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Full Length Research paper

Effect of supplementation of Bambara groundnut (*Vigna subterranean* L.) flour on the quality of biscuits

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The objectives of the present study prepare composite flours by different proportions of Bambara groundnut flour with wheat flour. Ratio range of 5 to 30% Bambara groundnut supplementation to prepare biscuits and determine the physical properties (diameter, thickness and spread factor), so as to check the effect of supplementation and sensory evaluation to assess the suitable level of Bambara groundnut flour supplementation were determined. Data showed the total carbohydrates were higher than protein in wheat flour. Bambara flour was higher in protein than wheat flour. Bambara groundnut flour was supplemented with wheat flour at 5, 10, 15, 20, 25 and 30% level. Biscuits prepared without Bambara groundnut flour were kept as control. The mean quality score of the biscuits decreased with the level of the Bambara groundnut flour was increased. Thickness of the biscuits showed gradual increase as the level of Bambara groundnut flour replacement. The highest value (60 mm) was found in T6 (30%) while lowest value (43.32 mm) was found in T0 that was control. Diameter of the biscuits showed gradual increase as the level of Bambara groundnut flour replacement. Data revealed that highest significant value (280.20 mm) was observed for the biscuits prepared from T6 while lowest values were found for biscuits prepared from T0 and T1 were 250.04 and 251.79 mm, respectively. Spread factor of the biscuits showed gradual decrease as the level of Bambara groundnut flour replacement. Data revealed that highest significant value (57.72) was observed for the biscuits prepared from T0 and lowest values (47.48 and 46.70) have been found in T5 and T6, respectively. While colour and crispiness of the biscuits showed a declining trend, there is improvement in the flavour and texture of biscuits formed. Biscuits containing 20% and lower level of the Bambara groundnut flour were acceptable in retention to their overall acceptability. Significant addition of the Bambara groundnut flour restricted the spread of the biscuits.

Key words: Bambara groundnut**,** flour, biscuits, physico-chemical analysis.

INTRODUCTION

Biscuits are confectionery dried to very low moisture content. According to Fayemi (1981), biscuit is defined as a small thin crisp cake made from unleavened dough. Biscuits are an important baked product in human diet and are usually eaten with tea and are also used as weaning food for infants. The school children who are often under weight (ACC/SCN, 1987) use them as snack. The ingredients are simple; they contain soft wheat flour, shortening, sugar, fat, eggs. These ingredients are considered to be low in nutritive and biological values since soft wheat flour used for the production of biscuits is deficient in several nutrients including some vitamins, mineral elements as well dietary fiber (Awan et al., 1991) and contains only 7 to 10% protein (Yamazaki and Greenwood, 1981). Wheat flour lacks certain essential amino acids such as lysine, tryptophan and threonine (Kent, 1975); hence, the low nutritive value of biscuits is an issue of great concern because biscuits are the most commonly eaten snacks by school children who need more protein per unit body weight than adults. The need of production of biscuits with a suitable amount and high biological value of protein will help in developing of

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nutritionally balanced biscuits to produce high density protein biscuits.

Legumes are generally good sources of proteins and contain on an average from 18 to 25%. Legumes have an important role in the suitability of monotonous diets the world over and also many dietary uses. Legumes such as chickpea and soybean are normally added to the pasta, pastry products and bakery products (Erbas et al., 2005; Sanchez et al., 2004).

Bambara groundnut are the untraditional seeds, the new cultivated and promising crop is convenient to adapt in South Upper Egypt for increasing the local planted production and is currently being imported due to lack of legumes in Egypt. They contain 7.2% moisture, 18 24% protein, 6.0 to 7.0% fat and 60 to 63% carbohydrates (Okonkwo and Mary, 2010).

Bambara groundnut (*Vigna subterranean* L.) is a rich source of protein (14 to 24%), carbohydrates (54.5 to 69.3%) and phosphorus (380 mg/ 100 g) (Elegbede, 1998). The seed contain fair amount of iron (7.6 mg/ 100 g) and significant level of calcium (73 mg/ 100 g). The seed grain has a good balance of essential amino acids with relatively high proportion of lysine (6.6%) and 1.3% methionine. Elegbede (1998) and Stephens (2003) noted that Bambara groundnut protein contain higher amount of an essential amino acid, methionine than other grain legumes Stephens (2003), while the oil content is less than half of that found in legume like peanuts and calories of about 36 to 414 Kcal/ 100 g. As a result of its high nutritive value, this legume has a potential to influence the nutritional profile of food (Sripriya et al., 1997). The red-coloured type of the beans could be useful in areas where iron deficiency is a problem as they contain almost twice as much iron as the cream-coloured (De Kock, 2004). Thus, Bambara groundnut could be used to complement cereal grains in order to provide a blanched amino acid profile.

