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Effect of Bambara Groundnut Flour (*Vigna subterranea* (L.) Verdc.) Supplementation on Chemical, Physical, Nutritional and Sensory Evaluation of Wheat Bread

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Abstract: Bambara groundnut (*Vigna subterrenea* (L) Verdc) is a major source of vegetable protein in sub-Saharan Africa. And the aim of this study was to enhance the nutritional value of wheat bread through the addition of bambara groundnut flour to wheat four. For this, bambara groundnut seeds were soaked in tap water, manually decorticated, sun dried and milled into fine flour. Proximate analysis of flours of de-hulled bambara groundnut and wheat were conducted. Flour of de-hulled bambara groundnut was used for bread supplementation in ratios of 5, 10 and 15%. Rheological properties of the control flour and wheat flour supplemented with 10% of de-hulled bambara groundnut flour were conducted. The total area and dough development time increased. However, water absorption, stability and extensibility respectively decreased, from 71.3; 8.5; 190 in the control flour to 71.0; 5.5; 180 in the 10% supplemented flour. The increases in the resistance to extension and proportional number from 260 to 280 and 1.37 to 1.56, respectively resulted in stiff dough. The most important effect of wheat bread supplementation was the improvement of protein quantity from 13.74±0.02% for the control bread to 15.49±0.02, 17.00±0.05 and 18.98±0.02% for the 5, 10 and 15% blending ratios, respectively. The *in-vitro* protein digestibility progressively increased from 84.33±0.03 in the control bread to 85.42±0.04, 86.57±0.04 and 87.64±0.03 in breads containing 5, 10 and 15% bambara groundnut flour. The sensory attributes of different types of bread showed that, a significant difference was observed in texture, colour and overall acceptability. However, the panelists gave higher score for 10% de-hulled bambara groundnut flour bread than bread made from other blends. The loaf weights, loaf volume and specific volume increased. However, while the loaf weight increased with addition of 15% de-hulled bambara groundnut flour, both of loaf volume and specific volume decreased. Nutritional value of wheat bread can be enhanced by the addition of de-hulled bambara groundnut flour at a level of up to 10%.

Key words: Bambara groundnuts flour, proximate analysis, bread making, sensory evaluation, nutritional value

INTRODUCTION

The shortage of food protein in the world, especially in developing countries, dictated the search for new sources of protein is very important to substitute or to supplement the existing protein sources. Many foods commonly designated as proteins, are accurately called protein-rich foods. The legumes have been given great attention to utilize them in various types of food having advantages of wide distribution through out the developing countries, in addition to the high protein content (Guthrie, 1971).

Bambara groundnut (*Vigna subterranea* (L.) Verdc.) is an indigenous grain legume grown mainly by subsistence women farmers in drier parts of sub-saharan Africa (FAO, 2001; Mkandawire, 2007). The crop has advantages over more favored species in terms of nutritional value and tolerance to adverse environmental conditions (FAO, 2001; Mkandawire, 2007). Bambara groundnut is an annual crop, which resembles groundnut (*Arachis hypogaea*) in both cultivation and habitat. It is one of the five most important protein sources for many Africans (Chittaranjan, 2007). Adu-Dapaah and Sangwan, (2004), reported that the seed is regarded as a completely balanced food because it is rich in iron 4.9-48 mg/100 g, compared to a range of 2.0-10.0 mg/100 g for most food legumes, protein 18.0-24.0% with high lysine and methionine contents, ash 3.0-5.0%, fat 5.0-7.0%, fiber 5.0-12.0%, potassium 1144-1935 mg/100 g, sodium 2.9-12.0 mg/100g, calcium 95.8-99mg/100 g, carbohydrate

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51-70%, oil 6-12% and energy 367-414 kcal/100 mg. Bambara groundnut is a tropical food legume in Sudan and other tropical areas (Yagoub and Abdalla, 2007). Due to the high price of meat and fish, much importance is now placed on grain legumes as a source of proteins in all the developing countries. Legumes are rich not only in proteins, but in other nutrients such as starch (Yagoub and Abdalla, 2007). In Sudan, bambara groundnuts is grown in rainfed areas of Darfur, Kordofan and Gadarif and it's consumed as a salt-boiled snack food beside maze and cowpea. The aim of this study is to enhance the nutritional value of wheat beard through the addition of bambara groundnut flour to wheat four.

MATERIALS AND METHODS

Source of materials: Bambara groundnut seeds were collected from Um-Gouna village (Southern Darfur State, Sudan) during harvesting period of the year 2008. The seeds were carefully cleaned and freed from foreign materials. Wheat flour (72% extraction) was obtained from Sayga Company, Khartoum, Sudan.

