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Effect of Roasted Bambara Groundnut (*Voandzeia subterranea*) Fortification on Quality and Acceptability of Biscuits

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Abstract: Biscuits were produced from refined wheat flour and roasted Bambara Groundnut (BGN) flour (140°C for 20 min) at ratio: 100:0, 80:20, 70:30, 60:40 and 50:50 respectively. The physical, chemical and organoleptic properties and acceptability of the biscuits were evaluated. The BGN fortified biscuits contained high quantities of crude protein (11.42-13.96%), total fat (14.30- 15.46%) and carbohydrate (64.85- 74.04%). The moisture content (3.42-3.74%) and the caloric value (451.94-454.38 kcal/100 gm) were similar in all the blends, while crude ash (0.56-2.13%) significantly ($p<0.05$) differed from each other. No significant difference ($p>0.05$) was observed between weight, thickness and spread ratio of the 100:0 wheat (control) and BGN fortified biscuits. However, there were significant differences (p<0.0.5) between the control and the fortified biscuits in breaking strength with the 100:0 ratio wheat flour biscuit having the higher value of 1.41. Sample with 50:50 ratio roasted BGN flour was significantly ($p<0.05$) darker in color than the control (100:0 wheat flour biscuit) and those fortified with 80:20 and 70:30 BGN flour. Sensory evaluation result indicates that all the fortified biscuits had high sensory ratings for the attributes evaluated. There were no significant ($p>0.05$) differences between biscuits with 80:20, 70:30 and 60:40 BGN flour and the control sample in crust color, crust surface characteristics and taste. Although, biscuits with ratio 50:50 BGN flour had lower mean scores in crumb color, texture and taste, they were generally acceptable to the panelist. In all, biscuits with up to 70:30 wheat flour/roasted BGN flour ratio blend compared favorably well with the control in all the evaluated quality attributes.

Key words: Bambara groundnut, roasting, biscuit, fortification, quality

INTRODUCTION

Malnutrition is one of the greatest health challenges experienced in the developing world. Enrichment of food products, such as biscuits and bread, with high protein fractions from plant and animal sources, could be used to increase the protein content and essential amino acid balance of the resultant food (Okafor *et al*., 2006; Okafor, 2012; Ayo *et al*., 2007). Biscuits which are ready-to-eat snacks that are convenient, inexpensive and are popular especially among children in Nigeria and other countries (Addo *et al*., 1987). Report by Ayika and Uwaegbute (2005) indicated an increasing tendency among Nigerian children and adolescents to adopt dietary habits of eating snacks like biscuits as an alternative to the traditional eating pattern of three meals per day. Good eating qualities make biscuits one of the most welcome snacks by children (Tsen, 1976; Lorenz, 1983). Nutritionally, biscuits can be easily fortified with protein rich flour from legume and other sources to provide a convenient rich food to supplement the diet, especially in school feeding programme for children as they are readily accepted by children (Lorenz, 1983; Kansas, 2006). Among the numerous potentially protein rich sources used for biscuit fortification include legumes such as bambara groundnut, which is nutritious, comparably cheaper than other legumes to produce, but is largely under-utilized (Ayinde and Olusegun, 2003).

In Nigeria, bambara groundnut is the third most important legume after cowpea and groundnut (Baryeh, 2001). The seed have high nutritional value with 24% protein, 6.8% lysine, 1.8% methionine and about 50% carbohydrate content (Mkandawire, 2007) It is also rich in vitamins (niacin, riboflavin, thiamin) and minerals (FAO, 1982). The high nutritional quality makes it an excellent crop to be used for enrichment or fortification of cereal products such as biscuits. Nevertheless, bambara groundnut, like most legumes has strong beany flavor, bitter taste, anti nutritional factors and hard-to-cook defects which limit their utilization in food formulation (Uvere *et al*., 1999). Different processing treatments like roasting and other heat processing methods have been reported to improve the protein digestibility and protein efficiency ratio, taste and acceptability of legumes (Salunke *et al*., 1985). Roasting brings about changes in aroma which are described as nutty, burnt and coffee like due to the formation of

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pyrazine compounds in the roasted food. It has been reported that the level of pyrazine compounds is also related to the extent of browning (Powrie and Nakai, 1981). Roasting time is very important in enhancing Protein Efficiency Ratio in legumes such as bambara groundnut. The optimum time to maintain maximum protein quality considering available lysine is 15 min of roasting at 200°C (Powrie and Nakai, 1981). The bambara groundnut used in this work was roasted to improve the aroma, taste and acceptability of the flour (roasting gives it a groundnut-like aroma and taste), This will enhance the level to be incorporated in the biscuit, make significant improvement in protein content and consequently, the nutritional quality. Hence, the objective of this study was to produce biscuits containing various percentage of roasted bambara groundnut flour and study their physical, chemical, sensory properties and acceptability.

