced by 15–64% and 2.7–27%. It was reported by Moretzsohn et al., 2013 that groundnuts by virtue of their low content in saturated fat and cholesterol, could lead to a reduction in the risk of heart diseases. Incorporating partially-defatted groundnut paste into wheat flour for biscuit production did not only afford consumers of the above mentioned benefits, it equally gives them the opportunity of consuming biscuits that are very rich in terms of protein, crude fat and ash contents and with improved flavor, a result similar to the report of Hefferon, 2015. The protein content of the biscuits produced was far higher than that reported by Onabanjo & Ighere, 2014. They reported 9.34%–12.71% protein content for biscuit made from wheat and sweet potato flour, while Ayo, Ayo, Nkama, & Adewori, 2007 reported 5%–14.19% for Acha-wheat biscuit that was complemented with soybean flour. The high concentration of the protein recorded in these biscuits supported the report of Khan et al., 2004, that groundnut is second only to soybean in terms of protein content and equally improves flavour (Alper & Mattes, 2003). It showed a direct increase in the crude protein content as the quantity of partially-defatted groundnut paste was being added.

The moisture content ranged from 7.86% to 13.05%. Biscuits produced from ratio 90:10 wheat and partially-defatted groundnut paste had the highest moisture content. The values of the moisture content recorded showed that the biscuit produced could store for an appreciable period of time, when compared with the recommended storage moisture content of grains and biscuits made from wheat flour.

The ash content ranged between 1.07 and 2.76%. Samples F (75% wheat flour and 25% partially-defatted groundnut paste) had the highest ash content, while sample A containing 100% wheat flour had the lowest values. The ash content increased, as the quantity of the added partially-defatted groundnut paste was increasing and quantity of wheat flour decreasing. The increase in the ash content was a reflection of an increase in the mineral content of the biscuit produced, which was comparable to that reported by Oluwamukomi et al., 2010 (1.06%–2.78%) for biscuit made from blend of wheat and soybean flour.

The crude fibre ranged from 0.84% to 2.34%, with Sample A (100% wheat flour) having the highest value (2.34%). Crude fibre decreased with increase in the quantity of partially-defatted groundnut paste content. The result obtained was similar to that of Niaba-Koffi, Gildas, Beugre, & Gnakri, 2013 (0.85%–2.44%) for wheat biscuit fortified with Macrotermes Subhyalinus. Crude fibre increase may lead to bulkiness and low caloric intake from nutrients (Alvisi et al., 2015).

The fat contents ranged from 25.38% to 28.12%. Sample G (70% wheat flour and 30% partially-defatted groundnut paste) had the highest value, while sample A containing 100% wheat flour had the least value (25.38%). The values obtained were still higher than that reported by Grah, Beda, Aubin, Niaba, & Gnakri, 2014 (19.1%–21.4%) for biscuit made from wheat flour and lentil seeds, even with partial defattening and that reported by Usman, Ameh, Alifa and Babatunde, 2015 (22.86%–25.41%) for biscuits made from wheat and maize bran composite flour. It should be noted that Cherkaoui, Alizadehr, Asai, Edmond, & Laurie, 2015 reported that availability of refined groundnut oil will not cause allergic reactions in most people with peanut allergies, which informed the use of partially-defattening.

The carbohydrate content ranged from 35.24% to 46.35%. Sample A containing 100% wheat flour had the highest value, while sample F containing 75% wheat flour and 25% partially-defatted groundnut paste had the least. It was seen that as the quantity of partially-defatted groundnut was increasing, the quantity of carbohydrate was reducing.

Table 2 shows the result of the colour determination of the biscuit produced from the blend of wheat and partially-defatted groundnut paste. From the results, significant differences (at $p < .05$) was noticed among some of the samples. It was observed that L* value was increasing as the quantity of partially-defatted groundnut paste was being increased. The values ranged from 48.77 to 66.33. The addition of the groundnut paste increases the brightness of the product. The a* and b* values decreased with increase in the fortification of the wheat flour with the partially-defatted groundnut paste. The a* values decreased from 5.87 to 3.28 and b* values decreased from 21.04 to 14.36. Damiana, Tiziana, Lucia, Lucia, & Patricia, 2014 reported that yellowness and redness in biscuit was related to high protein content. The changes noticed in the yellowness and whiteness of the biscuit as a result of the addition of the groundnut paste could be termed discolouration, which may be due to the period of baking, that is, heat treatment (Hsu, Chen, Weng, & Tseng, 2003).

Functional properties are those parameters that determine the application and use of food material for various food products (Adebowale, Adegoke, Sanni, Adegunwa, & Fetuga, 2012). Table 3

Table 2
Colour determination of wheat-partially defatted groundnut paste biscuits.

