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Effect of Full and Partial Substitution of Sesame Seeds with Bambara Groundnuts and Peanuts on the Quality of Sudanese Traditional Food (Khemiss-tweria)

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ABSTRACT

In this study, de-hulled Bambara groundnuts and peanuts flours were used for full and partial substitution of sesame seeds in production of khemiss-tweria. The proximate analysis of de-hulled Bambara groundnuts flour, peanuts, sesame seeds and pearl millet flour were conducted. The chemical analysis of control and developed khemiss-tweria indicated that the contents of moisture and ash ranged between 4.00±0.03 to 4.28±0.04% and 2.50±0.01 and 4.86±0.04%, respectively, while the contents of protein, fat, crude fiber and carbohydrate ranged from (15.06±0.02 to 24.19±0.03%) (6.69±0.03 to 10.88±0.02%) (2.12±0.03 to 2.50±0.01%) and (62.27±0.02 to 68.40±0.01%), respectively. On the other hand, the *in vitro* protein digestibility ranged from (75.52±0.02 to 93.16±0.04%). The most significant effect of de-hulled Bambara groundnuts flour and peanuts addition, in production of khemiss-tweria was the improvement of protein quality. Khemiss-tweria made from millets bread and peanuts had the highest *in vitro* protein digestibility. The sensory analysis of the different types of khemiss-tweria revealed that there was a significant differences in colour while there were no significant differences between the various types of khemiss-tweria products. However, peanuts gave higher scores to the khemiss-tweria whereby peanuts fully replaced sesame seeds than the products made from other blends.

Key words: Bambara groundnuts, chemical composition, Sudanese traditional food (khemiss-tweria) production, nutritional quality

INTRODUCTION

Khemiss-tweria is a food product virtually confined to the region of Darfur. The usefulness and attractiveness of this food should have been enough incentive to justify its widespread production in the country. The fact that this did not happen may be taken as an indication that the product may have been only recently invented or perhaps introduced from other African countries (Dirar, 1993). This food is important for travelers, farmers and gum Arabic workers in western Sudan. The starting material of the khemiss-tweria is whole millet grains, half of which is malted, sun dried and reduced to fine flour and the other half is turned into flour and then fermented. The fermented dough is cooked into kissra-hamra and then kneaded with the millet malt flour when it has cooled to room temperature (Dirar, 1993). Half an hour is given for amylolysis to precede to the correct degree before water is added to further thin the batter and the container incubated overnight for

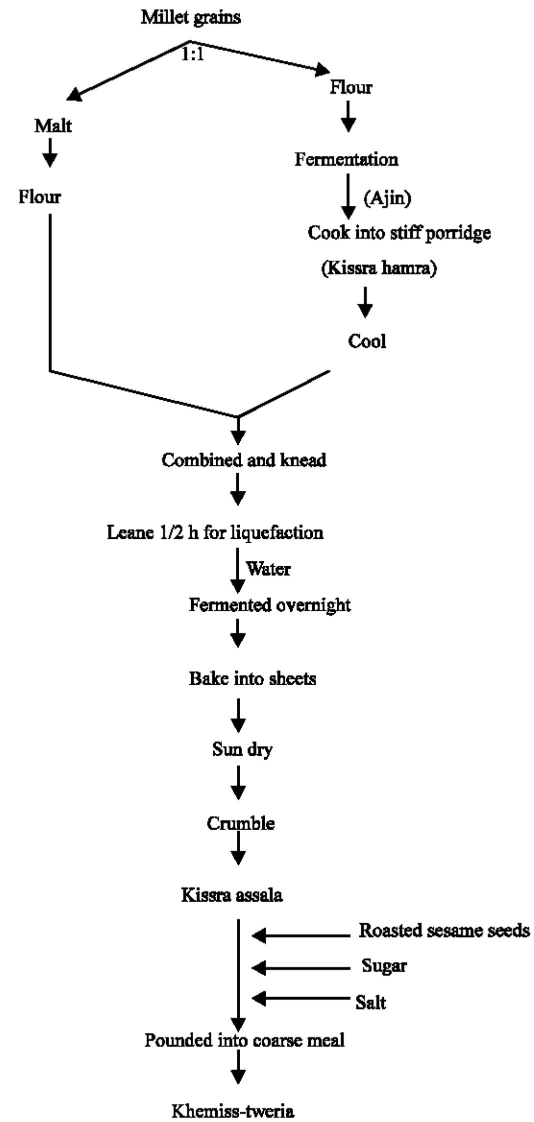

Fig. 1: Kissra-assala and khemiss-tweria production (Dirar, 1993)

