Application of Bambara Groundnut in the Production of Cookies

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Abstract
This study aimed to produce cookies from flour blends of Bambara groundnut (BGN) and wheat flour (WF) at ratios 100:0, 80:20, 70:30, 60:40, 50:50 and 0:100 (WF: BGN) respectively. The proximate results showed significant differences ($p \geq 0.05$) among the flour blends with protein, crude fibre, crude fat, total ash and carbohydrate content ranged from 9.30–22.75; 0.42–2.42; 12.51–18.98; 0.91–2.99 and 43.62–71.38% respectively. The increase in the protein and fat content resulted from the increase in BGN of the blend flour respectively. The functional properties of the blend flours showed that oil absorption capacity (OAC), water absorption capacity (WAC), swelling index and bulk density ranged from 3.08–4.20; 2.00–2.30; 1.05–1.31 and 0.62–0.72 g/ml respectively. However the low OAC and WAC of BGN blend flour might be due to low levels of hydrophobicity of proteins. All cookies had a good sensory scores, except cookies made from 100% BGN, therefore up to 50% BGN flour be used in the substitution of WF in the production of cookies for adequate nutritional quality.
Keywords: Bambara groundnut, cookies, functional, physical, sensory evaluation.
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1. Introduction

Most cookies are low in protein and if present is often of poor nutritional quality. This is because they are prepared mostly from plants food products, especially cereals Akpapunam and Darbe (1994). The world protein demand is on the increase Eltayeb et al. (2011) and so the need for improvement of cookies as they are highly consumed by both children and adult. If properly processed and enriched, using local available protein source, it may help as a channel to manage the world protein deficiency, must especially of the low income group, who cannot afford expensive western food.

Bambara groundnut (*Vigna subterranean*) is a legume extensively cultivated in Nigeria and many African countries. It is rich in protein (19–28 g 100 g^{-1}) and carbohydrate (57–68 g 100 g^{-1}) (Oyeyinka et al., 2015). The proteins of BGN may be used as a functional ingredient in the industry due to its balanced amino acid profile (Bamshaiye et al., 2011).

Wheat (*Triticum aestivum* L) is the most extensively grown cereal crop in the world, Wheat has been cultivated in Nigeria for centuries (Olugbemi et al., 1979; Ohiagu et al., 1987). However, Oyewole (2016) reported that Nigeria's domestic wheat production has remained at a very low level in spite of the ever rising demand for the crop due to climatic requirements, appropriate agronomic practices and preference for the cultivation of vegetables (Ohiagu et al., 1987). In the present study, cookies made from the blends of BGN and WFwere analysed for their proximate composition, functional properties, physical properties, and sensory evaluation in order to establish the best blend for cookies production and enrichment.

2. Materials and methods

2.1 Materials

Bamabara groundnut (*Vigna subterranea)* and Whole wheat (*Triticum eastrum*) flour used for this study were purchased from Oja Oba market, Akure, and authenticated at the Department of Crop, Soil and Pest Management, Federal University of Technology, Akure. All chemicals are analytical grade and were purchased from Sigma Chemicals (St. Louis, MO, USA).

2.2 Methods

Sample preparations

Bambara groundnut (BGN) was processed into flour using a modified method described by Nwosu. (2013). BGN were sorted, soaked with distilled water at ratio 1:2 for 24 h at room temperature, dehulled using attrition mill, dried using electrical air-oven at 60 °C for 3 h, milled into a fine particle size using electrical stainless steel blender, sieved using 1 mm sieve. The fine flour of the groundnut was blend with whole WF using the blending ratios (100:0, 90:10, 80:20, 70:30, 60:40, 50:50 and 100:0%) of BGN flour and whole WF labelled WB1, WB2, WB3, WB4, WB5 and WB6, respectively.

Preparation of cookies

The cookies was prepared by the procedure described by Okaka (2009) using the recipe shown in Table 1. The fat and sugar were mixed until fluffy. Egg and milk were added while mixing continued for 40 min, appropriate amount of flour, baking powder, nut-meg, vanilla flavouring and salt were slowly introduced into the mixture. The dough was rolled and cut into circular shapes of 5 com diameter. Baking was carried out at 120 ^{o}C for 25 min using the flour blends. The cookies was collected and stored in a closed high density polyethene nylon until further analysis.