The use of composite flours for the production of bread, cakes, buns and biscuits to increase and improve the protein content has been carried out by several workers. Siddique (1989) used eight different legume flours, including mothbean for the production of 'chapati' and marked improvement in the quality of the fortified wheat flours was observed. Similar observations were recorded by Rawat et al. (1994) when wheat flour was fortified with defatted soy flour.

In our previous study, we presented the origin, the nutritional composition, functional properties (Water and oil absorption, foaming properties, emulsion properties and gelation properties of Bambara groundnuts flour (*Vigna subterranean*) (Eltayeb et al., 2011).

Composite flours are thus advantageous in the sense that inherent deficiencies of essential amino acids in wheat flour (lysine, tryptophan and threonine) are supplemented from other sources.

The objectives of the present study were to prepare composite flours by supplementing wheat flour with different proportions of Bambara groundnut flour to prepare biscuits and determine the physical properties of these biscuit. Sensory evaluation was carried out to determine the effect of supplementation the suitable level of Bambara groundnut flour.

Table 1. The composition of biscuits dough formula.

Weight (gm)	Ingredients
500	Flour
140	Sugar
70	Shortening
0.1	Sodium meta bisulphate
1.0	Sodium bicarbonate
9.0	Ammonium bicarbonate
3.0	Skimmed milk powder
0.2	Vanillia
10	Fructode syrup
100	Water

MATERIALS AND METHODS

Source of raw materials

Wheat flour (72% extraction) was purchased from local market, Cairo, Egypt and the Bambara groundnut (*Vigna subterranean* L.) were purchased from Nyala main in Western Sudan and kept in a polyethylene bags on a dry place. Other ingredients used in preparation of biscuits formula were obtained from a local market.

Reagents

All the reagents in this study were purchased from Merck (Darmstadt, Germany).

Preparation of Bambara groundnut flour

Bambara groundnut seeds were cleaned manually to remove all foreign materials such as dust, dirt, small branches and immature seeds. The cleaned sample were blended to powder (0.60 mm) form with a high speed blender (Braun KMM 30 mill), type 3045, CombiMax (Germany). The flour was extracted from defatted flour with n-hexane in a soxhlet for 9 h. The extracted flour was air dried at room temperature and stored in an airtight polyethylene bags and kept in a refrigerator of about 4°C prior to analysis.

Biscuit making

Biscuit making was carried out according to the method described in Mohamed (2000). The formula preparation of biscuits is shown in Tables 1 and 2 by using 0, 5, 10, 15, 20, 25 and 30% Bambara groundnut flour. The sugar powder and shortening were mixed together for 10 min at slow speed with a dough mixer and then dissolved sodium and ammonium bicarbonate in 50 ml water. During the mixing at slow speed, the vanillia, fructose syrup and

Table 2. Composition of flour (Wheat flour and Bambara groundnut flour).

Treatment	Wheat flour	Bambara groundnut flour
T0 (whole wheat flour)	100	0
T1 (5% Bambara flour)	95	5
T2 (10% Bambara flour)	90	10
T3 (15% Bambara flour)	85	15
T4 (20% Bambara flour)	80	20
T5 (25% Bambara flour)	75	25
T6 (30% Bambara flour)	70	30

sodium meta bisulphate were added. The skimmed milk, the flour and other ingredients were mixed together at slow speed for 10 min and water was added, mixed with other ingredients at high speed for 20 min. The mixing of the dough was continued until reached full development. The biscuits were baked in a conventional electric oven at 220°C for 7 min. Immediately after cooling, samples were evaluated for both physical and sensory characteristics.

Proximate analysis of wheat and Bambara groundnut flours

Wheat and Bambara groundnut flours were analyzed for moisture, protein, fat, crude fiber and ash content according to the methods described in AOAC (2000). The total carbohydrates calculated by differences method.

Physical analysis of biscuits

For the determination of diameter (width), thickness and spread factor, AACC (2000) methods were followed.

Diameter

The diameter (D), of biscuits six biscuits was determined by placing six biscuits edge to edge. The total diameter of the six biscuits was measured in mm by using a ruler. The biscuits were rotated at an angle of 90° for duplicate reading. This act was repeated twice and average diameter was reported in millimeters (AACC, 2000).

Thickness

The thickness (T), of biscuits was determined by placing six biscuits on top of one another. The total height was measured in millimeters with the help of ruler. This process was repeated thrice to get an average value and results were reported in mm (AACC, 2000).