fermentation. The next morning the batter is baked into kissra sheets and then dried in the sun and crumbled. For preparation of khemiss-tweria, the dry crumbled kissra-assala is mixed with roasted sesame in ratio of 6:1, respectively and a little sugar and a dash of salt are added to taste. The mixture is pounded in a mortar to give a coarse meal comprising khemiss-tweria as presented in Fig. 1 (Dirar, 1993).

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). In much of Africa, Bambara groundnut is the third most important legume after groundnut (*Arachis hypogaea*) and cowpea (*Vigna unguiculata*) (FAO, 2001; Mkandawire, 2007). The crop has a number of production advantages in that it can yield on poor soils with little rainfall as well as produce substantial yields under better conditions. It is nutritionally superior to other legumes and is the preferred food crop of many local people (FAO, 2001; Mkandawire, 2007). Bambara groundnut is a rich source of protein (16-25%) and its seeds are valued both for their nutritional and economic importance. The seeds command a high market price, with demand far outweighing supply in many areas. However, despite these important attributes, the agro-ecological and genetic potential of Bambara groundnut have not yet been fully realized nor its full economic significance determined (FAO, 2001; Mkandawire, 2007). The crop is still cultivated from local landraces rather than varieties bred specifically for particular agro-ecological conditions or production systems (FAO, 2001; Mkandawire, 2007). In western Sudan, Bambara groundnut is not a part of the main dish in the table of the local people; it's consumed as a salt-boiled snack food (Yagoub and Abdalla, 2007). This study aimed to improve the nutritive value of khemiss-tweria using de-hulled Bambara groundnuts seeds flour and peanuts instead of sesame seeds.

MATERIALS AND METHODS

Materials: The seeds of Bambara groundnuts, peanuts, sesame and pearl millet grains were collected from the farm located at Um-Gouna village, Southern Darfur State, Sudan, during the harvesting period of the year 2008. The seeds were carefully cleaned and freed from foreign materials.

Preparation of de-hulled Bambara groundnuts flour: Bambara groundnuts seeds were soaked, manually decorticated, sun dried and milled into fine flour (Rekord A. Gbr, Jehmlich GmbH, Nossen, Germany) then the flour was passed through 60 mesh screen, bottled and kept at 5°C for all further studies.

Kissra-assala preparation: A traditional method described by Dirar (1993) was followed whereby kissra-assala was backed from 8 kg of pearl millet grains half of it were malted, sun dried and reduced to fine flour and the other half were turned into flour (1:2 w/v) water was added and then fermented. The fermented dough was cooked into aceda (stiff porridge) called kissra-hamra. The kissra-hamra, was then knead with the millet malt flour when it was cooled to room temperature. About half an hour was given for amylolysis to proceed to the correct degree before water (1:2 w/v) was added to further thin the batter and the container incubated overnight for fermentation. The next morning the batter was baked into sheets of kissra-kass, the kissra sheets were sun dried and crumbled and finally pounded by mortar and pestle to coarse crystals of kissra-assala.

Preparation of traditional and developed khemiss-tweria: The formulation of khemiss-tweria was carried out by mixing the coarse kissra-assala and roasted sesame seeds for the control sample in ratio of 6:1, kissra-assala and roasted peanuts in ratio of 6:1, kissra-assala, roasted sesame seeds and de-hulled Bambara groundnuts flour in ratio of 6:0.5:0.5 and kissra-assala, roasted peanuts and de-hulled Bambara groundnuts flour in ratios of 6:0.5:0.5 and designated as Kh_1, Kh_2, Kh_3 and Kh_4, respectively. Amount of 50 g sugar and 15 g salt were added to 1000 g of each of the above mixtures. Then the mixtures were well mixed to comprise the various types of khemiss-tweria. The produced samples were bottled and kept at room temperature for all further studies.