Table I: Recipe for cookies production

Ingredients	Quantity (g)
Flour	500.00
Fat (Vegetable oil)	200.00
Sugar	125.00
Salt	5.00
Egg	2.50
Milk	7.50
Nut-meg	1.50
Vanilla flavour	2.50
Baking powder	5.00

2.3 Determination of functional properties of bamabara groundnut-wheat flour blends

Oil & Water Absorption Capacity (OAC & WAC)

Oil and water absorption capacity of flours blends determined according to the centrifugation method (AOAC 2005).

Swelling index (SI)

The method of Ukpabi and Ndimele (1990) was used. Fifty grams of each flour samples were put into a 500 mL measuring cylinders. Three hundred (300) mL of cold water were added and allowed to stand for 4 h before observing the level of swelling. The swelling index were then calculated as the multiple of the original volume.

Bulk density (BD)

Bulk density was estimated as described by Maninder et al. (2007). The flour samples were gently filled into 10 ml graduated cylinders, previously tared. The bottom of each cylinder was gently tapped on a laboratory bench several times until there was no further diminution of the sample level after filling to the 10 ml mark. Bulk density was calculated as weight of sample per unit volume of sample (g ml^{-1}). Measurements were made in triplicate.

2.4 Determination of physical properties of bamabara groundut-wheat flour cookies

Weight

The weight of cookies was determined using Oluwamukomi et al. (2011). The weight of the biscuits was measured by weighing on a weighing balance (Model Mettler PE1600, Mettler Instruments Corporation, Greifensee, Zurich, Switzerland) with an accuracy of 0.1 mg).

Diameter

Diameter was estimated using Ayo et al. (2007) method. The diameter was measured with a calibrated ruler.

Spread ratio and Height

The spread ratio was determined using Ayo et al. (2007) method. Three rows of the five well-formed biscuits were made and the height measured as well as arranging the same biscuits horizontally edge and the sum of the diameter measured.

$$\text{Spread ratio} = \frac{\text{Diameter}}{\text{Height}}$$

2.5 Determination of proximate composition of Bambara groundnut-wheat flour cookies

Proximate composition was determined using the method of A.O.A.C. (2005) and the carbohydrate content was obtained by difference.

2.6 Sensory evaluation of Bambara groundnut-wheat flour cookies

Sensory analysis was carried out on the cookies produced from each of the flour blends. Thirty (30) members' semi-trained panelists were involved. Quality attributes evaluated were appearance, texture, taste, flavor, crispiness, and overall acceptability using a 9-point Hedonic scale, where 9 is like extremely and 1 is dislike extremely.

2.7 Statistical analysis

Triplicate replications were used to obtain mean values and standard deviations. Statistical analysis was performed with SAS (Statistical Analysis Software 17.0, USA) using one-way ANOVA. Duncan's multiple-range test was carried out to compare the mean values for samples with significant differences taken at p <0.05.

3.0 Results and discussion

3.1 Proximate Composition

The result of the proximate composition of the flour blends is presented in Table 2.The result shows that the moisture content of the flour ranges from 3.40–11.24%, crude protein, 9.38–22.75%; crude fibre, 0.42–2.42%; crude fat, 12.51–18.98%; total ash, 0.91–2.99% and carbohydrate, 43.62–71.38%. The protein content (22%) of BGN flours (WB6) obtained in this present finding is significantly ($p \leq 0.05$) higher than the 9% of whole WF (WB1). The protein content of the flour sample increase with increasing BGN flour. This was expected since BGN is a legume while wheat is a cereal grain and legumes naturally contain more protein than cereals although the prevalent protein in wheat occurs as gluten which is needed in baking. The protein content of WB6 is in agreement with values (21–28 g 100 g^{-1}) reported from past studies (Adebowale et al., 2002; Arise et al., 2015; Oyeyinka et al., 2018). Moisture, ash and crude fibre of the flour blends were generally low and are similar to the findings of Oyeyinka et al., 2018. In contrast, the present crude fiber contents obtained in this study (0.42%) is lower than the 1.47% reported by Oyeyinka et al., 2018 and this could be influence by difference source, origin and processing conditions respectively.