Spread factor

Spread factor is the ratio that depends on the values of the thickness and diameter of the biscuits**.** Spread factor (SF) was determined from the diameter and thickness using the formula:

$$SF = \frac{D \times CF \times 10}{T}$$

where, CF is a correction factor at constant atmospheric pressure. Its value was 1.0 in this case (AACC, 2000).

Sensory evaluation of biscuits

To evaluate the quality and acceptability of the biscuits (0, 5, 10, 15, 20, 25 and 30%) using panelists of ten well-trained judges, the sensory evaluation was carried out for colour, flavour, crispiness, texture and overall acceptability. Biscuits were evaluated using a 9-point hedonic scale (1-dislike extremely to 9 = like extremely). The rating scale was used for all other parameters according to methods described by Larmond (1980).

Statistical analysis

The data obtained from study and sensory evaluation was statistically subjected to analysis of variance (ANOVA) and means separation was by Snedecor and Cochran (1980). The least significant difference (L.S.D) value was used to determine significant differences between means and to separate means at $p< 0.05$ using SPSS package version 15.0.

RESULTS AND DISCUSSION

Proximate composition of different type of flours

The chemical composition of flour extracted from Bambara groundnut and wheat flour on dry weight basis are presented in Table 3. Results show that the dry matter of Bambara groundnut flour and wheat flour were high in protein and carbohydrate contents.

Regarding the results, total carbohydrate was higher than protein in wheat flour. Bambara flour was higher in protein than wheat flour were 17.70 and 12.90%, respectively. These results confirmed by statistical analysis, highly significant differences ($P< 0.05$) were observed between the two contents in the two samples.

Bambara groundnut flour contains highest amount of fat (6.57%) as compared to wheat flour (1.02%). Moisture content was higher in wheat flour (11.95%) than Bambara groundnut flour (6.77%). Ash and crude fiber were also detected but at lower levels in Bambara and wheat flour.

Similar results were observed in Bambara groundnut flour. Chikwendu (2007) and Yusuf et al. (2008) showed that fat, protein, ash, crude fiber and total carbohydrates were 6.0 to 7.3, 17.40 to 22.36, 3.4 to 4.4, 3.30 to 6.10 and 53.1 to 70.52%, respectively.

Table 3. Proximate composition of different type of flour (% on dry weight basis).

Item	Chemical composition of different type of flour		LSD at 5 %
	Wheat flour	Bambara flour	
Moisture	$11.95^{a} \pm 2.0$	$6.77^{b} \pm 0.42$	0.87
Protein	$12.90^{b} \pm 0.02$	$17.70^{a} \pm 0.44$	0.70
Fat	$1.02^{b} \pm 0.02$	$6.57^{a} \pm 0.12$	0.19
Fiber	$0.86^{b} \pm 0.02$	$3.50^{a} \pm 0.15$	0.24
Ash	$0.62^{b} \pm 0.01$	$4.22^{a} \pm 0.12$	0.19
Total *carbohydrates	$84.60^{a} \pm 3.06$	$68.00^{b} \pm 2.15$	0.62

*Carbohydrates: calculated by differences. All values are means of triplicate determinations ± standard deviation (SD). All values within rows of having same superscripts are significantly ($p<0.05$).

Table 4. Physical characteristics of the biscuits with different Bambara groundnut flour content.

Treatment	Thickness mm	Diameter mm	Spread factor
T0 (whole wheat flour)	$43.32^{b} \pm 1.0$	$250.04^{c} \pm 3.0$	$57.72^{a} \pm 1.0$
T1 (5% Bambara flour)	$44.33^{b} \pm 2.0$	$251.79^{c} \pm 4.0$	$56.80^{a} \pm 3.0$
T2 (10% Bambara flour)	$47.33^{b} \pm 3.0$	$254.93^{c} \pm 3.0$	$53.82^{a} \pm 3.0$
T3 (15% Bambara flour)	$48.32^{bc} \pm 3.0$	$268.47^{b} \pm 3.0$	$55.56^{ab} \pm 3.0$
T4 (20% Bambara flour)	$55.00^{a} \pm 2.0$	$273.02^{b} \pm 2.0$	$49.64^{bc} \pm 3.0$
T5 (25% Bambara flour)	$58.00^{a} \pm 3.0$	$275.38^{ab} \pm 4.0$	$47.48^{c} \pm 3.0$
T6 (30% Bambara flour)	$60.00^{a} \pm 3.0$	$280.20^{a} \pm 3.0$	$46.70^{c} \pm 3.0$
LSD at 5%	5.08	7.16	4.91

All values are means of triplicate determinations ± standard deviation (SD). All values within columns of having same superscripts are significantly ($p<0.05$)

Physical evaluation of biscuits prepared from composite flour

Physical characteristics of biscuits prepared from different levels of Bambara groundnut flour substituted wheat flour and control biscuits (100% wheat flour) are shown in Table 4.

