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Chemical, Minerals, Fatty Acid and Amino Acid Compositions of Sudanese Traditional Khemiss-Tweria Supplemented with Peanut and Bambara Groundnuts

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ABSTRACT
This study aimed to evaluate impact of utilization of peanut and bambara groundnuts for improving the nutritive value of Sudanese traditional khemiss-tweria. For this, proximate analysis, mineral, fatty acids and amino acids were studied. The crude protein contents of developed khemiss-tweria improved by 6.16, 49.37 and 53.55% over the control sample. In addition, the contents of calcium, phosphorus, plamitic and oleic acids were increased meanwhile; the contents of iron, zinc, stearic and linoleic acids were reduced as a result of peanut substitution. Furthermore, utilization of sesame seeds and bambara groundnuts in case of kh_3 and peanut and bambara groundnuts in case of kh_4 improved the contents of calcium, phosphorus, iron, plamitic and oleic acid whilst, decreased the contents of zinc, stearic and linoleic acids compared to control sample. However, the developers khemiss-tweria are superior with respect to arginine, leucine, phenylaline, theronine, valine and total essential amino acids, when compared to FAO/WHO reference pattern. It could be concluded that, the study remarkably developed new types of khemiss-tweria with high contents of crude protein, calcium, phosphorus, iron, plamitic oleic acids and essential amino acids.

Key words: Peanut, bambara groundnuts, preparation of khemiss-tweria, minerals, fatty acid, amino acid

INTRODUCTION
Khemiss-tweria is a food product virtually confined to the region of Darfur and to date, it seems to be made from pearl millet only. Khemiss-tweria is a food for travelers, boarding school pupils, soldiers and rural workers. School boys and girls returning to schools, those are far from their home towns, carry khemiss-tweria with them as food for road and as a welcome alternative at the boarding school to the repetitive pattern of formal alimentation. Now a days, as well as in the past, khemiss-tweria is taken by army soldiers as a quick food. Nutritionally, khemiss-tweria should provide a balanced meal, containing the necessary carbohydrate, protein, oil, mineral and vitamins (Dirar, 1993). The fermentation process involved in the production of khemiss-tweria, which is expected to improve the B vitamin group, also results in dropping the pH so that the final meal has a pH of 4.4. In a way, khemiss-tweria is similar to the fortified, spray-dried mahewu of Southern Africa (Okafor, 1981). The product is a dry meal of brownish color and pleasant sweetish and slightly salty flavor.

Bambara groundnut (*Vigna subterrenea* L.) is a major source of vegetable protein in sub-Saharan Africa (Adu-Dapaah and Sangwan, 2004). It is well adapted to harsher conditions and constitutes an important part of the local diet, culture and economy. 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 (2.0-10.0 mg/100 g) for most food legumes, potassium (1144-1935 mg/100 g), sodium (2.9-12.0 mg/100 g), calcium (95.8-99 mg/100 g), 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%), carbohydrate (51-70%), oil (6-12%) and energy (367-414 kal 100 mg^{-1}). Adu-Dapaah and Sangwan (2004), Amarteifio *et al*. (2002), Anchirinah *et al*. (2001) and Lackroix *et al*. (2003) have been shown that, the energy value of bambara groundnut seed is greater than that of several other pulses. Bambara groundnuts can be eaten in many ways, immature pods can be boiled and consumed as snacks. However, at maturity the seeds become hard and require boiling for long time. Recently, a trial of bambara groundnuts milk was carried out which compared its flavor and composition with those of milk prepared from cowpea, pigeon pea and soybean (Mkandawire, 2007). In Sudan, bambara groundnuts is grown in rainfed areas of Darfur, Kordofan and Gadarif and consumed as salt-boiled snack food beside maze and cowpea. To date, there are no reports on impact of utilization of the neglected crop bambara groundnut for improving the nutritive value of khemiss-tweria. Also there are no studies investigate the nutritional quality of Sudanese traditional khemiss-tweria before. Therefore, this study aimed (1) To substitute sesame seeds and peanuts with bambara groundnut as available low cost crop for the poor's in production of khemiss-tweria and (2) To determine the proximate analysis, mineral, fatty acids and amino acids composition of the newly types khemiss-tweria. The study would provide better understandings regarding the effect of bambara groundnut on the nutritive value of khemiss-tweria.

