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Supplementation of Sudanese Sorghum Bread (Kissra) with Bambara Groundnut Flour (*Vigna subterranea* (L.) Verdc.)

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ABSTRACT

Proximate analysis of Bambara groundnut flour and production of Sudanese sorghum bread (kissra) supplemented with various ratios of Bambara groundnut flour were conducted. Bambara groundnut flour was used in supplementation of Sudanese baked product sorghum bread (kissra), in the ratios of 10, 20 and 30%. The pH values of Bambara groundnut flour supplemented dough's were dropped. The titrable acidity and total soluble solids were increased as a result of fermentation process. The most significant effect of kissra supplementation was the increases in protein content from 12.20±0.02% for the control sorghum bread kissra to about 13.38±0.02, 13.76±0.02 and 15.54±0.04% for kissra supplemented with 10, 20 and 30% of Bambara groundnut flour, respectively. The contents of crude fiber and ash of supplemented sorghum kissra were also increased. The replacement ratios of Bambara groundnut flour also resulted in a concomitant increase in the *in vitro* protein digestibility of kissra breads. The sensory evaluation revealed that the supplemented sorghum kissra was accepted by the panelists up to 10% of Bambara groundnut flour supplementation. The overall acceptance level of the different samples decreased with the additional increases of Bambara groundnuts flour supplementation. In view of the findings of this study, it is recommended that, future studies focus on the utilization of Bambara groundnuts flour on other Sudanese traditional foods such as thin and thick porridges.

Key words: Bambara groundnut flour, chemical composition, Sudanese sorghum kissra, sensory evaluation, nutritional quality

INTRODUCTION

Kissra is the staple Sudanese diet. It is a morsel or piece of bread prepared from fermented sorghum flour (Sulieman *et al*., 2003). The nutritive value of kissra is basically a discussion of the nutritive value of sorghum or millet; it was found that in Gezira and Managil areas, cereals provided 80% of the protein and together with sugar 84.4% of calories in the diet (Dirar, 1993). The word kissra is Arabic word (El-Tayeb, 1964) and together with the word Aceda, has been mentioned in the early Arabic books (Al-Jahiz, 1981). Literally, the word kissra is a morsel or a piece of bread (Tothill, 1948). Two kinds of kissra can be described based on the method of spreading the dough during baking, kissrat-kass and kissrat-gergriba. In the baking of former, the batter is transferred with kass and poured directly into centre of the hot plate used for baking. The empty kass is then held by the edge in an upright position and the batter spread with the bottom of the gourd by moving the container in whirl pool motion in progressively widening circles until the whole batter has been flattened out into a rippled, circular sheet (Dirar, 1993).

Bambara groundnut (*Voandzeia subterranea*) is a tropical food crop in Sudan and other tropical areas (Yagoub and Abdalla, 2007). Bambara groundnut was once said to be the third most important grain legume after groundnut (*Arachis hypogaea* L.) and cowpea (*Vigna unguiculata* (L.) Walp) in Sub-Saharan African (Aremu *et al.*, 2006a). In Sudan, Bambara groundnuts is grown in the rainfed areas of Darfur, Kordofan, Gadarif and Blue Nile regions by the traditional farmers both of male and female and consumed as a salt-boiled snack food beside maize and cowpea. The flours of Bambara groundnuts seeds and pearl millet grains are blended and used to make the traditional thick and thin porridges locally known as Madida and Nesha, respectively with addition of slight amounts of salt and sugar especially in western Sudan. Bambara groundnuts can be cultivated up to 1600 m above sea level. An average day temperature of 20 to 28°C is ideal for the crop (Chittaranjan, 2007). A growth plant period of 110 to 150 day is required for the crop to develop, depending upon environment and landrace. Bambara beans will grow on any well-drained soil but light, sandy; loams with a pH of 5.0 to 6.5 are most suitable. The crop does well on poor soil which is low in nutrients (Chittaranjan, 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). The reported proximate chemical composition of Bambara groundnut seeds is water (14.7), ash (3.24), crude protein (22.2), fat (6.6), cellulose (4.4) and carbohydrates (63.56%) (Chittaranjan, 2007).