Thickness

Results showed that the thickness of the biscuits prepared from the composite flour containing Bambara groundnut flour varied significantly ($P<0.05$) between the treatments. The thickness of the biscuits was affected positively. Thickness of the biscuits showed gradual increase as the level of Bambara groundnut flour replacement from T1 (5%) to T6 (30%). Table 4 and Figure 1 showed the mean values of thickness of the biscuits. The Table showed that highest value (60 mm) was found in T6 (30%) while the lowest value (43.32 mm) was found in T0 that was the control. These findings were in agreement with what was observed by Awan et al. (1995), who found that the thickness of the biscuits was affected positively as there was an increase in the thickness of the biscuits by increasing levels of Mothbean Flour supplementation. Thickness increased with increasing amount of crude fiber and crude protein.

Diameter

Mean diameter of the biscuits (Table 4 and Figure 2) prepared from the different of the composite flour containing Bambara groundnut flour varied significantly ($P<0.05$) between the treatments. Diameter of the biscuits showed gradual increase as the level of Bambara groundnut flour replacement. Data revealed that highest significant ($P<0.05$) value (280.20 mm) was observed for the biscuits prepared from T6 (30%) whereas lowest values were found for biscuits prepared from T0 (control) and T1 (5%) (250.04 and 251.79 mm, respectively). The mean values of the diameter of biscuits prepared from other treatments ranged between 254.33 and 275.38 mm, respectively. These findings were in agreement with what was observed by Claughton and Pearce (1989).

Spread factor

Spread factor is the ratio that depends on the values of the thickness and diameter of the biscuits. The mean

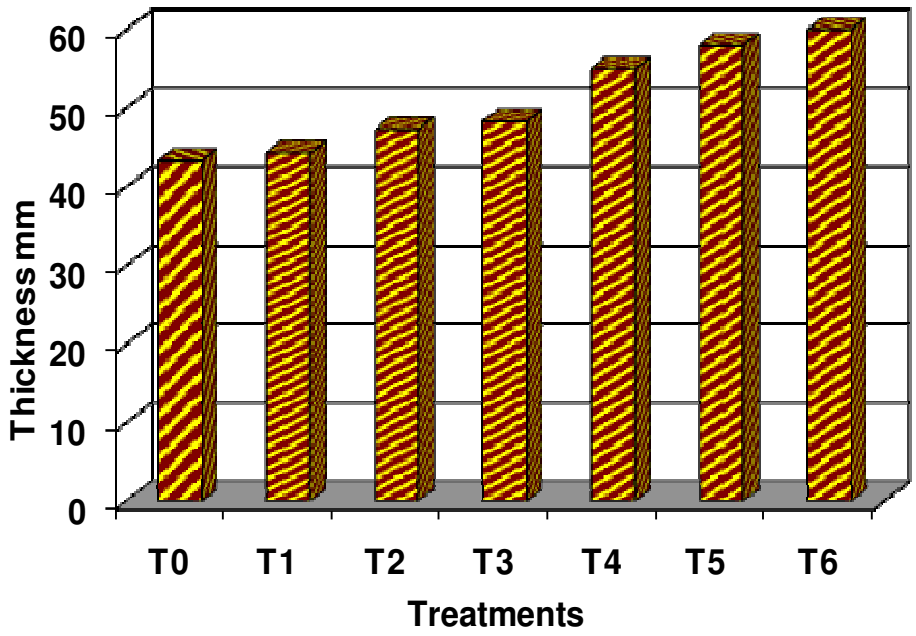

Figure 1. Thickness of the biscuits with different Bambara groundnut flour content.