MATERIALS AND METHODS

Materials: Bambara groundnuts, peanut, pearl millet grains and sesame seeds were collected from a farm located at Um-Gouna village, Southern Darfur, Sudan. The seeds were carefully cleaned, freed from foreign materials and kept for further studies. Sulfuric acid (PubChem CID: 1118), Sodium hydroxide (PubChem CID: 14798), Methyl alcohol (PubChem CID: 887), Petroleum ether (PubChem CID: 241), Copper (II) sulfate (PubChem CID: 24463), Sodium sulfate (PubChem CID: 24436), Methyl red (PubChem CID: 10303), Ethanol (PubChem CID: 702), Bromocresol green (PubChem CID: 6451), Boric acid (PubChem CID: 7628), Hydrochloric acid (PubChem CID: 313), Nitric acid (PubChem CID: 944), Mono-potassium phosphate (PubChem CID: 516951), Chloroform (PubChem CID: 6212), Caproic acid (PubChem CID: 8892), Citrate (PubChem CID: 31348), Ninhydrin (PubChem CID: 10236), Glycine (PubChem CID: 750) were purchased from Sigma Chemical Co. (St. Louis, MO, USA). All chemicals and solvents were of analytical grade.

Sample preparation: Bambara groundnuts seeds were washed, sun dried, roasted at 120°C for 10 min and milled into fine flour using (Rekord A. Gbr, Jehmlich GmbH, Nossen, Germany). The flour was then passed through 60 mm mesh sieve, vacuum-packaged in a thick low density polyethylene film and kept at 4°C for further studies.

Preparation control and developed khemiss-tweria: Khemiss-tweria was prepared according to method of Dirar (1993) with some modifications. In brief, 12 kg of pearl millet grains were divided into two groups, the first 6 kg were malted, sun dried and reduced to fine flour and another half were turned into fine flour directly and (1:2 w/v) water was added and fermented. The fermented dough was cooked into kissra-hamra. Kissra-hamra was then kneaded with the millet malt flour, when it was cooled at room temperature. A half an hour was given for amylolysis before water (1:2 w/v) was added to further thin the batter and then incubated overnight for fermentation at room temperature. The next morning the batter was baked into sheets of kissra-kass using a steel hot plate (155°C), 85 g of fermented dough was spread on the hot plate into a thin sheet and peeled off the plate after 12 sec baking. The kissra sheets were sun dried, crumbled and pounded into coarse meal of kissra-assala. Kissra-assala was mixed with roasted sesame seeds in ratio of 6:1 (control), kissra-assala and roasted peanuts in ratio of 6:1, kissra-assala, roasted sesame seeds and roasted bambara groundnuts seeds in ratio of 6:0.5:0.5 and kissra-assala, roasted peanuts and roasted bambara groundnuts seeds in ratios of 6:0.5:0.5 and designated as Kh_1, Kh_2, Kh_3 and Kh_4, respectively. Beside this, 75 g of sugar and 15 g of salt were added to each 1Kg sample and the mixtures were mixed to comprise different types of khemiss-tweria, vacuum-packaged in an airtight container and kept at room temperature for further studies.

Proximate analysis: A proximate analysis of peanut, bambara groundnuts and different types of khemiss-tweria in term of moisture, ash, crude fiber and crude oil were carried out in triplicate as described by Mertens (2005). Crude protein was calculated as N%×6.25 using micro Kjeldahl digestion, distillation and titration method as described by Pearson (1976). Moisture content was determined by drying the samples at 105°C overnight (Mertens, 2005). The total carbohydrate content was calculated by subtracting the previous components from 100.

Minerals analysis: Minerals analysis of peanut, bambara groundnuts and different types of khemiss-tweria were determined by the dry-ashing method in triplicate as described by Egan *et al*. (1987). In brief, half a gram from each sample was weighed into a crucible and ashed in a muffle furnace at 600°C for 6 h. The ash was cooled and dissolved in dilute HCl (HCl: distilled water 1:3, v/v) and a few drops of concentrated nitric acid was added. The crucible was kept on a hot sand bath and boiled. The content was cooled and transferred to 50 mL volumetric flask and the volume made up to the 50 mL with distilled water. Zinc, calcium and Ferrous were determined using Atomic Absorption Spectrophotometer (Perkin-Elmer model 403, USA). Phosphorus was determined colorimetrically using spectronic 20 (Gallenkamp, UK) with KH_2PO_4 as standard as described by Pearson (1976).

Fatty acids analysis: Gas chromatography (GC-14A, Kyoto, Japan) was used in which nonvolatile fatty acids were chemically converted to the corresponding volatile methyl esters. The resulting volatile mixture was analyzed by gas chromatography.