MATERIALS AND METHODS

Cream coloured bambara groundnut seeds [*Voandzeia subterranae* (L) Thouar] weighing 10 kg were purchased from a local market in Lagos, Nigeria. They were sorted with hand, cleaned to remove dirt and extraneous materials. They were packaged in sealed air tight plastic bags and carried to Central Food Technological Research Institute (CFTRI) Mysore, India where the research was conducted. The bambara seeds were splitted into two parts (cotyledons) and dehulled using versatile dhal mill (CFTRI Mysore, India). After dehulling, the dhals (splitted cotyledons) were roasted at 140°C for 20 min using In-Lab electric roaster (In-Lab Furnaces, Mysore, India). The roasted dhals were cooled and ground into flour using hammer mill (Bathibol Ltd., India). The milled flour was sieved through BS no.80 mesh sieve and packaged in polyethylene bags. The wheat flour used for the biscuit preparation was processed by CFTRI Mysore, India.

Preparation of biscuits: The preparation of the biscuits involved the replacement of part of the Wheat Flour (WF) with bambara flour in the ratio 100:0, 80:20, 70:30, 60:40 and 50:50, respectively. The 100:0 ratio WF formulation without bambara served as control. All the biscuit contained 40% sugar, 40% Margarine, 1% salt, 1% baking powder and 0.8% baking soda. The method described by Leelavathi and Haridas Rao (1993) was used for the production of biscuits. The process includes creaming of sugar and shortening, followed by mixing of other ingredients. This is followed by kneading and sheeting of the mixed dough, cutting into shapes using the stamp cutting method. The cut dough pieces were transferred into fat greased pans and baked at 180-230°C for 15-20 min in an APV baking oven (APV Baker, Australia).

Analysis

Proximate composition: The official methods of the American Association of Cereal Chemists (AACC, 1990) were used to determine moisture, crude protein, lipid, ash and crude fiber contents of the wheat flour, bambara groundnut flour, their blends and fortified biscuits. Moisture content of the wheat flour, bambara groundnut and flour blends were determined according to method 44-19 and expressed as dry basis. Crude protein was determined by an automated Kjedahl method, using Tecator digestion unit model 2006. Crude fat content was determined using soxhlet apparatus, with petroleum ether to extract the lipid according to method 20-26. Method 48-06 was used to determine crude fiber content. The carbohydrate content was obtained by difference (100-crude protein, moisture, total fat and crude ash contents) while the caloric value was obtained by multiplying the values of the crude protein, fat and carbohydrate by their respective physiological fuel values 4, 9 and 4, respectively and taking the sum of the products. Results were expressed on dry weight basis.

Physical evaluation: When cooled, biscuits weights were taken using analytical balance (Ohaus city, United State of America) while the width and thickness (diameter) was measured with calipers. Spread ratio was expressed as ratio of width/thickness. The texture of the biscuits (breaking strength) was estimated and reported as force required in breaking the biscuit in a texture Analyzer (Lloyd LR-5K, UK).

Organoleptic evaluation of biscuits: Sensory qualities of the biscuits were evaluated by experienced panelist. The scoring were 1-20 (1 = very poor, 20 = excellent) for texture and taste and 1-10 (1 = very poor and 10 = excellent) for crust and crumb color, crust surface characteristics and the sum total of these scores for the overall quality.

Statistical analysis: Data were reported as mean±SD. Statistical significance was established using One-Way Analysis of Variance (ANOVA) at 5% level of probability and differences between means were compared using Duncan Multiple range test (Duncan, 1955). Statistical analysis was carried out using SPSS for Windows, version 14.0 (SPSS Inc. Chicago, IL USA).