Sensory evaluation: A panel of fifteen members composed of darfurain adults male and female were used to judge the quality of the different types of khemiss-tweria. 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 khemiss-tweria 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).

Chemical analysis: Proximate analysis of de-hulled Bambara groundnuts, peanuts, sesame seeds, pearl millet and the different types of khemiss-tweria 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). Total carbohydrate content was calculated by subtracting the previous components from 100.

***In vitro* protein digestibility:** *In vitro* protein digestibility of de-hulled Bambara groundnuts and the different types of khemiss-tweria were carried out according to the three-enzyme method as 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) was used in the determination.

Aflatoxin content

Sample preparation: Twenty grams from Kh_2 (6:1 (kissra:peanuts)) khemiss-tweria were defatted using hexane according to Coomes *et al.* (1965). The residual solvent was dried off from the defatted sample by heating in oven at 105°C for 30 min as described by Sulieman *et al.* (2008). The moisture content of the defatted sample was carried out according to AOAC (2005).

Toxin extraction: Ten grams from defatted Kh_2 sample were placed into a 250 mL conical flask then thoroughly mixed in 10 mL distilled water using a glass rod. Hundred milliliters chloroform were then added and the flasks were stoppered with a rubber plug coated with aluminum foil to protect the rubber from the corrosive action of the chloroform. The flasks were shaken for 30 min on a Griffin shaker to ensure good extraction. The contents of each flask were shaken and filtered using Whatman No. 1 filter paper (24 cm). The chloroform was then evaporated to dryness in a water bath (70°C). The dried extracted sample was washed in 200 mL chloroform. Twenty five microliter of the solution were spotted by a micro syringe on the prepared coated plates. Twenty five milliliters of the standard samples (AFB_1) were also placed, an air dryer was used. The plates were developed on a solvent system of toluene, acetic acid and formic acid at 6: 3: 1. AFB_1 was visualized under long wave UV light (366 nm); the mixture of AFB_1 standard spot and samples spots were combined to determine the concentration of AFB_1. The toxin extraction was carried out as described by Abdel-Hameed (2000) and Sulieman *et al.* (2003,2008).

Estimation of aflatoxin concentration: The visible fluorescence of the sample was compared with AFB_1 standard spots on the same chromatoplates. If the spots of the smallest volume of sample were too intense to match with the standards, the sample would be diluted and re-chromatographed. The concentration of AFB_1 in μg kg^{-1} was calculated according to Coomes *et al.* (1965) as follows:

$$\text{AFB1 content } (\mu g\ kg^{-1}) = \frac{S \times Y \times V}{W \times Z}$$

Where:

S = Volume, in µL, of aflatoxin (µL) B_1 standard of equivalent intensity
Y = Concentration of aflatoxin B_1 standard (µg mL^{-1})
V = Volume, of solvent (µL) required to dilute the final extract
W = Weight, of original sample (g) contained in final extract
Z = Volume, of sample (µL) required to give florescence intensity comparable to that of S µL of the B_1 standard

RESULTS AND DISCUSSION

Proximate analysis of de-hulled Bambara groundnuts flour, peanuts, sesame seeds and pearl millet flour showed that the contents of moisture and protein are higher than that of peanuts, sesame seeds and pearl millet flour as shown in Table 1.