Table II: Proximate composition **(%)** of Bamabara groundnut-wheat flour blend

Samples	Moisture	Protein	Crude Fibre	Crude Fat	Total Ash	Carbohydrate
WB1	3.40 ± 0.10^{d}	9.38 ± 0.12^{f}	2.42 ± 0.01^{a}	12.51 ± 0.07^{e}	0.91 ± 0.01^{d}	71.38 ± 0.11^{a}
WB2	5.72 ± 0.70^{c}	11.68 ± 0.08^{e}	2.16 ± 0.04^{b}	18.08 ± 0.03^{d}	1.35 ± 0.58^{c}	61.01 ± 0.03^{c}
WB3	5.89 ± 0.12^{b}	11.83 ± 0.05^{d}	1.97 ± 0.02^{c}	18.16 ± 0.02^{c}	1.22 ± 0.02^{c}	60.93 ± 0.44^{bc}
WB4	5.06 ± 0.40^{c}	12.56 ± 0.06^{c}	1.87 ± 0.03^{d}	18.22 ± 0.24^{bc}	1.10 ± 0.02^{c}	61.19 ± 0.10^{b}
WB5	5.59 ± 0.02^{c}	14.58 ± 0.06^{b}	1.87 ± 0.01^{d}	18.54 ± 0.02^{b}	2.65 ± 0.01^{b}	56.77 ± 0.06^{c}
WB6	11.24 ± 0.23^{a}	22.75 ± 0.02^{a}	0.42 ± 0.02^{e}	18.98 ± 0.04^{a}	2.99 ± 0.02^{a}	43.62 ± 0.26^{d}

Values are Means ± SEM. Values with different superscripts within the same column are significantly different ($p \leq 0.05$).

Keys: WB1 = 100% Wheat flour, WB2 = 80% Wheat flour and 20% Bambara flour, WB3 = 70% Wheat flour and 30% Bambara flour, WB4 = 60% Wheat flour and 40% Bambara flour, WB5 = 50% Wheat flour and 50% Bambara flour, WB6 = 100% Bambara flour.

3.2 Functional properties

The functional properties of samples is shown in Table 3. The values ranges from 3.08–4.20; 2.00–2.30; 1.05–1.31 and 0.62–0.72 g/ml for Oil Absorption Capacity (OAC), Water absorption Capacity (WAC), Swelling Index (SI) and Bulk Density (BD) respectively. There was a significant difference ($p \geq 0.05$) between 100% WF sample (WB1) and other samples substituted with BGN as WB1 exhibited the highest OAC & WAC (4.20 g oil g^{-1} sample and 2.40 g water g^{-1} sample) while the 100% BGN flour (WB6) had the lowest OAC & WAC (3.08 g oil g^{-1} sample and 2.00 g water g^{-1} sample). The findings in this report is close to 3.65 g oil g^{-1} findings of Akpapunam and Darbe (1993) but slightly lower than 3.80 g water g^{-1} of BGN flour. Although the finding in this report are in agreement with Abbeh and Ibeh (1987) findings. The low OAC and WAC of BGN products flour might be due to low levels of hydrophobicity of proteins which show superior binding of lipids. The bridge caused by protein in fat and water emulsion may not make BGN flour products a suitable ingredient in the cold meat industry particularly for sausages.

The swelling index increase (1.05–1.31) significantly ($p \leq 0.05$) as the BGN flour increases within the samples from 0% up to 100%, while no significant difference ($p \leq 0.05$) was observed in bulk density (0.62 g ml^{-1}) of substituted blend samples of BGN flour from 20%–100%. This result were comparable to 0.56 and 0.62 g ml^{-1} reported by previous findings (Eltayeb et al., 2011 and Adeleke et al., 2018). The presence of higher proportion of carbohydrate in WF may be responsible for the high BD demonstrated. Starch polymer structure has been seen to influence BD and loose starch polymer could result in low bulk density (Plaanmi 1997).