RESULTS

Chemical composition of the Wheat Flour (WF), roasted Bambara Groundnut (BGN) flour and their blends (Table 1) shows increase in the crude protein, total fat and crude ash contents and decrease in the carbohydrate content of the blends with increase in roasted BGN flour addition. The roasted BGN flour and its blends had significantly ($p<0.05$) higher protein content than the 100:0 wheat flour sample. The protein content of the

Table 1: Chemical composition of wheat flour, bambara groundnut flour and their blends (%)

Proximate parameters	Wheat flour	Bambara flour	*80:20	*70:30	*60:40	*50:50
Moisture	12.30ᵃ±0.82	10.90ᵃ±0.93	11.44ᵃ±0.96	11.01ᵃ±0.84	11.20ᵃ±0.61	11.09ᵃ±0.90
Crude protein	9.60ᶠ±1.01	22.90ᵃ±0.72	12.26ᵉ±0.57	13.59ᵈ±6.43	14.92ᶜ±0.82	16.25ᵇ±0.79
Fat	1.30ᵉ±0.62	7.30ᵃ±0.83	2.50ᵈ±1.02	3.10ᶜᵈ±0.88	3.70ᵇᶜ±0.73	4.30ᵇ±0.48
Ash	0.50ᶜ±0.21	3.70ᵃ±0.32	1.41ᵇ±0.75	1.46ᵇ±0.94	1.78ᵇ±0.87	2.10ᵇ±0.62
Carbohydrate	76.52ᵃ±0.15	55.20ᶠ±0.09	72.39ᵇ±0.70	70.84ᶜ±0.61	68.40ᵈ±0.33	66.26ᵉ±0.54
Calorie	356.18	378.10	361.10	365.62	366.58	368.74

Values represents means±SD (n = 3). Means with same letter as superscript in the same row are not significantly (p>0.05) different.
*Ratio = Wheat flour : Bambara flour

Table 2: Chemical composition of biscuits produced from Wheat (WF) and Bambara Groundnut (BGN) flour blends

WF:BGN	Moisture %	Protein %	Fat %	Ash %	Carbohydrate %	Calorie
100:00	3.42ᵃ±0.38	8.18ᵃ±0.45	13.80ᵃ±0.29	0.56ᵃ±0.30	74.04ᵃ±0.11	453.10
80:20	3.74ᵃ±0.62	11.42ᵇ±0.16	14.30ᵃᵇ±0.55	1.19ᵇ±0.54	69.39ᵇ±1.02	451.94
70:30	3.71ᵃ±0.85	12.28ᵇᶜ±1.09	14.79ᵇᶜ±0.32	1.56ᵇᶜ±0.29	67.66ᵇᶜ±0.88	452.87
60:40	3.16ᵃ±0.14	13.08ᶜᵈ±0.81	14.81ᵇᶜ±0.91	1.82ᵇᶜ±0.74	67.13ᶜ±0.63	454.13
50:50	3.60ᵃ±0.20	13.96ᵈ±0.73	15.46ᶜ±1.01	2.13ᶜ±0.82	64.85ᵈ±0.91	454.38

Values are means±SD (n = 3). Means having same letter as superscript in the same column are not significantly (p>0.05) different

Table 3: Physical properties of biscuits supplemented with roasted bambara groundnut flour

WF:BGN	Average wt (g)	Diameter (cm)	Thickness (cm)	Spread ratio	Breaking strength N
100:00	8.45ᵃ±0.28	5.47ᵃ±0.12	0.65ᵃ±0.20	8.44ᵃ±0.21	1.41ᶜ±0.08
80:20	8.40ᵃ±0.19	5.34ᵃ±0.20	0.63ᵃ±0.15	8.43ᵃ±0.10	1.36ᵇ±0.62
70:30	8.50ᵃ±0.45	5.33ᵃ±0.62	0.64ᵃ±0.60	8.40ᵃ±0.29	1.35ᵇ±0.11
60:40	8.40ᵃ±0.90	5.33ᵃ±0.90	0.63ᵃ±0.81	8.43ᵃ±0.06	1.30ᵇ±2.00
50:50	8.48ᵃ±0.34	5.36ᵃ±0.16	0.64ᵃ±0.04	8.43ᵃ±0.31	1.21ᵃ±0.05

Values are means±SD (n = 3). Means having same letter as superscript in the same column are not significantly (p>0.05) different

Table 4: Organoleptic properties of biscuits produced from Wheat Flour (WF) and bambara groundnut blends