The oil of peanut, bambara groundnuts and different types of khemiss-tweria were extracted as described by Berry (1982) and the fatty acid methyl esters were carried out in triplicate as described by Indarti *et al*. (2005) with slightly modifications. In brief, 20 mg oils were placed into clean 10 mL screw-top glass bottles to which 4 mL fresh mixture of methanol, concentrated sulfuric acid and chloroform (1.7:0.3:2.0, v/v/v) were added. The bottles were closed tightly with Teflon cap to avoid leakage and then weighed. Transesterification was studied at 100°C for 30 min. On completion of the reaction, the bottles were cooled to room temperature and weighed again to dismiss leaking samples. Then, 1 mL of distilled water was added into the mixture and thoroughly vortexes for 1 min. After the formation of two phases, the lower phase containing FAME was transferred to a clean, 10 mL bottle and dried with anhydrous Na_2SO_4. One microliter caproic acid (C6:0) methyl ester diluted in chloroform (1:499 v/v) as an internal standard was added to 0.5 mL dried solution in a vial. The samples were stored in freezer (-20°C) until GC analysis. The GC was used for determination and the percentage levels of fatty acid were calculated based on the peak area of a fatty acid species to the total peak area of all fatty acids in the oil samples.

Amino acids analysis: Amino acids composition of peanut, bambara groundnuts and different types of khemiss-tweria were measured in triplicate on hydrolysates using amino acids analyzer (Sykam-S433, Eresing, Germany). Sample hydrolysates were prepared following the method of Moore and Stein (1963). In brief, 200 mg from each sample were taken in hydrolysis tube. Then 5 mL 6 M HCl were added to samples into the tube, evacuated, tightly closed and incubated for 24 h at 110°C. After incubation, the solutions were filtered and 200 mL of the filtrate were evaporated to dryness at 140°C for an hour. The dried hydrolysate was diluted with 1 mL of 0.12 M, pH 2.2 citrate buffers, the same as standards (amino acid standards H; Pierce Inc., Rockford; IL, USA). An aliquot of 150 µL of the sample hydrolysate was injected in a cation separation column at 130°C. Ninhydrin solution and an eluent buffer (the buffer system contained solvent A, pH 3.45 and solvent B, pH 10.85) were delivered simultaneously into a high temperature reactor coil (16 m length) at a flow rate of 0.7 mL min^{-1}. The buffer/ninhydrin mixture was heated in the reactor at 130°C for 2 min to accelerate chemical reaction of amino acids with ninhydrin. The products of the reaction mixture were detected at wavelengths of 570 and 440 nm on a dual channel photometer. The amino acids composition was calculated from the areas of standards obtained from the integrator and expressed as percentages.

Statistical analysis: All results were carried out in triplicate and expressed as Mean±Standard Deviation (SD) using Microsoft Office Excel 2007.

RESULTS AND DISCUSSION

Proximate composition: As shown in Table 1, it can be seen that, the contents of moisture, crude protein and crude fiber of bambara groundnut are higher than the findings of Aremu *et al*. (2006b). The contents of crude oil and crude protein in peanut are similar with the results of Atasie *et al*. (2009) who showed that, crude oil among 29 cultivars ranged from 47.0-50.1% and protein from 26.3-30.9%. However, oil it's an important in diets as it's promotes oil soluble vitamin absorption and it's a high energy nutrient and doesn't add to the bulk of the diet. In addition, crude fiber contents of peanut and bambara groundnuts showed that, they had ability to maintain internal distention for a normal peristaltic movement of the intestinal tract, its physiological role of crude fiber. However, diets with low fiber content is undesirable as it could cause constipation and that such diets have been associated with diseases of colon like piles, appendicitis and cancer. Furthermore, low moisture contents were observed in the different types of khemiss-tweria; hence, this is an indication of better quality and longer shelf life. In addition, the contents of ash and crude fiber of developed khemiss-tweria in case of Kh_2, Kh_3 and Kh_4 (4.78±0.01 and 3.26±0.01%), (4.80±0.01 and 3.27±0.01%) and (4.75±0.01 and 3.26±0.01%) respectively close similar to that of control. The contents of moisture, crude protein, ash and carbohydrate in different types of khemiss-tweria are agreement with findings of (Abdualrahman and Ali, 2012) for traditional khemiss-tweria. However, Ali *et al*. (2010) studied values of (8.32±0.14 and 2.20±0.26%) for moisture and ash of khemiss-tweria. On the other hand, crude protein contents of developed