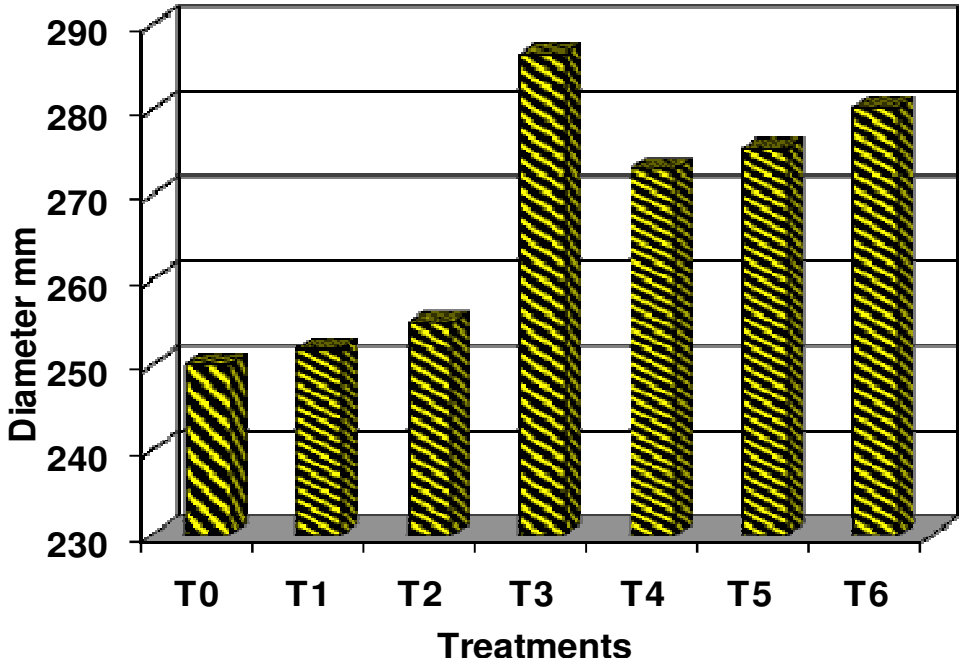

Figure 2. Diameter of the biscuits with different Bambara groundnut flour content.

spread ratio of the sample of composite biscuits is shown in (Table 4 and Figure 3). The results showed that the spread factor gradually decrease as the level of Bambara groundnut flour replacement. Results revealed that highest significant ($P<0.05$) value (57.72) was observed for the biscuits prepared from T0 (control) and lowest values (47.48 and 46.70) have been found from T5 (25%) and T6 (30%), respectively.

Results regarding the physical evaluation of the biscuits are in agreement with Tsen (1976) who reported that fortified wheat flour with soy flour up to the level of 50% drastically reduced spread factor and increased biscuits thickness. Replacement of navy bean and sesame seed flour at 20 and 30% reduced the spread factor of the

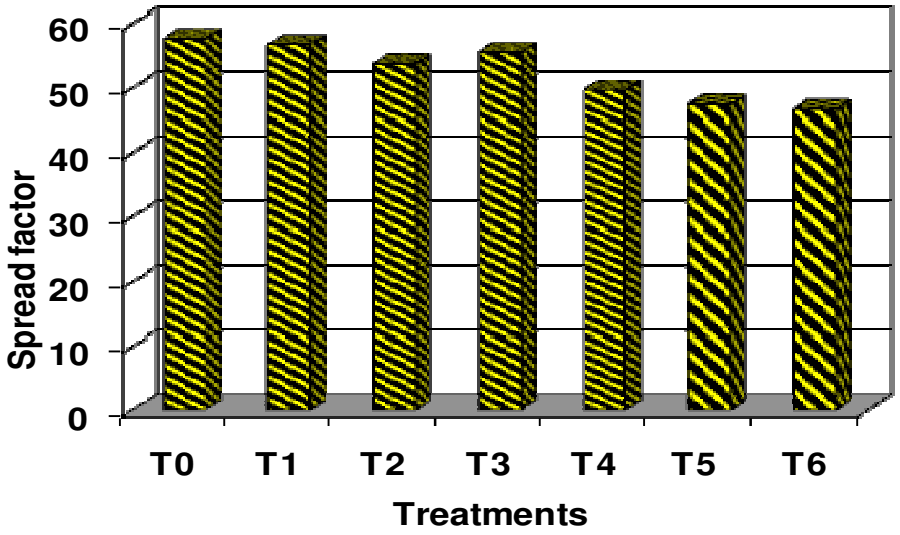

Figure 3. Spread factor of the biscuits with different Bambara groundnut flour content.

Table 5. Sensory attributes of the biscuits containing Bambara groundnut flour.

Treatment	Colour	Flavour	Crispiness	Texture	Overall acceptability
T0 (whole wheat flour)	8.61^{a} ± 1.0	8.59^{a} ± 1.03	8.59^{a} ±1.01	8.70^{a} ±1.04	8.61^{a} ±1.01
T1 (5% Bambara flour)	8.29^{b} ± 1.04	8.33^{a} ± 0.97	8.30^{b} ±1.02	8.49^{b} ±1.03	8.34^{b} ±1.04
T2 (10% Bambara flour)	7.98^{b} ± 1.02	8.08^{b} ± 1.01	8.08^{c} ±1.02	8.25^{c} ±1.03	8.13^{c} ±0.97
T3 (15% Bambara flour)	7.76^{c} ± 1.03	7.81^{b} ± 1.02	7.85^{d} ±1.03	8.04^{c} ±1.02	7.90^{d} ±1.01
T4 (20% Bambara flour)	7.54^{d} ± 1.04	7.62^{bc} ± 1.03	7.61^{d} ±1.03	7.80^{d} ±1.04	7.66^{e} ±1.03
T5 (25% Bambara flour)	7.27^{e} ± 1.02	7.43^{c} ±1.03	7.43^{e} ±1.03	7.58^{e} ±1.03	7.46^{f} ±1.02
T6 (30% Bambara flour)	7.01^{f} ± 1.02	7.21^{d} ±0.98	7.22^{f} ±0.98	7.37^{f} ±0.97	7.27^{g} ±1.02