Sample	L*	a*	b*
A	$48.17^{d} \pm 0.74$	$5.87^{a} \pm 0.10$	$21.37^{a} \pm 0.96$
B	$52.09^{c} \pm 1.28$	$4.40^{a} \pm 0.02$	$17.76^{b} \pm 0.53$
C	$53.70^{c} \pm 0.02$	$4.25^{b} \pm 0.50$	$15.92^{bc} \pm 0.67$
D	$56.64^{b} \pm 0.01$	$4.00^{b} \pm 0.01$	$15.37^{bc} \pm 0.03$
E	$58.14^{b} \pm 0.02$	$3.80^{b} \pm 0.07$	$14.92^{c} \pm 0.66$
F	$63.14^{a} \pm 5.22$	$3.66^{c} \pm 0.07$	$14.77^{c} \pm 1.93$
G	$66.33^{a} \pm 0.01$	$3.28^{cd} \pm 0.40$	$14.36^{c} \pm 1.11$

Mean ± SD of three replicates.* Mean values within a column with different letters are significantly different ($p < .05$).
KEY:
A = 100% Wheat flour for biscuits (Control sample).
B = 95%: 5% Ratio of wheat and defatted groundnut paste in the biscuits respectively.
C = 90%: 10% Ratio of wheat anddefatted groundnut paste in the biscuits respectively.
D = 85%: 15% Ratio of wheat anddefatted groundnut paste in the biscuits respectively.
E = 80%: 20% Ratio of wheat anddefatted groundnut paste in the biscuits respectively.
F = 75%: 25% Ratio of wheat anddefatted groundnut paste in the biscuits respectively.
G = 70%: 30% Ratio of wheat anddefatted groundnut paste in the biscuits respectively.

Table 3
Functional properties of Wheat-defatted groundnut paste Biscuits.

Samples	OAC (ml/g)	WAC(ml/g)	SC (ml/g)
A	$0.54^{c} \pm 0.06$	$0.70^{b} \pm 0.02$	$0.62^{a} \pm 0.02$
B	$0.69^{b} \pm 0.01$	$0.84^{a} \pm 0.04$	$0.61^{a} \pm 0.02$
C	$0.99^{a} \pm 0.00$	$0.87^{a} \pm 0.02$	$0.59^{a} \pm 0.02$
D	$0.40^{d} \pm 0.02$	$0.84^{a} \pm 0.04$	$0.56^{ab} \pm 0.01$
E	$0.95^{a} \pm 0.04$	$0.80^{a} \pm 0.01$	$0.57^{ab} \pm 0.01$
F	$0.93^{a} \pm 0.03$	$0.77^{b} \pm 0.02$	$0.55^{ab} \pm 0.02$
G	$0.92^{a} \pm 0.01$	$0.71^{b} \pm 0.02$	$0.53^{b} \pm 0.03$

Mean ± SD of three replicates.* Mean values within a column with different letters are significantly different ($p < .05$).
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B = 95%: 5% Ratio of wheat and defatted groundnut paste in the biscuits respectively.
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G = 70%: 30% Ratio of wheat anddefatted groundnut paste in the biscuits respectively.

presents the result of the functional properties of wheat and partially-defatted groundnut paste blends. The value recorded for oil absorption capacity ranged from 0.40 ml/g for sample D (85% wheat flour and 15% partially-defatted groundnut paste) to 0.99 ml/g recorded for sample C (90% wheat flour and 10% partially-defatted groundnut paste) with significant difference ($p < .05$). Abbey and Ibey (1986) reported that the mechanism of fat retention is not clear but could be attributed to physical entrapment of oil. It was reported that this is a parameter responsible for the baking quality of flour (Kumar et al., 2011), which is an important property for flavour retention in foods, shelf life improvement and palatability (Kumar et al., 2011). Good oil absorption capacity of flour suggests that they may be useful in food preparation that involves oil incorporation such as in baking, where oil is an important ingredient (Fagbemi & Olaofe, 2000).

The water absorption capacity gives an indication of the amount of water available for gelatinization. The water absorption capacity of the flour samples ranged from 0.70 ml/g to 0.87 ml/g which showed significant difference ($p < .05$) between the samples. Sample C containing 90% wheat flour and 10% partially-defatted groundnut paste had the highest water absorption capacity (0.87 ml/g), while sample A (control), 100% wheat flour, had the least value (0.70 ml/g). The high water absorption capacity recorded could be as a result of its high starch content, which enables it to absorb more water. It could also be as a result of the initial moisture content of the samples, as well as the presence of hydrophilic components such as carbohydrates (Ikujenlola, Oguntuase, & Omosuli, 2013). The water absorption capacity of the control sample was lower when compared with that of the other blends or samples. The incorporation of partially-defatted groundnut paste could have conferred higher water binding capacity on the wheat flour, which in turn improved textural properties and re-constitution ability. This could be attributed to lose structure of starch polymer, while the lower value indicated compactness of structure (Ajanaku, Ajanaku, Edobor, & Nwinyi, 2012). High water absorption capacity can also be attributed to lose structure of starch polymers, while low value indicates the compactness of the structure (Adebowale, Sanni, & Awonarin, 2005; Oladipo & Nwokocha, 2011).