WF:BGN	Crust color	Crumb color	Crust surface appearance	Texture	Taste	Overall quality
100:00	7.55ᵃ±0.95	8.20ᵃ±0.05	8.25ᵃ±0.09	17.20ᵃ±0.16	17.55ᵃ±0.01	59.05ᵃ±0.66
80:20	7.60ᵃ±0.61	7.50ᵃᵇ±0.13	7.85ᵃᵇ±0.68	16.80ᵃ±1.03	16.30ᵃᵇ±0.94	56.30ᵃᵇ±0.34
70:30	7.35ᵃ±0.59	7.50ᵃᵇ±0.29	7.75ᵃᵇ±0.77	14.95ᵇ±0.93	15.82ᵃᵇ±0.89	53.00ᵃᵇ±0.52
60:40	7.35ᵃ±0.11	7.20ᵃᵇ±0.04	7.75ᵃᵇ±0.18	14.60ᵇᶜ±0.65	14.80ᵇᶜ±0.55	51.60ᵇᶜ±0.83
50:50	6.90ᵃ±0.72	6.80ᵇ±0.65	7.30ᵇ±0.01	14.05ᶜ±0.54	13.75ᶜ±0.77	50.40ᶜ±0.95

Values are means±SD. Means having same letter as superscript in the same column are not significantly (p>0.05) different

blends ranged between 12.26-16.25% with the sample ratio 50:50 having the highest value (16.25%) and the 80:20 ratio blend having the least (12.26%). The carbohydrate ranged between 66.26-72.39% with the 50:50 blend having the least value and the 80:20 the highest, sample with 50:50 blend had 368.74 kcal/100 g while the 80:20 formulation had least caloric value of 361.10 kcal/100 g.

Table 2 shows chemical composition of ratio 100:0 biscuit and those fortified with roasted BGN at ratio 80:20, 70:30, 60:40 and 50:50. The BGN fortified biscuits had significantly (p<0.05) higher crude protein, total fat and crude ash contents compared to the control. Addition of roasted BGN flour significantly (p<0.05) increased the crude protein content from 8.18% to 11.42% in 80:20 fortified biscuit and to 13.96% in 50:50 BGN fortified biscuits, which was over 40% increase in the crude protein content. Equally, the crude ash content was increased from 0.56% in 100:0 WF biscuit to 2.13% in 50:50 BGN biscuits which was over 100% increase, the total fat contents was increased significantly in the 50:50 BGN fortified biscuits. There were no significant (p>0.05) differences between the samples in moisture content (3.16-3.74%).

The physical properties of the biscuits (Table 3) indicated that there were no significant (p>0.05) differences between the 100:0 biscuit and roasted BGN fortified biscuits in weight, diameter, thickness and spread ratio. However, significant (p<0.05) difference exist between the control sample and the fortified ones in breaking strength (texture), the 100:0 WF biscuit had significantly higher values 1.41 (breaking strength) compared to 1.21 and 1.36 in ratio 50:50 and 80:20 blends biscuit respectively.

The organoleptic properties result (Table 4) indicated that all the biscuits had high sensory rating for the quality attributes evaluated. There were no significant (p>0.05) differences between biscuits with 80:20, 70:30 and 60:40 flour blends and 100:0 WF in crust color, crust surface characteristic, taste/mouth feel. Although, biscuit with 50:50 formulation had significantly (p<0.05) lower mean scores ratings compared to the 100:0 WF biscuit in most of the attributes, they were still acceptable to the panelist.

DISCUSSION

The result of the proximate analysis in Table 1 shows that Bambara Groundnut (BGN) contain 22.9% protein, which is in the range 15.8-28.0% reported by Brough and Azam-Ali (1992) for different varieties of BGN. This was however, higher than 19.2-21% range reported by Ojimelukwe and Ayernor (1996) and 18.81% reported by Akpapunam and Darbe (1994). The fat content of 7.3% was similar to 7.0-9.2% reported by Obizoba and Egbuna (1992). Carbohydrate content of 55.2% was comparable to the outcome of earlier studies 54-60% by Ojimelukwe and Ayernor (1996). Some of these differences in the composition by different authors may be due probably to variety of bambara groundnut used and soil composition. Significant ($p<0.05$) difference was observed between the wheat flour, BGN flour and their blends in crude protein, total fat, crude ash and carbohydrate content. Both the BGN flour and their blends had significantly ($p<0.05$) higher crude protein, total fat and crude ash content than the wheat flour. Consequently, addition of BGN flour to wheat flour would increase the crude protein, fat and ash content of the fortified biscuits.