Sorghum (*Sorghum bicolor* L. Moench) plays an important role as a major staple crop of the arid and semi-arid tropics. Sorghum is mainly produced by small holder farmers under rain-fed conditions that have been predicted to be adversely affected by climate change (Abdulai *et al.*, 2012). *Sorghum bicolor* is the most extensively cultivated in the drier Northern Guinea, Sudan Savannah and Greenland of Africa, Plains of India and the Great plains of United State of America. It is known to be the fourth most important cereal crop after wheat, rice and maize and is a dietary staple of millions of the world's poorest people in the Sahelian zone of Africa, Middle East, India and China (Adetuyi *et al.*, 2007). *S. bicolor* the fifth most important cereal crop after wheat, rice, maize and barley in terms of production. Total world annual sorghum production is about 60 million tons from cultivated area of 46 million ha (Dicko *et al.*, 2006). Fifty percent of sorghum is grown directly for human consumption. It is one of the major staple foods in Africa, Middle East and Asia. Sorghum is an important animal feed used in countries like United State, Mexico, South America and Argentina. Good quality sorghum is available with nutritional feeding value that is equivalent to that of corn (Adebiyi *et al.*, 2005). The grain is higher in protein and lower in fat content than corn (Yohe, 2002). This study was aimed to improve the nutritive value of sorghum kissra by the supplementation with various levels of Bambara groundnuts seeds flour.

MATERIALS AND METHODS

Materials: Bambara groundnut seeds were collected from a farm located at Um-Gouna village, Southern Darfur State, Sudan, during the harvesting period in 2008. The seeds were carefully cleaned and freed from foreign materials. Sorghum flour (Tabat variety) were purchased from the local market in Wad-Medani; Gezira State, Sudan.

Preparation of Bambara groundnuts flour: The seeds were washed, sun dried and milled into fine powder using a Wiley mill (Rekord A. Gbr, Jehmlich GmbH, Nossen, Germany), then the flour was passed through 60 mm mesh sieve (British standard). The flour was bottled and kept at room temperature (31°C) for further studies.

Chemical analysis: Proximate analysis of flours of Bambara groundnut and sorghum; control sorghum kissra and sorghum kissra supplemented various ratios of Bambara groundnut flour were conducted for the contents of moisture, ash and crude fat according to the AOAC (2005). Crude protein was calculated as N×6.25 according to the AOAC (1990). Crude fiber was determined by acid/alkali digestion method according to the AOCS (1985). Total carbohydrate content was calculated by subtracting the previous components from 100.

***In vitro* protein digestibility:** *In vitro* protein digestibilities of the different types of kissra were determined 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 mL^{-1}) was used in the determination.

Preparation of the control and supplemented kissra: In the control sample, 1000 g of sorghum flour were mixed with 2 L water in a round earthenware container (Khumara) (250 g) of previously fermented dough were added to the mixture to act as a starter culture. In supplemented samples, 10, 20 and 30% of Bambara groundnut flour were used to supplement sorghum flour in such a way that the dough contained a total of 1000 g of flours of sorghum and Bambara groundnut. Two liters of water and 250 g of starter culture were then added. All the samples were allowed to ferment for 18 h at 32°C (Sulieman *et al.*, 2003).

Dough analysis: All of the dough samples were analyzed for pH, Total Titrable Acidity (TTA) and Total Soluble Solids (TSS) before and after fermentation period. The pH was determined using (Hanna, pH 211) Microprocessor pH meter). Total titrable acidity was determined by titration against 0.1 N KOH according to the AOAC (1990). The total soluble solids were determined using (Atago, N1, brix 0~32, Japan) refractometer as described by Pomeranz and Meloan (1987).

Baking of kissra: The kissra sheets were baked traditionally as described by Dirar (1993) method with some modification. A steel plate (Saj) was heated to about 155°C. A small amount of fermented dough (85 g) was spread on the hot plate into a thin sheet which was peeled off the plate after 12 sec baking. The produced kissra sheets were stacked one over the other and were ready for further analysis.

Sensory evaluation: A panel of twenty members composed of adults male and female was used to judge the quality of the different types of kissra supplemented with various ratios of Bambara groundnut flour, as well as the control kissra. 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 sorghum kissra 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 DISCUSSIONS

Proximate analysis of flours of Bambara groundnut and sorghum showed that the contents of protein, ash, fat and crude fiber of the Bambara groundnut are higher than of sorghum; while the contents of moisture and carbohydrate are lower as presented in Table 1.