Table 1: Chemical composition of peanut, bambara groundnuts and different types of khemiss-tweria

	Component (%)						
Samples treatment	Moisture	Crude protein	Ash	Crude oil	Crude fiber	Carbohydrate	Energy (KJ/100 g)
Peanut	5.10±0.02	30.80±0.03	3.60±0.01	47.34±0.01	4.10±0.01	9.06±0.02	2429.20±0.03
BG	4.00±0.03	29.17±0.02	4.17±0.01	6.20±0.03	4.69±0.01	51.77±0.03	1605.38±0.01
Kh_1	4.11±0.01	15.76±0.01	4.81±0.01	10.94±0.01	3.39±0.01	60.99±0.02	1709.53±0.02
Kh_2	4.14±0.01	16.73±0.01	4.78±0.01	10.45±0.01	3.26±0.01	60.64±0.01	1701.94±0.01
Kh_3	4.13±0.01	23.54±0.01	4.80±0.01	7.70±0.01	3.27±0.01	56.56±0.02	1646.60±0.02
Kh_4	4.10±0.01	24.20±0.01	4.75±0.01	7.30±0.01	3.26±0.01	56.39±0.01	1640.13±0.01

Means are calculated from triplicate samples, BG: Bambara groundnuts, Kh_1: Control khemiss-tweria prepared in ratio of 6:1 (kissra-assala: roasted sesame seeds), Kh_2: Khemiss-tweria prepared in ratio of 6:1 (kissra-assala: roasted peanuts), Kh_3: Khemiss-tweria prepared in ratio of 6: 0.5: 0.5 (kissra-assala: roasted sesame seeds: roasted bambara groundnuts), Kh_4: Khemiss-tweria prepared in ratio of 6: 0.5: 0.5 (kissra-assala: roasted peanuts: roasted bambara groundnuts), energy (KJ/100 g) is calculated as (crude protein×17+crude oil×37+Carbohydrate×17)

Table 2: Mineral composition of peanut, bambara groundnuts and different types of khemiss-tweria

	(mg/100 g)				
Samples treatment	Calcium	Phosphorus	Iron	Zinc	Ca/P
Peanut	65.50±0.01	69.7±0.010	6.70±0.03	6.50±0.02	0.94
Bambara groundnuts	62.00±0.01	66.70±0.01	6.00±0.01	4.00±0.01	0.92
Kh_1	37.81±0.02	38.01±0.01	16.66±0.01	4.64±0.02	0.99
Kh_2	38.30±0.01	39.73±0.01	16.00±0.01	4.12±0.01	0.96
Kh_3	39.01±0.01	41.54±0.01	16.91±0.01	4.58±0.01	0.94
Kh_4	39.43±0.01	41.75±0.01	21.23±0.01	4.45±0.01	0.94

Means are calculated from triplicate samples, Ca/P: Ratio of calcium to phosphorus

khemiss-tweria are improved by 6.16, 49.37 and 53.55%, respectively over the control. However, crude protein of the studied samples are higher than (10.87±0.21%) as reported by Ali *et al*. (2010). The energy values of developed khemiss-tweria ranged from 1640.13±0.01-1709.53±0.02 KJ/100 g indicated that, the studied products have high energy compared to other cereals products.

Minerals composition: From Table 2, peanut was higher in calcium, iron and zinc contents than bambara groundnuts. However (Aremu *et al*., 2006a) and (Adu-Dapaah and Sangwan, 2004) have been reported values of (60.20±0.3-63.80±0.4) and (95.80-99.00) mg/100 g, respectively for calcium in bambara groundnuts, meanwhile, Asibuo *et al*. (2008) studied values of (44-134, 0.20-3.70 and 0.0- 6.5) mg/100 g for calcium, iron and zinc in peanut. On the other hand, iron content of bambara groundnuts is in agreement with the findings of Adu-Dapaah and Sangwan (2004) and higher than the findings of Aremu *et al*. (2006a). In addition, peanut is close similar to bambara groundnuts in phosphorus contents and higher than the findings of Aremu *et al*. (2006b). However, Ndidi *et al*. (2014) reported values of (76.98, 100.97 and 132.25) mg/100 g, phosphorus contents, respectively for raw, boiled and roasted bambara groundnuts.