The moisture, crude protein, ash, fat, crude fiber and total carbohydrate contents 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. However, 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 peanuts moisture content is (6.0±0.06%). The data is close agreement to the value of (5.8%) that determined by Atasie *et al.* (2009) and (5.7%) that reported by Boutros (1986). The protein content (27.93±0.03%) falls within the range of (20-50%) that reported by Nwokolo and Smartt (1996) and higher than (26.7%) reported by Boutros (1986). Ash content (2.66±0.04%) is lower than (3.8%) reported by Atasie *et al.* (2009) and higher than (2.3%) that found by Boutros (1986). The fat content (47.34±0.01%) is higher than (47.0%) that determined by Atasie *et al.* (2009) and lower than (49.2%) that found by Boutros (1986). The fiber content is (2.12±0.07%). The data is lower than (3.70%) as found by Atasie *et al.* (2009). The carbohydrate content (19.95±0.08%) is much higher than (1.81%) that reported by Atasie *et al.* (2009) and (14.6%) that found by Boutros (1986).The *in vitro* protein digestibility (91.61±0.02%) is lower than (93.06±0.042%) reported by Elsheikh and Mohamedzein (1998).

The moisture content of sesame seeds (3.5±0.05%) is lower than (5.8 and 4.59%) that reported by Joshi (1961) and Gopalan *et al.* (1982), respectively. The protein content is (25.44±0.02%). The value is higher than (19.30%) that reported by Joshi (1961) and (18.30%) that found by Gopalan *et al.* (1982). The ash content (4.48±0.05%) is lower than (5.2 and 5.7%) found by Gopalan *et al.* (1982) and Joshi (1961), respectively. The fat content is higher (50.15±0.02%). The fat content is lower than (51.09%) reported by Joshi (1961) and higher than (43.3%) determined by Gopalan *et al.* (1982). The carbohydrate content is (15.58±0.01%). The data obtained is lower than (21.20%) found by Joshi (1961) and (25%) that determined by Gopalan *et al.* (1982).

The moisture content of pearl millet flour (7.38±0.04%) is lower than the range of (10.09-10.95%) reported by Modu *et al.* (2005) and (8.0%) that found by Boutros (1986). The

Table 1: Chemical composition and *in vitro* protein digestibility of de-hulled Bambara groundnuts, peanuts, sesame seeds and pearl millet

Component (%)	Pearl millet	Sesame seeds	Peanuts	DBGF
Moisture	7.38±0.04	3.50±0.05	6.00±0.06	7.50±0.04
Crude protein	11.74±0.06	25.44±0.02	27.93±0.03	32.16±0.04
Ash	2.16±0.03	4.48±0.05	2.66±0.04	3.24±0.01
Crude fat	5.41±0.02	50.15±0.02	47.34±0.01	6.49±0.02
Crude fiber	2.30±0.03	4.35±0.05	2.12±0.07	1.08±0.03
Carbohydrates	78.39±0.02	15.58±0.01	19.95±0.08	57.03±0.04
Digestibility	ND	ND	91.61±0.02	81.95±0.05

DBGF: De-hulled Bambara ground nut flour, ND: Not determined

protein content (11.74±0.06%) is within the range of (11.34-12.97%) found by Modu *et al.* (2005) and higher than (9.7%) reported by Boutros (1986). The ash content is (2.16±0.03%). The data is higher than the range of (1.20-1.52%) determined by Modu *et al.* (2005) and (1.7%) found by Boutros (1986). The fat content (5.41±0.02%) is higher than the range of (3.67-4.51%) determined by Modu *et al.* (2005) and lower than (5.8%) found by Boutros (1986). The fiber content is (2.30±0.03%). The value is higher than (2.0%) that reported by Boutros (1986). The carbohydrates content (78.39±0.02%) is higher than the range of (70.15-72.52%) that found by Modu *et al.* (2005) and lower than (72.8%) that reported by Boutros (1986).

The proximate analysis and *in vitro* protein digestibility of the various types of khemiss-tweria are presented in Table 2.