The moisture content of Bambara groundnut flour (4.0±0.03%) is similar to that reported by Doku and Karikari (1971) and Duke (1981), lower than that reported by Omoikhoji *et al.* (2006) and higher than that found by Aremu *et al.* (2006b) who reported values of (3.0-4.0, 10.12 and 2.07%), respectively. The low moisture content will afford a long shelf-life for the legume flours (Aremu *et al.*, 2006b). The variation in moisture content could be attributed to the environmental conditions. The estimated protein content (29.17±0.05%) is higher than the values of (22.10, 11.56, 19.61%) reported by Yagoub and Abdalla (2007), Aremu *et al.* (2006a) and Omoikhoji *et al.* (2006), respectively. The ash contents are 4.17±0.01%. The data is higher than the values of 3.76, 3.41% that reported by Yagoub and Abdalla (2007) and Omoikhoji *et al.* (2006), respectively and lower than the value of 4.28% reported by Aremu *et al.* (2006a). The variations in the ash contents of Bambara groundnut could be due to the agronomic practices and the variety or the soil type. Generally, the end products were made from the low ash content sample were brighter and more uniform in colour than those made from high ash content (Eltayeb, 2005). The fat contents 5.20±0.03% are higher than 5.0% reported by Yagoub and Abdalla (2007) and lower than that of Omoikhoji *et al.* (2006) and Aremu *et al.* (2006a), who reported the values of 6.45, 6.72%, respectively. The variations in fat contents may probably be due to the genetic types and the environmental conditions. The estimated value of crude fiber (4.69±0.04%) is higher than that of Aremu *et al.* (2006a), Yagoub and Abdalla (2007) and Omoikhoji *et al.* (2006) who found the values of 2.07, 3.72, 4.45%, respectively. The carbohydrates content (56.77±0.03%) is higher than the value of 54.95% reported by Omoikhoji *et al.* (2006) and lower than the values of Yagoub and Abdalla (2007) and Aremu *et al.* (2006a) who reported the values 65.0, 73.30%, respectively. The *in vitro* protein digestibility (79.24±0.05%) is in agreement with (78.75%) that reported by Yagoub and Abdalla (2007). However, the Bambara groundnut seeds are also reported to contain trypsin and chymotrypsin inhibitors, which act as anti-nutritional factors. Roasting the Bambara groundnut helps greatly in reducing the trypsin inhibitors and subsequently improves their nutritional value (Chittaranjan, 2007).

The sorghum contents of moisture, fat and fiber (7.5±0.04, 3.64±0.06, 2.00±0.05%) are lower than the values 9.8, 3.90, 2.5% and 12, 3.7, 2.2%, that reported by Mustafa (2002) and Leung *et al.* (1972), respectively. However, the contents of protein, ash and carbohydrate 11.03±0.04, 1.73±0.04 and 81.60±0.02% are higher than the values 10, 1.55, 72.25% and 10, 1.5, 72.7% that determined by Mustafa (2002) and Leung *et al.* (1972), respectively.

Table 1: Chemical composition and *in-vitro* protein digestibility of flours of Bambara groundnut seeds and sorghum grains, on dry weight-basis

Component (%)	Bambara groundnut flour	Sorghum flour
Moisture	4.0±0.030	7.50±0.040
Crude protein	29.17±0.05	11.03±0.04
Ash	4.17±0.01	1.73±0.040
Fat	5.20±0.03	3.64±0.060
Crude fiber	4.69±0.04	2.00±0.050
Carbohydrate	56.77±0.03	81.60±0.02
In vitro protein digestibility	79.24±0.05	ND

ND: Not determined

The pH, total titrable acidity and total soluble solids contents of control, fermented and non-fermented dough supplemented with different ratios of Bambara groundnut flour are presented in Table 2.

The pH values of all the fermented samples are slightly lower than that of non-fermented samples. The drop in pH values is accompanied with an increase in titrable acidity. El-Tinaysp *et al.* (1985) reported a drop of control dough from 5.28 to 3.76 at the end of fermentation. Au and Fields (1981) reported that a pH drop from 6.7 to 3.8 during the first 2 days of sorghum fermentation and gradually leveled off on the 3rd and 4th day. They also reported a concomitant rise in titrable acidity.

The contents of total titrable acidity are increased. The increases in total titrable acidity resulted in production of very thin kissra sheets; an explanation of this was given by Novellie (1982) who stated that the acid produced by fermentation softens the protein matrix so that the fermented dough becomes more coherent and can easily spread out into very thin sheet which can be peeled off the plate easily. The estimated total soluble solids are higher in supplemented dough as a result of Bambara groundnut flour supplementation process. However, the total soluble solids contents of fermented dough are lower than that of non-fermented dough.