Table III: Functional properties **(**g ml^{-1}**)** of Bambara groundnut-wheat flour blend

Samples	Oil absorption	Water absorption	Swelling index	Bulk density
WB1	4.20 ± 0.20^{a}	2.30 ± 0.30^{a}	1.05 ± 0.02^{c}	0.72 ± 0.10^{a}
WB2	3.40 ± 0.20^{b}	2.00 ± 0.02^{b}	1.06 ± 0.03^{c}	0.69 ± 0.03^{ab}
WB3	3.40 ± 0.01^{b}	2.00 ± 0.01^{b}	1.06 ± 0.03^{c}	0.69 ± 0.01^{ab}
WB4	3.20 ± 0.02^{b}	2.00 ± 0.02^{b}	1.11 ± 0.01^{b}	0.66 ± 0.03^{ab}
WB5	3.20 ± 0.02^{b}	2.00 ± 0.01^{b}	1.12 ± 0.02^{b}	0.64 ± 0.02^{ab}
WB6	3.08 ± 0.20^{c}	2.00 ± 0.03^{b}	1.31 ± 0.01^{a}	0.62 ± 0.03^{ab}

Values are Means ± SEM. Values with different superscripts within the same column are significantly different ($p \leq 0.05$).

Keys: WB1 = 100% Wheat flour, WB2 = 80% Wheat flour and 20% Bambara flour, WB3 = 70% Wheat flour and 30% Bambara flour, WB4 = 60% Wheat flour and 40% Bambara flour, WB5 = 50% Wheat flour and 50% Bambara flour, WB6 = 100% Bambara flour.

3.3 Physical characteristics

Physical parameter of Bambara groundnut-wheat cookies are presented in Table 4. Values ranges from 10.06–12.01 g, 0.57–1.08 cm, 5.07–6.31 cm and 9.76–10.96 for weight, height, diameter and spread ratio respectively. Weight of the cookies increase significantly ($p \geq 0.05$) with increase in the amount of BGN in the sample blends and this effect is applicable to height, diameter and spread ratio. Cookies made from 100% WF cookies (WB1) had the least weight (10.06 g), while 100% BGN flour cookies had (12.01 g) weight and this is similar to 13.78 g of cookies made from BGN flour as reported by Akpapunam and Darbe (1993). There is no significant difference ($p \geq 0.05$) in the spread ratio of the cookies made from WF and those made from blend constituted with BGN flour however, significantly ($p \geq 0.05$) lower than cookies make form 100% BGN flour.

Table IV: Physical characteristics of Bambara groundnut-wheat flour cookies

Samples	Weight (g)	Height (cm)	Diameter (cm)	Spread ratio
WB1	10.06±0.18^{b}	0.67±0.06^{bc}	5.07±0.35^{c}	9.76±0.10^{b}
WB2	10.20±0.62^{b}	0.50±0.10^{bc}	5.12±0.03^{c}	10.04±2.10^{ab}
WB3	10.32±0.01^{b}	0.57±0.06^{bc}	5.47±0.12^{c}	10.13±0.96^{ab}
WB4	10.66±0.77^{b}	0.57±0.12^{bc}	5.60±0.10^{b}	10.35±1.99^{ab}
WB5	11.26±0.73^{b}	0.70±0.01^{b}	5.77±0.21^{b}	10.58±1.51^{ab}
WB6	12.01±0.01^{a}	1.08±0.03^{a}	6.31±0.01^{a}	10.96±0.03^{a}

Values are Means ± SEM. Values with different superscripts within the same column are significantly different ($p \geq 0.05$).

Keys: WB1 = 100% Wheat flour, WB2 = 80% Wheat flour and 20% Bambara flour, WB3 = 70% Wheat flour and 30% Bambara flour, WB4 = 60% Wheat flour and 40% Bambara flour, WB5 = 50% Wheat flour and 50% Bambara flour, WB6 = 100% Bambara flour.