There is slight variation in moisture contents of various types of khemiss-tweria (4.25±0.02, 4.15±0.03 and 4.28±0.04%). The data are higher than (4.0±0.03%) of control sample and lower than (8.32±0.14%) reported by Ali *et al.* (2010). However, the low moisture contents in the various types of khemiss-tweria, it is indication of better quality and the long shelf life of the products. The protein contents are increased (15.89±0.01, 23.55±0.03 and 24.19±0.03%). The protein contents are higher than (15.06±0.02%) of control sample and (10.87±0.21%) as reported by Ali *et al.* (2010). However, there are concomitant increase in protein contents with the additional increases of peanuts and de-hulled Bambara groundnut flour. The estimated ash contents are decreased (4.08±0.02, 3.90±0.02 and 2.50±0.01%). The data are lower than (4.86±0.04%) of control sample and exceeded the value of (2.20±0.26%) that reported by Ali *et al.* (2010). The fat contents are decreased (9.44±0.01, 7.68±0.04 and 6.69±0.03%). The data are lower than (10.88±0.02%) of control sample and higher than (7.94±0.2%) reported by Ali *et al.* (2010). The crude fiber contents (2.19±0.01, 2.30±0.01 and 2.12±0.03%) are lower than (2.50±0.01%) of control sample and (2.64±0.4%) that reported by Ali *et al.* (2010). The carbohydrate contents are decreased; however, in case of (Kh_2) sample the carbohydrate content is increased. The *in vitro* protein digestibility are decreased (80.60±0.03 and 75.52±0.02%); however, in case of (Kh_2) the *in vitro* protein digestibility is increased (93.16±0.04). The contents of *in vitro* protein digestibility are comparable to the findings of Ali *et al.* (2010) who reported a value of (79.96-82.49%) for khemiss-tweria supplemented with seinat flour and the finding of Suleiman *et al.* (2003) who reported value of (83.6-84.2%) for cookies fortified with 10-30% of cow pea flour.

The Kh_2 sample was not detected with aflatoxin (AFB_1). However, the data is agreement with that of Sulieman *et al.* (2008), who reported that roasting reduces the (AFB_1) levels in contaminated peanuts.

Table 2: Chemical composition and *in vitro* protein digestibly of different types of khemiss-tweria

	Kind of khemiss-tweria			
Component (%)	Kh_1	Kh_2	Kh_3	Kh_4
Moisture	4.00±0.03	4.25±0.02	4.15±0.03	4.28±0.04
Crude protein	15.06±0.02	15.89±0.01	23.55±0.03	24.19±0.03
Ash	4.86±0.04	4.08±0.02	3.90±0.02	2.50±0.01
Crude fat	10.88±0.02	9.44±0.01	7.68±0.04	6.69±0.03
Crude fiber	2.50±0.01	2.19±0.01	2.30±0.01	2.12±0.03
Total carbohydrate	66.70±0.04	68.40±0.01	62.27±0.02	64.23±0.02
In vitro protein digestibility	84.50±0.02	93.16±0.04	80.60±0.03	75.52±0.02

Kh_1: 6:1 (kissra:sesame seeds) control sample, Kh_2: 6:1 (kissra:peanuts), Kh_3: 6: 0.5:0.5 (kissra:sesame seeds:de-hulled Bambara groundnuts flour), Kh_4: 6: 0.5:0.5 (kissra:peanuts:de-hulled Bambara groundnuts flour)

Table 3: The mean scores for sensory attributes of different types of khemiss-tweria

Kind of khemiss-tweria	Flavour	Colour	Texture	Appearance	Overall acceptability
Kh_1 (control)	7.4^a	4.8^b	7.3^a	5.6^a	6.5^a
Kh_2	7.3^a	6.7^{ab}	6.2^a	6.6^a	7.4^a
Kh_3	5.9^a	6.1^{ab}	6.1^a	5.7^a	6.3^a
Kh_4	6.1^a	8.1^a	6.7^a	7.6^a	6.5^a

Means based on 9 points scale (9 = excellent, 1 = extremely bad), ^{a,b}Means within the same columns having the same letters are not significantly different according to the Duncan's multiple range tests, Kh_1: 6:1 (kissra:sesame seeds) control sample, Kh : $_2$6:1 (kissra:peanuts), Kh_3: 6: 0.5:0.5 (kissra: sesame seeds:de-hulled Bambara groundnuts flour), Kh_4: 6: 0.5:0.5 (kissra:peanuts:de-hulled Bambara groundnuts flour)

The mean score for sensory attribute of the different types of khemiss-tweria are presented in Table 3. The data indicated that there are no significant differences as regard to appearance, texture, flavour and overall acceptability. However, the panelist gave higher score for overall acceptance to the Kh_2 (peanuts substituted) sample.