As shown in Table 3, the moisture contents of supplemented sorghum breads kissra (55.0±0.07, 58.15±0.04, 60.0±0.04%) are increased as a result of Bambara groundnut flour supplementation. The moisture contents are higher than the range of 52-53% reported by El-Tinay *et al.* (1979) and lower than the range of 70.2-73.6% reported by Muller (1981). The most significant effect of Bambara groundnut flour supplementation is the increases in protein contents (13.38±0.02, 13.76±0.02, 15.54±0.04%). The protein contents are in agreement with the range of 9.5-15.4% that reported by Muller (1981) and higher than the value of 12.5% that determined by El-Mahdi (1985) and El-Tinaysp *et al.* (1985). The protein contents are also higher than 12.52%

Table 2: pH, total titrable acidity (TTA) and total soluble solids (TSS) contents of control, fermented (F) and non-fermented (NF) dough supplemented with different ratios of Bambara groundnut flour

	TSS (%)		TTA (%)		pH	
Kind of dough	F	NF	F	NF	F	NF
Control	6	8	2.35	0.56	3.70	5.64
10% BGF	6.3	8.2	2.46	0.58	3.65	5.61
20% BGF	6.5	8.5	2.55	0.65	3.55	5.55
30% BGF	6.6	8.8	2.58	0.67	3.39	5.23

BGF: Bambara groundnuts flour

Table 3: Chemical composition and *in vitro* protein digestibility of control kissra and kissra supplemented with various ratios of Bambara groundnut flour

	BGF (%)			
Component (%)	30	20	10	Control
Moisture	60.00±0.04	58.15±0.04	55.00±0.07	52.50±0.04
Crude protein	15.54±0.04	13.76±0.02	13.38±0.02	12.20±0.02
Ash	2.23±0.02	1.98±0.03	1.72±0.01	1.47±0.05
Fat	3.86±0.02	3.70±0.01	3.53±0.02	3.35±0.03
Crude fibers	3.75±0.03	3.64±0.03	3.50±0.02	3.39±0.03
Carbohydrate	74.62±0.04	76.92±0.03	77.87±0.05	79.59±0.05
Digestibility	81.56±0.04	78.23±0.02	74.90±0.05	71.57±0.02

BGF: Bambara groundnuts flour

Table 4: The mean scores for sensory attributes of control and sorghum bread kissra supplemented with different ratios of Bambara groundnut flour

Kind of kissra	Overall acceptability	Flavour	Colour	Texture	Appearance
Control	7.9[a]	7.6[a]	7.7[ab]	7.8[a]	7.9[ab]
10% BGF	7.9[a]	7.8[a]	8.3[a]	7.6[a]	8.0[a]
20% BGF	7.4[a]	7.1[a]	7.0[b]	7.1[a]	7.0[b]
30% BGF	7.0[a]	7.0[a]	7.0[b]	7.0[a]	6.7[b]

Means based on 9 points scale (9: Excellent, 1: Extremely bad), BGF: Bambara groundnut flour, [a, b]Means within the same column having the same letters are not significantly different according to the Duncan's multiple range tests

of a weaning food formulated from un-germinated sorghum and steamed cooked cowpea that reported by Elemo *et al.* (2011). The ash contents (1.72±0.01, 1.98±0.03, 2.23±0.02%) increases as a result of additional increase of Bambara groundnut flour. The ash contents are higher than of Elemo *et al.* (2011) who reported 1.6% as a weaning food ash content. The fat contents (3.53±0.02, 3.70±0.01, 3.86±0.02%) are lower than 5.1% reported by Eggum *et al.* (1983) and higher than the range of (0.81-1.54%) that reported by Muller (1981). The fiber contents (3.50±0.05, 3.64±0.03, 3.75±0.03%) are higher than (2.58%) that reported by El-Mahdi (1985) and El-Tinaysp *et al.* (1985) and lower than (3.8%) determined by El-Tinay *et al.* (1979). The carbohydrate content of control sample (79.59%) is higher than the contents of supplemented sorghum kissra (77.87±0.05, 76.92±0.03, 74.62±0.04%). The carbohydrate contents are lower than (80, 82.6%) reported by Sukkar *et al.* (1975) and Boutros (1977), respectively. The increase in the replacement levels of Bambara groundnut flour led to the increase in the *in vitro* protein digestibility of sorghum bread kissra from 71.57±0.02% for the control kissra to the 74.90±0.05, 78.23±0.02 and 81.56±0.04% of supplemented kissra. The *in vitro* protein digestibility is in agreement within the range of 65-86% that reported by Axtell *et al.* (1981).