-All values within columns of having same superscripts are significantly ($p<0.05$).

whole wheat flour biscuits (Hoojat and Zebik, 1984). This can be attributed probably to the effects of composite flours that form aggregates with increased numbers of hydrophilic sites found within the oligosaccharides, polysaccharides and protein which increased competing for the limited free water in cookies dough (Hallen et al., 2004). Also, the rapid partitioning of free water of these hydrophilic sites could occur during dough mixing that would increase dough viscosity, and might leads to decrease the spread factor (MacWatters, 2003).

The spread ratio of cookies made with high protein flour does not develop during baking, as non-wheat high protein flours used in biscuits exhibit greater water retention than those made from wheat flour (Ordorica and Peredes, 1990). The water in the system was insufficient to dissolve the sugar during baking which increased the viscosity and the biscuits spread at a slower rate. This decrease indicated that the biscuits lost more water upon baking.

The low spread ratio of the sample showed that starch polymer molecules are highly bond with the granules with the granules and swelling is limited when heated. On cooling, the starch rapidly forms a rigid gel with capacity characteristics of large molecular aggregates (Awan et al., 1991).

These results were in close agreement Awan et al. (1995) who reported that spread factor, like that of width, decreased with increasing level of Mothbean flour supplementation Such a decrease occurs also when fat content is lowered in soft dough biscuits (Ordorica and Paredes, 1990)

Sensory evaluation of biscuits prepared from composite flour

Colour

Colour is very important parameter in judging properly baked biscuits that not only reflect the suitable raw material used for the preparation but also provides information about the formation and quality of the product (Figure 4). Mean quality score of the colour of the biscuits are given in the Table 5. It is evident from the results that

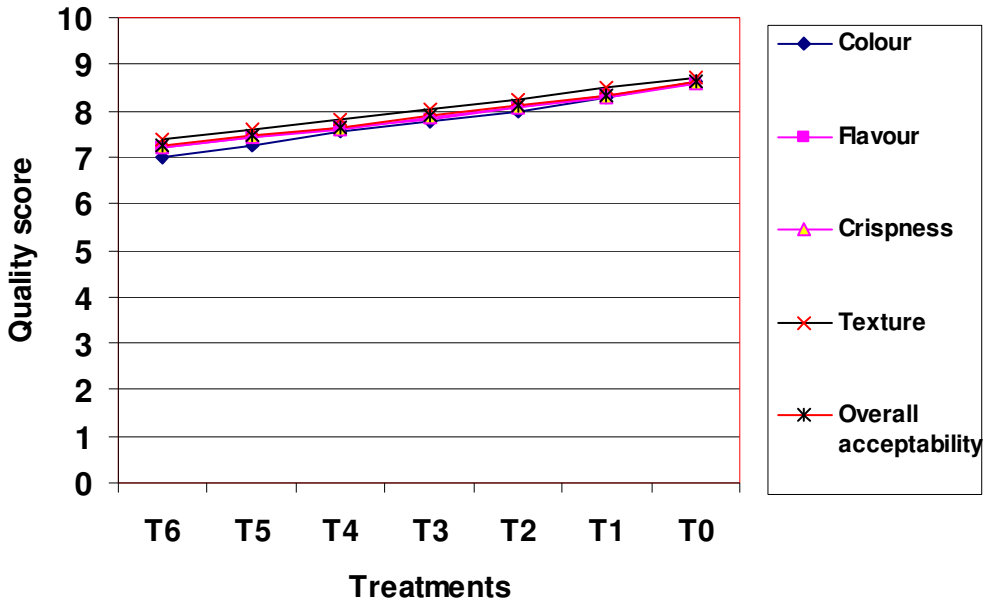

Figure 4. Quality score of the biscuits with different Bambara groundnut flour content.

significantly (P< 0.05) highest was by biscuits prepared from T0 (8.61) while significantly (P< 0.05) lowest by biscuits prepared from T6 (7.01). Judges disliked the biscuits prepared from T5 (25%) and T6 (30%) with respect to colour when subjected to sensory evaluation. Darkness in the colour of the biscuits was observed as the level of the supplementation of the Bambara groundnut flour was increased in the wheat flour that may be subjected to the dark brown color of the Bambara flour. The level of raw cowpea incorporation increased (5, 10, 15 and 20%); the darkness in the crumb and crust of the bread was increased (Hallen et al., 2004). Similar effect (darkness) on colour was observed when wheat flour was substituted with different levels of sunflower protein isolate for the production of biscuits (Claughton and Pearce, 1989).