Preparation of de-hulled bambara groundnuts flour: The cleaned bambara groundnuts seeds were soaked for 18 h, manually decorticated, sun dried and milled into fine flour (Rekord A. Gbr, Jehmlich GmbH, Nossen, Germany) then the flour was passed through 60 mm mesh sieve (British standard). The flour was kept in an airtight container at room temperature (32°C) pending further use.

Preparation of control and wheat flour supplemented bread: The bread dough formula as shown in Table 1 was: wheat flour (100%), compressed yeast (1%), salt (1.5%), sugar (4%), oil (2%), commercial bread improver (Top bake 400) and de-hulled bambara groundnuts flour at (0, 5, 10 and 15%) levels. Percentages are based on flour weight. The bread making performances of flours (control and blends) were determined using the modified method as described by Badi *et al.* (1978). The dough was made in specified mixer from (wheat and de-hulled bambara groundnut) flours for 5 min at medium speed. The dough was rested for 15 min and then scaled, molded up into round balls and allowed to rest for another 15 min, then molded, up into pans and placed in the fermentation cabinet for final proof (1 h), then baked. After baking, the loaf weight was immediately determined using sensitive balance. Loaf volume was determined using rapeseeds displacement volumeter method according to Pyler (1973). However, the method was modified by using pearl millets seeds instead of the rapeseeds. Specific volumes were calculated by dividing the loaf volume by its weight.

Chemical analysis: Proximate analysis of flours of de-hulled bambara groundnuts seeds and wheat grains and breads supplemented with different ratios of de-hulled bambara groundnuts flour were conducted for the contents of moisture, ash and crude fat according to the (AOAC, 2005) Crude protein was carried out according to the AOAC (1990). Crude fiber was determined by acid/alkali digestion method according to the AOCS (1985). The total carbohydrate content was calculated by subtracting the previous components from 100.

***In-vitro* protein digestibility:** The *in-vitro* protein digestibility of different types of bread was measured according to the three-enzyme method which was described by Hsu *et al.* (1977) and (Satterlee *et al.*, 1979) in which a multi-enzyme solution of (1.6 mg trypsin, 3.1 mg chymotrypsin and 1.3 mg peptidase per milliliter) were used in the test.

Table 1: Physicochemical characterization of mixture used in the manufacture of wheat bread

	Groundnut Conc.(%)			
Parameters	Control: 0	5	10	15
Wheat flour 72% extraction (g)	500	475	450	425
Water (mL)	300	300	300	300
Yeast (g)	5	5	5	5
Salt (g)	7.5	7.5	7.5	7.5
Sugar (g)	20	20	20	20
Oil (g)	10	10	10	10
De-hulled bambara groundnuts flour (g)	0.0	25	50	75
Mixing time (min)	5	5	5	5
Dough weights (g)	750	750	750	750
Dough characteristics	Soft	Soft	Soft	Soft
First proof (min)	30	30	30	30
Proofing time (min)	60	60	60	60
Proofing temperature (°C)	45	45	45	45
Baking time (min)	12	12	12	12
Baking temperature (°C)	255	255	255	255

Rheological properties: The dough rheological properties for the control wheat flour and flour containing 10% of de-hulled bambara groundnut flour were carried out using Farinograph and Extensograph according to (AACC, 2000) method. The water absorption, dough development time, stability, mixing tolerance index and weakening were determined using Farinograph (Model Type No: 81010, Duisburg, Germany). The total area, extensibility, elasticity and proportional number were determined using Extensograph (Brabender, Duisburg Nr. 185511, type 601203).

Sensory evaluation: A panel of fifteen members composed of adult male and female was used to judge the quality of the different types of bread supplemented with various ratios of de-hulled bambara groundnuts flour compared to the control bread. The panelists were asked to evaluate each sample for appearance, texture, colour, flavour and overall acceptability using a 9 point hedonic scale from 1 to 9 as follows: 1: Extremely bad, 2: Very bad, 3: Bad, 4: Fairly bad, 5: Satisfactory, 6: Fairly good, 7: Good, 8: Very good, 9: Excellent as described by Iwe (2002). The order of presentation of the various samples was randomized and given codes before being tested by the panelists.

Statistical analysis: Data of organoleptic evaluation of the different types of wheat bread were subjected to the analysis of variance procedure and the means were separated at 0.05 levels according to the method described by Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

The proximate analysis of flours of de-hulled bambara groundnuts and wheat indicated that, the contents of moisture, crude protein, ash and fat of de-hulled bambara groundnuts flour are higher than that of wheat flour; while the contents of crude fiber and carbohydrate are lower as presented in Table 2.