The mean scores for sensory attributes of the control sorghum kissra and sorghum kissra supplemented with different ratios of Bambara groundnut flour are presented in Table 4. The sensory evaluation indicated that there were significant differences as regarded to appearance and colour and there were no significant differences as regard to flavour and overall acceptability. The supplemented kissra was accepted by the panelists at all levels of Bambara groundnut flour supplementation. However, the sorghum kissra supplemented with 10% of Bambara groundnut flour was rated by the panelists as good as control sorghum bread kissra. The overall acceptance level of the different samples decreased with the additional increase of Bambara groundnut flour.

CONCLUSION

It could be concluded that, the study succeeded to develop in the development of new product of sorghum bread kissra of high nutritive value through the utilization of the Darfurian neglected crop (Bambara groundnut seeds flour). The most significant effect of sorghum kissra supplementation is the improvement in quantities of protein and *in vitro* protein digestibility. Kissra supplemented with 10% of Bambara groundnut flour is similar to the control sample in all properties of the sensory attributes.

REFERENCES

AOAC, 1990. Official Methods of Analysis. 15th Edn., Association of Official Analysis Chemists, Washington, DC., USA., ISBN-13: 978-0935584424.

AOAC, 2005. Official Methods of Analysis. 18th Edn., Association of Official Analytical Chemists, Washington, DC., USA.

AOCS, 1985. Official Tentative Methods of Analysis. 4th Edn., American Oil Chemists Society, Champain, IL., USA.

Abdulai, A.L., H. Parzies, M. Kouressy, M. Vaksmann, F. Asch and H. Brueck, 2012. Yield stability of photoperiod sensitive sorghum (*Sorghum bicolor* L. Moench) accessions under diverse climatic environments. Int. J. Agric. Res., 7: 17-32.

Adebiyi, A.O., A.P. Adebiyi and E.O. Olaniyi, 2005. Nutritional composition of *Sorghum bicolor* starch hydrolyzed with analyse from *Rhizopus* sp. Afr. J. Biotechnol., 4: 1089-1094.

Adetuyi, A.O., V. Akpambang, V.O. Oyetayo and F.O. Adetuyi, 2007. The nutritive value and antimicrobial property of *Sorghum bicolor* L. Stem (poporo flour used as food colour additive and its infusion drink. Am. J. Food Technol., 2: 79-86.

Al-Jahiz, A.O., 1981. Al-Bukhala. The Modern Arab Bureau, Cairo, Egypt.

Aremu, M. Olaleke, Olaofe, Olorunfemi, Akintayo and T. Emmanuel, 2006a. A comparative study on the chemical and amino acid composition of some Nigerian under-utilized legume flours. Pak. J. Nutr., 5: 34-38.

Aremu, M.O., O. Olaofe and E.T. Akintayo, 2006b. Chemical composition and physicochemical characteristics of two varieties of Bambara groundnut (*Vigna subterranea*) flours. J. Applied Sci., 6: 1900-1903.

Au, P.M. and M.L. Fields, 1981. Nutritive quality of fermented sorghum. J. Food Sci., 46: 652-654.

Axtell, J.D., A.A. Kirleis, M.M. Hassen, N. D'Groz-Mason, E.T. Mertz and L. Munck, 1981. Digestibility of sorghum proteins. Proc. Nat. Acad. Sci. USA., 78: 1333-1335.

Boutros, J.Z., 1977. Sudan Food Composition Tables. Vol. 2, The National Chemical Laboratories. Ministry of Health, Khartoum, Sudan.

Chittaranjan, K., 2007. Genome Mapping and Molecular Breeding in Plants. Vol. 3, Springer-Verlag, Berlin Heidelberg, New York.

Dicko, M.H., H. Gruppen, A.S. Traore, A.G.J. Voragen and W.J.H. van Berkel, 2006. Sorghum grain as human food in Africa: relevance of content of starch and amylase activities. Afr. J. Biotechnol., 5: 384-395.

Dirar, H.A., 1993. Gariss. Dairy Products. The Indigenous Fermented Foods of the Sudan. CAB International, Wallingford, UK.

Doku, E.V. and S.K. Karikari, 1971. Bambara groundnut. Econ. Bot., 25: 255-262.

Duke, J.A., 1981. Hand Book of Legumes of World Economic Importance. Plenum Press, New York.

Eggum, B.O., L. Monawar, K.E. Bachknudsen, L. Munck and J. Axtell, 1983. Nutritional quality of sorghum and sorghum foods from Sudan. J. Cereal Sci., 1: 127-137.