Flavour

Flavour is the main criterion that makes the product to be liked or disliked. Quality score for the flavour of the biscuits revealed that the flavour of the biscuits varied significantly (P<0.05) among different treatments. The results in Table 5 and Figure 4 indicated that the biscuits prepared from T0 (control) were scored significantly (P< 0.05) high (8.59) for flavour. With respect to the flavour, the judges accepted biscuits from all the treatments of the composite flour containing Bambara groundnut flour. Similar observation were noted during supplementing wheat flour with mustard protein concentrate and cotton seed flour for the production of cookies (Rajpoor, 1988).

Crispiness

Table 5 and Figure 4 showed the quality scores for the crispiness of the biscuits; from the results, quality score for the crispiness of the biscuits ranged from 7.22 to 8.59. The highest (8.59) significant value (P<0.05) for the quality score of the biscuits prepared from T0 (control). Judges have disliked the biscuits prepared from T6 (30 %) when subjected under sensory evaluation.

Texture

Table 5 and Figure 4 show the texture of the biscuits containing Bambara groundnut flour in their formulation was significantly affected with the increase in the level of Bambara flour. Biscuits prepared from T0 (control) got highest (8.70) significant (P<0.05) score while lowest score was obtained in the biscuits prepared from T6 (30%). With respect to the texture, Judges accepted biscuits prepared from all the treatments of the composite flour containing Bambara groundnut flour. These results are similar to the findings of (Rajpoot, 1988).

Overall acceptability

The statistical analysis regarding the overall acceptability of biscuits prepared from Bambara groundnut flours is depicted in Table 5 and Figure 4. The results show that supplementation significantly affected the overall acceptability of the biscuits. Maximum score (8.61) by biscuits prepared from T0 (control) while minimum scores

(7.46) and (7.27) were scored by the biscuits prepared from T5 (25%) and T6 (30%). Biscuits prepared from T5 and T6 have been were rejected by judges with respect to overall acceptability. The results of the sensory evaluation of the biscuits prepared from the different treatments of the composite flour are according to the findings of Gambus et al. (2003) and Shearer (2002), who reported increasing the levels of flaxseed flour, matric flour, caw pea flour in the biscuit which resulted in significant decrease in the sensory attributes of the biscuits.

Conclusion

This study characterized the functional properties of Bambara groundnut flour and their blends with wheat flour for the production of good quality biscuits. The mean quality score of the biscuits decreased with increase in the level of the Bambara groundnut flour supplementation. Biscuits containing 20% and lower level of the Bambara groundnut flour were acceptable in relation to their overall acceptability. Significant reduction in the spread factor of the biscuits was observed. Addition of the Bambara groundnut flour restricted the spread of the biscuits. This study has opened up new possibilities of application for Bambara groundnut and wheat flours. However, evaluation of protein quality of the biscuits in future research would be desirable.

REFERENCES

AACC (2000). Approved Methods of the American Association of Cereal Chemists.American Association of Cereal Chemists (10th ed.). The Association INC. St., Paul, Minnesota, USA.

ACC/SCN (1987). First Report on the World Nutrition Situation. Food and Policy Division, FAO, Rome.

AOAC (2000). Official Methods of Analysis of the Association of Official Analytical Chemists International 17th Ed. Published by the Association of Official Analytical Chemists International, Suite 400 2200 Wilson Boulevard, Arlington, Virginia 22201-3301, USA.

Awan JA, Ateeq-ur-Rehman, Saleem ur Rehman, Ismail Siddique MI, Abu Saeed H (1995). Evaluation of biscuits prepared from composite flour containing mothbean flour. Pak. J. Agric. Sci, 32(1): 211-217.

Awan JA, Salim-ur-Rehman, Ullah E, Siddique MI, Aziz T (1991). Nutrition of wheat flour in Islamic perspective. JAPS, 1(2): 1-7.

Chikwendu NJ (2007). Chemical composition of four verities of ground bean (*Kerstingiella geocarpa*). J. Agric. Food Environ. Ext., 6(2): 73-64.