The swelling capacity ranged from 0.53 ml/g to 0.62 ml/g. Sample A, the control (100% wheat flour), had the highest swelling capacity, while sample G (70% Wheat flour and 30% defatted-groundnut paste) had the least swelling capacity. The interaction between starch and protein structure of the blends could have affected the swelling ability of samples B to G. Higher protein content in flour may cause the starch granules to be embedded within a stiff protein matrix, which subsequently limits the access of the starch to water and restricts the swelling capacity (Akpapunam & Darbe, 1999).

The mean values of the results of the sensory evaluation by the panelists were analyzed statistically to assess the significant difference among the biscuits produced (see Table 4). The results revealed that biscuits from wheat flour only (control sample) was not significantly different ($p > .05$) in aroma, appearance, taste, crunchiness and general acceptability from samples B (95/5%), C (90/10%), F (75/25%)

Table 4
Sensory evaluation results of biscuits made from wheat-partially defatted groundnut paste.

Sample	Aroma	Appearance	Taste	Crunchiness	Acceptability
A	$7.40^{a} \pm 0.94$	$7.05^{a} \pm 1.54$	$7.60^{a} \pm 1.19$	$7.55^{a} \pm 1.50$	$7.65^{a} \pm 1.31$
B	$7.50^{a} \pm 1.10$	$7.60^{a} \pm 1.10$	$7.70^{a} \pm 1.08$	$7.70^{a} \pm 1.46$	$7.80^{a} \pm 1.44$
C	$6.95^{ab} \pm 1.05$	$7.35^{a} \pm 1.31$	$7.30^{a} \pm 1.13$	$7.35^{a} \pm 1.59$	$7.60^{a} \pm 1.27$
D	$6.15^{b} \pm 1.38$	$6.65^{ab} \pm 1.40$	$6.20^{b} \pm 1.36$	$5.90^{b} \pm 1.55$	$6.35^{b} \pm 1.18$
E	$6.05^{b} \pm 1.46$	$6.10^{b} \pm 1.48$	$6.10^{b} \pm 1.52$	$5.50^{b} \pm 2.07$	$6.15^{b} \pm 1.93$
F	$6.60^{ab} \pm 1.50$	$7.00^{ab} \pm 1.26$	$7.10^{ab} \pm 1.33$	$7.15^{ab} \pm 1.14$	$6.95^{ab} \pm 1.47$
G	$5.65^{c} \pm 1.98$	$6.10^{b} \pm 1.48$	$5.75^{c} \pm 2.17$	$5.05^{bc} \pm 2.19$	$5.70^{c} \pm 2.16$

Mean ± SD of three replicates.* Mean values within a column with different letters are significantly different ($p < .05$).
KEY:
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G = 70%: 30% Ratio of wheat anddefatted groundnut paste in the biscuits respectively.

and partially close to sample D (85/15%) wheat flour to partially-defatted groundnut paste. The aroma could have been affected by the proportion of the blend. The appearance judged how well the biscuits were baked and equally provides information about the formulation and product quality (Hussain, Anjum, Butt, Khan, & Ashaghar, 2006). It was observed that the appearances of the biscuits were getting darker as the quantity of partially-defatted groundnut paste was increasing. It was reported that taste parameter normally determines the acceptability of the product (Banureka & Mahendran, 2009). For the product crunchiness, decrease in crunchiness was observed as the level of incorporation of partially-defatted groundnut paste was increasing, which could, however, be attributed to lower gluten content of the groundnut paste (Kent, 2000, p. 166). Though the consumers were used to eating wheat flour biscuits, samples with the incorporation of 5%, 10%, 15% and 25% of partially-defatted groundnut paste were accepted by the panelists.

4. Conclusion

This research work revealed that the nutritional composition of the biscuit improved. The protein, fat and ash contents increased with increase in the addition of partially-defatted groundnut paste, while carbohydrate, moisture and crude fibre decreased with the increasing quantities of the partially-defatted groundnut paste. Colour determination showed that lightness increased with addition of partially-defatted groundnut paste, while redness and yellowness decreased with the addition. The swelling capacity, oil absorption and water absorption capacity decreased with addition of partially-defatted groundnut paste. The fortification increase nutritional qualities and equally enhanced consumer's acceptability, a step that could help in fighting against children protein malnutrition by improving the nutritional quality of snacks eating by children, most especially in the third world countries of which Nigeria is inclusive. Here, malnutrition and poor quality protein consumption is prevalent. This study indicates that though the samples were accepted, but the blend of 95% wheat and 5% partially-defatted groundnut paste was the most preferred. Addition of partially-defatted groundnut paste to wheat flour helped to reduce carbohydrate content, but enhanced availability of desirable mineral. Therefore, incorporating partially-defatted groundnut paste into biscuit production would improve nutritional content, prevent malnutrition among children and reduce the cost of production.

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