El-Mahdi, Z.M., 1985. Microbial and biochemical characteristics of legume protein supplemented kissra. M.Sc. Thesis, University of Khartoum, Sudan.

El-Tayeb, A., 1964. The changing customs of the riverain Sudan-III. Sudan Notes Records, 45: 12-28.

El-Tinay, A.H., A.M. Abdel Gadir and M. El-Hidai, 1979. Sorghum fermented kissra bread. 1-nutritive value of kissra. J. Sci. Food Agric., 30: 859-863.

El-Tinaysp, A.H., Z.M. El Mahdi and A. El Soubki, 1985. Supplementation of fermented sorghum Kisra bread with legume protein isolates. J. Food Technol., 20: 679-687.

Elemo, G.N., B.O. Elemo and J.N.C. Okafor, 2011. Preparation and nutritional composition of a weaning food formulated from germinated sorghum (*Sorghum bicolor*) and steamed cooked cowpea (*Vigna unguiculata* Walp.). Am. J. Food Technol., 6: 413-421.

Eltayeb, A.S.M., 2005. The utilization of dehulled and defatted sesame flour in bread making. M.Sc. Thesis, University of Gezira, Wad-Madani, Sudan.

Hsu, W.W., D.L. Vavak, L.D. Satterlee and G.A. Miller, 1977. A multienzyme technique for estimating protein digestibility. J. Food Sci., 42: 1269-1273.

Iwe, M.O., 2002. Handbook of Sensory Methods and Analysis. 1st Edn., Rejoint Communication Services Ltd., Enugu, Nigeria, Pages: 71.

Leung, W.W., R.R. Butrum and F.H. Chang, 1972. Food composition table for use in East Asia. Part 1. Proximate Composition Mineral and Vitamin Contents of East Asian Foods. FAO and U.S. Dept. HEW. http://www.fao.org/docrep/003/X6878E/X6878E00.htm

Muller, H.G., 1981. Fermented Cereal Products of Tropical Africa. In: Advances in Biotechnology. Moo-Young, M. and C.W. Robinson (Eds.). Vol. 2, Pergamon Press, New York, pp: 541-546.

Mustafa, W.A., 2002. Formulation, processing and evaluation of biscuits made from wheat and sorghum flours. M.Sc. Thesis, University of Gezira, Wad-Medni, Sudan.

Novellie, L., 1982. Fermented porridges. Proceedings of the International Symposium on Sorghum Grain Quality, October 28-31, 1981, Patoncheru, India, pp: 121-128.

Omoikhoji, S.O., A.M. Bamgbose and M.B. Aruna, 2006. Determination of the nutrient and anti-nutrient component of raw, soaked, de-hulled and germinated Bambara groundnut seeds. J. Anim. Vet. Adv., 5: 1022-1025.

Pomeranz, Y. and C.E. Meloan, 1987. Food Analyst: Theory and Practice. 3rd Edn., Van Nastrand Reinfold Co., New York.

Satterlee, L.D., H.F. Marshall and J.M. Tennyson, 1979. Measuring protein quality. J. Am. Oil Chem. Soc., 56: 103-109.

Snedecor, G.W. and W.G. Cochran, 1980. Statistical Methods. 7th Edn., Iowa State University Press, Iowa, USA., ISBN-10: 0-81381560-6, Pages: 507.

Sukkar, M.Y., J.Z. Boutros and M.K. Yousif, 1975. The composition of common Sudanese foods. Sudan Med. J., 13: 51-51.

Sulieman, A.E., A.O. Ali and E.A. Elkhalifa, 2003. Some characteristics of the Sudanese bread (Kissra) supplemented with fenugreek (*Trigonella foenum-graecum* L.). Gezira J. Agric. Sci., 1: 15-25.

Tothill, J.D., 1948. The Problem of Nutrition and Tribal Diet from Agricultural Point of View. In: Agricultural in the Sudan, Tothill, J.D. (Ed.). Oxford University Press, London, pp: 271-274.

Yagoub, A.E.G.A. and A.A. Abdalla, 2007. Effect of domestic processing methods on chemical composition, *in vitro* digestibility of protein and starch and functional properties of Bambara groundnut (*Voandzeia subterranea*) seed. Res. J. Agric. Biol. Sci., 3: 24-34.

Yohe, J., 2002. Increased value o sorghum as forage and silage for cattle. Science, 57: 2-14.