Claughton SM, Pearce RJ (1989). Protein enrichment of sugar snap cookies with sunflower protein isolate. J. Food Sci., 54(2): 354-356.

De Kock C (2004). Specialty Foods of Africa. Pvt Ltd, Harare, Zimbabwe.

Elegbede JA (1998). Legumes. Int: Osagie AU, Ou Eka (Eds.). Nutritional Quality of Plant Foods. Post. Harvest. Research Unit, University of Benin, Benin, Nigeria, pp. 53-83.

Eltayeb ARSM, Ali OA, Abou-Arab AA, Abu-Salem FM (2011). Chemical composition and functional properties of flour and protein isolate extracted from Bambara groundnut (*Vigna subterranean*). Afr. J. Food Sci., 5(2): 82-90.

Erbas M, Certel M, Uslu MK (2005). Some chemical properties of white lupin seeds (*Lupinus albus L.*). J. Food Chem., 89: 341-345.

Fayemi PO (1981). Home Economics Teacher Guide. Ibadan Macmillian Nigeria Publisher Ltd., P. 201.

Gambus H, Milulec A, Matusz A (2003). The Canadian muffins and hermit cookies with linseeds. Zywnosc, 10(3): 82-92.

Hallen E, Ibsnoglu S, Anisworth P (2004). Effect of fermented/ germinated cowpea flour addition on the rheological and baking properties of wheat flour. Food Eng., 63: 177-184.

Hoojat P, Zabik ME (1984). Sugar snap cookies prepared with wheat, navy bean, sesame seed flour blends. Cereal Chem., 61(1): 41-44.

Kent NL (1975). Technology of Cereals. Pergamon Press, Oxford, P. 216.

Larmond E (1980). Laboratory methods of sensory evaluation of food. Research branch Canada. Dept. Agric. Publications.

McWatters KG, Quedraogo JB, Resurrection AVA, Hung YC, Philips RD (2003). Physical and sensory characteristics of sugar cookies containing mixtures of wheat, fonio (*Digitaria exilis*) and cowpea (*Vigna unguiculata*) flours. International. J. Food Sci. Technol., 38: 403-410.

Mohamed RI (2000). Comparative studies about using some plant proteins in food processing. Ph.D. Thesis. Dep. Food Sci. Tech., Faculty of Agriculture Al-Azhar, University. Cairo, Egypt.

Ordorica FC, Paredes LO (1990). Effect of sunflower protein isolate on cookies characteristics. Int. J. Food Sci. Technol., 26: 39-43.

Okonkwo SI, Mary FO (2010). The analysis of Bambara Nut (Voandzeia *subterranean L. Thouars)* for sustainability in Africa. Res. J. Appl. Sci., 5(6): 394-396.

Rajpoot. LP (1988). Use of unconventional protein source it; high protein biscuits. J. Food. Sci. Technol., 25(1): 31-34.

Rawat I, Singh BG, Mital K, Mittal SK (1994). Effect of soy-fortification on quality characteristics of chapatis. J. Food Sci. Technol., 31(2): 114-116.

Sanchez MD, Altares P, Pedrosa MM, Burbano C, Cuadrado C, Goyoaga C, Muzquiz M, Jimenez-Martinez C, Davila- Ortiz G (2004). Alkaloid variation during germination of different lupin species. Food Chem., 90: 347-355.

Siddique ML (1989). Physico-chemical Properties of Composite Flour for Chapati Production. Ph.D. Thesis, Department of Food Technology, University of Agriculture, Faisalabad.

Snedecor GW, Cochran WG (1980). "Statistical Methods", 7th Ed. Oxford and IBIT Public. Co. New York.

Sripriya G, Antony CL, Chandra TS (1997). Changes in carbohydrate, free amino acids, organic acid, phytate and HCL extracted ability of minerals during germination and fermentation of the finger millet (*Eleusion coracana*). Food Chem., 58: 345-350.

Stephens JM (2003). Bambara groundnuts (*Voandezeia subterranean L. Thouars)* University of Florida, Institute of Food and Agricultural Sciences.

Tsen CC (1976). Regular and protein fortified biscuits from the composite flours. Cereal Foods World, 21: 633-640.

Yamazaki WT, Greenwood C (1981). Soft wheat: Production, breeding, milling and uses. American Association of Cereal Chemists, ST, Paul, Minnesota, USA, pp. 45-49.

Yusuf AA, Ayedun H, Sanni LO (2008). Chemical composition and functional properties of raw and roasted Nigerian benniseed (*Sesamum indicum*) and Bambara groundnut ((*Vigna subterranean*). Food Chem., 111: 277-282.