3.4 Sensory evaluation

The result of sensory evaluation is shown in Table 5 below. From the results; it was observed that the best crispness as indicated by the panellist was from the 100% WF (WB1) cookies which had a mean value of 6.80 closely followed by the product from 10% and 20% substitutions with BGN which had 6.70 and 6.60 respectively, though there was no significant difference ($p \geq 0.05$) between them. There occurred a significant difference ($p \leq 0.05$) with 100% BGN (WB6). From the result, the crispness of the biscuits decreased with increase in the level of BGN flour. This could be attributed to the lower gluten content of BGN since gluten is responsible for the extensibility of the dough.

Based on appearance, the WB1 sample ranked highest with a mean value of 7.70. This was very close to 20% substitutions of 7.35 and there was no significant difference ($p \geq 0.05$) between the two samples. Substitution up to 30:70; 40:60 and even up to 50:50 (Bambara: wheat) were fairly accepted by the panelists having a score of 6.30; and up to (100 % Bambara) with a mean value of 4.96.

Based on Aroma, there was a significant difference ($p \geq 0.05$) between WB1 and other samples. But there was no significant difference ($p \geq 0.05$) among substituted samples up to 50:50 substitutions (Bambara: wheat). Although there was a significant difference ($p \geq 0.05$) between WB2-5 (6.95) and WB6 (4.96). Since aroma is a determining factor in consumers' acceptance of cookies it can be deduced that the biscuit is accepted up to 50% substitution with BGN. The only handicap is the slight aroma of the beamy off flavour that was still noticed.

From the results of the overall acceptability of the samples, there was no significant difference ($p \geq 0.05$) between samples WB1, WB2, WB3 (up to 40% substitution with BGN) with mean scores of 7.40, 7.30 and 6.95 respectively. Also up to 50% substitution with a mean score of 6.35 was slightly liked by panelists. This showed that the panelists accepted this product up to 50% level of substitution of WF with BGN flour. Since all the parameters used in this sensory evaluation had good sensory scores, it could be recommended that up to 50% BGN flour be used in the substitution of WF in the production of cookies.

Table V: Sensory evaluation of Bambara groundnut-wheat flour cookies

Samples	Taste	Aroma	Crispness	Appearance	Overall acceptability
WB1	7.70±0.92^{a}	7.10±1.20^{a}	6.80±1.72^{a}	7.70±1.66^{a}	7.40±0.94^{a}
WB2	6.70±1.41^{b}	5.60±1.50^{b}	6.70±1.65^{a}	7.35±1.33^{a}	7.30±1.30^{a}
WB3	6.45±1.66^{b}	5.90±1.58^{b}	6.60±1.14^{a}	6.65±1.01^{b}	6.95±1.05^{ab}
WB4	6.45±1.50^{b}	5.90±1.48^{b}	6.65±1.30^{a}	6.50±0.82^{b}	6.95±1.19^{ab}
WB5	5.60±1.63^{b}	5.55±1.27^{b}	6.50±1.50^{a}	6.30±1.50^{b}	6.35±1.26^{b}
WB6	4.01±0.05^{c}	4.31±0.11^{c}	5.16±0.14^{b}	4.06±0.16^{c}	4.96±0.04^{c}

Values are Means ± SEM. Values with different superscripts within the same column are significantly different ($p \leq 0.05$).

Keys: WB1 = 100% Wheat flour, WB2 = 80% Wheat flour and 20% Bambara flour, WB3 = 70% Wheat flour and 30% Bambara flour, WB4 = 60% Wheat flour and 40% Bambara flour, WB5 = 50% Wheat flour and 50% Bambara flour, WB6 = 100% Bambara flour.

4. Conclusion

Wheat and Bambara flour can be combined to produce cookies with appreciable improved protein content, which can may be use in the management of protein energy malnutrition. The use of this flour blends will reduce the pressure on WF and help to improve the utilization of Bambara groundnut flour, and prevent it from going into extinction. This is an advantage in a non-traditionally wheat producing country like Nigeria. It is also of interest in child feeding programs and food for the low income groups.

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