The contents of moisture, crude protein, ash, fat, crude fiber and carbohydrate of de-hulled bambara groundnuts flour are (7.5±0.04, 32.16±0.04, 3.24±0.01, 6.49±0.02, 1.08±0.03 and 57.03±0.04%), respectively. Generally, the end products that are made from low ash content samples were brighter and more uniform in colour than those made from high ash content (Eltayeb, 2005). The *in-vitro* protein digestibility of de-hulled bambara groundnuts flour is (81.95±0.05%).

The wheat flour contents of moisture, ash and fat are (6.78±0.02, 1.67±0.03 and 2.58±0.02%), respectively. The data are lower than (8.40, 1.90 and 2.60%), respectively reported by Kent (1983). The crude protein content of wheat flour is (12.58±0.03%). The data is lower than (13.0 and 13.30%) found by Kent (1983) and Kamaljit *et al.* (2011), respectively. Ahmed (1995) reported moisture content of Sudanese wheat cultivars ranged from 6.33 to 8.6%. The crude fiber and carbohydrate contents are (2.73±0.02 and 80.44±0.07%), respectively. The data are higher than (2.70 and 71.40%) reported by Kent (1983), respectively.

As shown in Table 3, wheat-de-hulled bambara groundnuts flour blends decreased the amount of water required for optimum development of dough bread and the stability, respectively from 71.3; 8.5 in the control flour to 71%; 5.5 in the supplemented flour. Park *et al.* (1997) reported that, fortifying bread with added fiber and antioxidant increased the water absorption from 68 to 93%. However, development time, mixing tolerance index and weakening are respectively increased from 4.5; 30; 60 in the control flour to 5.0, 60; 80 in the supplemented flour. The increase of dough development time may be attributed to nature of bambara groundnuts flour. It is, however, evident that the addition has a diluting effect on wheat gluten and hence a negative effect on gluten strength as reflected by the high mixing tolerance index and weakening.

As shown in Table 4, the total area increased from 85 in the control flour to 126 in the supplemented flour.

Table 2: Chemical composition and *in-vitro* protein digestibility of flours of de-hulled bambara groundnuts and wheat (72% extraction)

Component (%)	DBGF	Wheat flour (72% extraction)
Moisture	7.5±0.04	6.78±0.02
Crude protein	32.16±0.04	12.58±0.03
Ash	3.24±0.01	1.67±0.03
Fat	6.49±0.02	2.58±0.02
Crude fiber	1.08±0.03	2.73±0.02
Carbohydrates	57.03±0.04	80.44±0.07
In-vitro protein digestibility	81.95±0.05	nd

DBGF: De-hulled bambara groundnuts flour, nd: Not determined

Table 3: Effect of de-hulled bambara groundnuts flour addition on the physical properties of wheat flour as measured by the farinograoph instrument

Parameter	Control	10% DBGF
Water absorption (%)	71.3	71.0
Dough development time (min)	4.5	5.0
Stability time (min)	8.5	5.50
Mixing tolerance index (BU)	30.0	60.0
Weakening (BU)	60.0	80.0

DBGF: De-hulled bambara groundnuts flour, BU: Brabender unit

Table 4: Effect of de-hulled bambara groundnuts flour addition on physical properties of wheat flour as measured by the extensograph instrument after 135 min

Parameters	Control	10% DBGF
Total area/energy (cm^2)	85	126
Extensibility (mm)	190	180
Resistance to extension (BU)	260	280
Proportional number	1.37	1.56

DBGF: De-hulled bambara groundnuts flour, BU: Brabender unit

Table 5: Chemical composition and *in-vitro* protein digestibility of control bread and bread supplemented with different ratios of de-hulled bambara groundnuts flour

Component (%)	Control	5% DBGF	10% DBGF	15% DBGF
Moisture	5.37±0.02	5.41±0.02	5.45±0.01	5.50±0.04
Crude protein	13.74±0.02	15.49±0.02	17.00±0.05	18.98±0.02
Ash	1.27±0.01	1.58±0.03	1.70±0.04	1.78±0.01
Fat	2.40±0.02	2.67±0.04	2.76±0.02	2.94±0.04
Crude fiber	2.51±0.02	2.46±0.03	2.39±0.04	2.31±0.02
Carbohydrates	74.71±0.02	72.39±0.03	70.70±0.01	68.49±0.01
In-vitro protein digestibility	84.33±0.03	85.42±0.04	86.57±0.04	87.64±0.03