Addition of BGN flour to wheat flour significantly ($p<0.05$) increased the crude protein content from 8.18% in the 100:0 wheat biscuit (control) to 13.96% in biscuits supplemented with 50:50 blends (Table 2). The wheat flour biscuits (control) had the lowest protein content of 8.18% which compared to 9.6, 9.3 and 7.4% protein for cream cracker; digestive and plain biscuits respectively reported by Pearson (1976). The high protein content 22.9% of the BGN flour makes it a useful protein supplement when used at 80:20, 70:30, 60:40 and 50:50 levels and greatly contributed to the high protein content of the biscuits. Similarly, there was slight increase in the fat content of the biscuit from 13.8% in the control biscuits to 15.46% in biscuit supplemented with 50:50 WF/BGN flours. The same trend was observed in the crude ash content which increased from 0.56% in the control (100:0) to 2.13% in the 50:50 WF/BGN fortified biscuits. The higher proportion of these components in the biscuits containing BGN could be probably due to higher proportions of crude fat 7.3% and ash 3.7% in BGN flour compared to wheat flour. However, the crude fat content of the biscuits were comparable to 12.0-21.0% reported for biscuits from different composite flour like wheat and soy, wheat and groundnut and wheat and cottonseed (Tsen, 1976). The carbohydrate content decreased from 74.04% in control biscuit to 64.85% in biscuits supplemented with 50:50 ratio blend (Table 2). The decrease could be probably due to the lower content of carbohydrate in the added BGN flour. Similar finding has been reported for biscuits supplemented with different defatted soyflour (Ranjana *et al*., 1996).

The result in Table 3 revealed that there were no significant ($p>0.05$) differences in weight, diameter, thickness and spread ratio between the 100:0 wheat flour biscuit (control) and those supplemented with roasted bambara nut flour. Similar result has been reported by Okafor *et al*. (2006) who indicated non-significant ($p>0.05$) difference in weight, diameter, thickness and spread ratio between 100% wheat flour biscuit and those fortified with 5-15 % Nigerian pleurotus plumonarius mushroom powder.

However, significant ($p<0.05$) differences existed between 100:0 wheat flour biscuit and those supplemented with 80:20-50:50 WF/BGN flour in breaking strength (hardness). It was observed that there was gradual decrease in breaking strength (hardness) with increase in addition of BGN flour. The more the quantity of BGN flour in the biscuits the lower the hardness or breaking strength, this could be probably due to the higher fat content of the biscuit containing more BGN flour, which might have resulted in making it softer. The breaking strength of the 100:0 biscuit (control) was 1.41N while those of the fortified biscuits ranged from 1.21-1.36N with the 50:50 biscuits having the lowest value. Similar observation was reported for cowpea and soybean supplemented biscuits by Okaka and Isieh (1990).

Table 4 revealed that significant ($p<0.05$) difference exist between the wheat flour biscuit (control) and those fortified with ratio 50:50 WF/BGN flour in all the organoleptic properties analyzed. However, there were no significant ($p>0.05$) differences between the 100:0 biscuits and those with 80:20 and 70:30 formulation in crust and crumb color, crust surface characteristics, taste and overall acceptability. Similarly, 60:40 fortified biscuits did not differ significantly ($p>0.05$) from the control biscuit in crust color, crumb color and crust surface characteristics. Although, the biscuits with ratio 50:50 formulation had lower ratings in taste, crumb color, crust surface characteristics and texture probably due to the slight beany flavor of the bambara nut and the texture of the biscuit, they were still acceptable to the panelist. Some of the panelist confessed they could not distinguish the difference between the 50:50 ratio blend and the 100:0 wheat biscuit.

The optimum level of legume (bambara groundnut) flour replacement in this experiment 70:30-60:40 blend ratios was higher than those reported for soybean, peanut, cottonseed and pigeon pea flours (Kulkarni, 1997).

Conclusion: Fortification of wheat flour with roasted bambara groundnut flour significantly increased and improved the crude protein content of the fortified biscuits. Thus roasted bambara groundnut flour could replace up to 40% of wheat flour in biscuit production without adversely affecting the baking characteristics and sensory qualities of the biscuit. The use of bambara groundnut flour at this optimum level 70:30-60:40 blend ratios increased the crude protein content by about 39.38-48.46%.

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