CONCLUSION

It could be concluded that, the nutritional quality of developed khemiss-tweria is improved as a result of de-hulled Bambara groundnut flour supplementation and peanuts and sesame seeds substitution.

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REFERENCES

AOAC, 1990. Official Methods of Analysis. 15th Edn., Association of Official Analytical Chemists, Washington, DC., USA.

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.

Abdel-Hameed, M.A., 2000. Mycotoxin Fungi. University Publishing House, Egypt.

Ali, A.O., M.I. Ahmed and E.A. Elkhalifa, 2010. The utilization of seinat seeds flour as sesame seeds substitute in the production of Sudanese traditional food Khemiss-tweria. Proceedings of the 4th International Conference on Innovation in Food Science and Nutrition: Future Challenges, September 27-29, 2010, NRC, Cairo, Egypt.

Atasie, V.N., T.F. Akinhanmi and C.C. Ojiodu, 2009. Proximate analysis and physico-chemical properties of groundnut (*Arachis hypogaea* L.). Pak. J. Nutr., 8: 194-197.

Boutros, J.Z., 1986. Sudan Food Composition Tables. Vol. 2, The National Chemical Laboratories, Ministry of Health, Khartoum, Sudan.

Coomes, T.J., P.C. Growther, B.J. Grancis and K. Stevens, 1965. The detection and estimation of aflatoxin in groundnuts and groundnut materials. Part IV. Routine assessment of toxicity due to aflatoxin B_1. Analyst, 90: 492-496.

Dirar, H.A., 1993. The Indigenous Fermented Foods of the Sudan and Nutrition. A Study in African Food and Nutrition. 1st Edn., Cambridge University Press, Cambridge, UK.

Elsheikh, E.A.E. and E.M.E. Mohamedzein, 1998. Effect of *Brady rhizobium*, VA mycorrhiza and fertilizers on seed composition of groundnut. Ann. Applied Biol., 132: 325-330.

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.

FAO, 2001. A global mapping system for Bambara groundnut production. Agricultural Information Management Series No. 1, Food and Agriculture Organization of the United Nations, Rome, Italy.

Gopalan, C., B.V. Ram Sastri and S.C. Balasubramanian, 1982. Nutritive values of Indian foods. National Institute of Nutrition (ICMR), Hyderabad, India, pp: 161.

Hsu, H.W., D.L. Vavak, L.D. Satterlee and G.A. Miller, 1977. A multienzymes 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, pp: 71.

Joshi, A.B., 1961. Sesamum: A Monograph. Indian Central Oil Seeds Committee, Hyderabad, India.

Mkandawire, C.H., 2007. Review of Bambara groundnut (*Vigna subterranea* (L.) Verdc.) production in Sub-Sahara Africa. Agric. J., 2: 464-470.

Modu, S.H., H. Laminu and I. Nkama, 2005. Production, chemical and sensory properties of Ogi from different pearl millet varieties. J. Biol. Sci., 5: 103-106.

Nwokolo, E. and J. Smartt, 1996. Peanut (*Arachis hypogaea* L.). In: Legumes and Oil Seeds in Nutrition, Nwokolo, E. and J.S. Mart (Eds.). Chapman and Hall, New York, USA., pp: 49-63.

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.

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.

Sulieman, A.M.E., M.A. Ali and A.M. Abdelrahim, 2008. Effect of heat treatment on the level of aflatoxin B_1 (AFB_1) on Some Sudanese peanut products. Sudan J. Agric. Res., 11: 9-16.

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 subterranean*) seed. Res. J. Agric. Biol. Sci., 3: 24-34.