DBGF: De-hulled bambara groundnuts flour

Table 6: Sensory evaluation and physical characteristics of control bread and bread supplemented with different ratios of de-hulled bambara groundnuts flour

Bread	Appearance	Texture	Colour	Flavour	Overall acceptability	Loaf volume $(cm)^3$	Loaf weight (g)	Specific volume $(cm^3\ g^{-1})$
Control	7.5^{a}	8.0^{a}	7.1^{b}	7.3^{a}	7.4^{ab}	220	64.50	3.41
5% DBGF	7.6^{a}	7.3^{ab}	7.5^{ab}	7.3^{a}	6.8^{a}	225	65.14	3.45
10% DBGF	8.0^{a}	8.2^{a}	8.3^{a}	8.0^{a}	7.8^{ab}	240	65.40	3.67
15% DBGF	6.6^{a}	6.4^{b}	7.2^{ab}	6.6^{a}	6.0^{b}	200	66.00	3.03

Means based on 9 points scale (9 = excellent, 1 = extremely bad), Means within the same column having the same letters are not significantly different ($p \geq 0.05$) according to the Duncan's multiple range tests, DBGF: De-hulled bambara groundnuts flour

However, addition of de-hulled bambara groundnuts flour caused a drop in extensibility with increases of de-hulled bambara groundnuts flour levels in the blend from 190 in the control flour to 180 in the supplemented flour. Addition of 10% de-hulled bambara groundnuts flour was the suitable blend for bread making relative to other ratios. The increases in the resistance to extension and proportional number from 260 to 280 and 1.37 to 1.56, respectively resulted in stiff dough.

The proximate analysis and *in-vitro* protein digestibility of different types of bread are presented in Table 5. There is slightly variation in moisture contents of supplemented breads (5.41±0.02, 5.45±0.01 and 5.50±0.04%). The moisture contents are higher than (5.37±0.02%) of control bread and lower than (12.6%) reported by Mepba *et al*. (2007). The increases in moisture contents are probably due to the nature of bambara groundnuts seeds which increased the overall water holding capacity. The estimated protein contents are increased (15.49±0.02, 17.00±0.05 and 18.98±0.02%). The data are higher than (13.74±0.02%) of control bread and (10.2%) reported by Mepba *et al*. (2007). The increases in protein contents revealed that, bambara groundnuts flour is a completely balanced food because it is rich in iron and protein with high lysine and methionine contents (Rowland, 1993). The ash contents are increased (1.58±0.03, 1.70±0.04 and 1.78±0.01%). The data are higher than (1.27±0.01%) of control bread and lower than (2.90%) found by Mepba *et al*. (2007). The fat contents (2.67±0.04, 2.76±0.02 and 2.94±0.04%) are increased. The results are higher than (2.40±0.02%) of control bread and (1.7%) determined by Mepba *et al*. (2007). The crude fiber contents are decreased. The crude fiber contents are lower than (2.51±0.02%) of control bread and higher than (0.09%) determined by Mepba *et al*. (2007). The carbohydrate contents are decreased (72.39±0.03%, 70.70±0.01 and 68.49±0.01%). The data are lower than (74.71±0.02%) of control bread and (71.7%) reported by Mepba *et al*. (2007). The increases in replacement levels of de-hulled bambara groundnuts flour led to increase the *in-vitro* protein digestibility of wheat bread (84.33±0.03 to 87.64±0.03%).

The sensory attributes and physical characteristics of different types of breads are presented in Table 6. The data indicated that, there are significant differences as regard to colour, texture and overall acceptability. However, the acceptability of supplemented beads decreased with the increasing of de-hulled bambara groundnuts flour in the blend. It seems that up to 10% of de-hulled bambara groundnuts flour did not affect the bread quality. The loaf weights, loaf volume and specific volume are respectively increased from 220; 64.50; 3.41 in the control bread to 240; 65.40; 3.67 in the 10% supplemented bread. However, they decreased with the addition of 15% de-hulled bambara groundnuts flour. The data are agreement with that of (Kamaljit *et al*., 2011), who reported that, specific volume was also found to be decrease with increase in level of incorporation of oat fiber, due to dilution of gluten protein.

CONCLUSION

In conclusion, this study succeeded to develop a new product of wheat bread of high nutritive value through utilization of Darfurain neglected crop (bambara groundnuts flour). The most significant effect of bread supplementation is the improvement of protein quantity and *in-vitro* protein digestibility and enhancement of nutritional quality.

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