In addition to this, utilization of peanut in preparation of khemiss-tweria improved the contents of calcium and phosphorus whilst, reduced the contents of iron and zinc when compared to control sample. Furthermore, calcium, phosphorus and iron contents in case of kh_3 and kh_4, respectively increased whilst, the contents of zinc (4.58±0.01 and 4.45) mg/100 g are decreased. The ratio of calcium to phosphorus is ranged from 0.92 in bambara groundnuts to 0.99 in control khemiss-tweria; hence, this is an indication of good sources of minerals for bone formation. However, Aremu *et al*. (2006b) reported that, modern diets which are rich in animal proteins and phosphorus may promote the loss of calcium in urine. Hence, this has led to the concept of the Ca/P ratio, if the Ca/P ratio is low more than the normal amount of calcium may be loss in the urine, decreasing the calcium level in bones. Furthermore, Aremu *et al*. (2006b) have been showed that, food is considered good if the ratio is above one and poor if the ratio is less than 0.5. The highest contents of calcium it's attributed to presence of roasted sesame seeds, whilst the increases in phosphorus content may clearly be due to the incorporation of roasting sesame seeds and bambara groundnuts.

Fatty acids composition: From Table 3, it can be seen that, the contents of palmitic and linoleic acids in bambara groundnuts are agreement with the findings of Brink *et al*. (2006) and higher than the findings of Okonkwo and Opra (2010). Bambara groundnut is higher in contents of palmitic and linoleic acids than peanut. However, Olanipekun *et al*. (2012) reported that, the presence of linoleic acid in bambara nut fermented within 0-72 h, indicated that, the oil extract are likely to be superior to the oils known to be generally lacking in linoleic acid. This component helps to reduce the risk of coronary heart diseases and improve inflammatory conditions such as arthritis and lower blood pressure. In addition, stearic and oleic acids contents of bambara groundnuts (8.50±0.01 and 24.00±0.01%) are agreement with the findings of (Brink *et al.,* 2006) whilst, oleic acid content is higher than the findings of Okonkwo and Opra (2010).

On the other hand, palmitic and oleic acids contents of developed khemiss-tweria in case of Kh_2, Kh_3 and Kh_4 are improved compared to control sample meanwhile, stearic and linoleic acids are decreased. In generally, the different types of khemiss-tweria had highest contents of unsaturated fatty acids; it's however, this is an indication of good nutritional quality and hence, the products shelf life will be limited by the presence of unsaturated fatty acids which necessitates its consumption within its specified shelf life. However, Okonkwo and Opra (2010) have been shown that, unsaturated fatty acids are used to produce hormone like substances that regulate wide range of functions. It's however, they regulate blood pressure, blood clothing and blood lipid level and inflammation response to injury infection, beside this, unsaturated fatty acids are essential in human diet since there are no synthetic mechanisms available for their production in the human body.

Amino acids composition: Amino acids composition of peanut, bambara groundnuts and different types of khemiss-tweria are illustrated in Table 4, bambara groundnuts was higher in lysine content than peanut, it's however, both results are higher than the findings of (Latif *et al*., 2013) for peanut and lower than the findings of Aremu *et al*. (2006b) for bambara groundnuts. On the other hand, peanut was higher in arginine content than bambara groundnuts (13.32 and 8.69) g/100 g protein. However (Yagoub and Ahmed, 2012) found a value of (15.09 g/100 g protein) arginine content for peanut cake. In addition, threonine content of peanut was higher than the findings of Latif *et al.* (2013) for peanut kernel and (Yagoub and Ahmed, 2012) for peanut cake. Furthermore, contents of valine, glycine and alanine in peanut are lower than the that results

Table 3: Fatty acids composition of peanut, bambara groundnuts and different types of khemiss-tweria

Samples treatment	Fatty acid (%) 16:0	18:0	18:1	18:2	Ratio of saturated to unsaturated
Peanut	10.83±0.02	8.20±0.01	50.27±0.02	21.47±0.01	0.27:1
Bambara nuts	21.00±0.01	8.50±0.01	24.00±0.01	36.50±0.02	0.49:1
Kh_1	11.40±0.01	6.68±0.01	37.34±0.01	44.82±0.02	0.22:1
Kh_2	14.55±0.01	5.21±0.01	45.06±0.01	35.18±0.02	0.24:1
Kh_3	14.09±0.01	5.50±0.01	46.52±0.01	33.88±0.01	0.24:1
Kh_4	15.53±0.01	5.14±0.01	39.77±0.01	39.56±0.01	0.26:1

Means are calculated from triplicate samples, 16:0: Palmitic acid, 18:0: Stearic acid, 18:1: Oleic acid and 18:2: Linoleic acid

Table 4: Amino acids composition of peanut, bambara groundnuts and different types of khemiss-tweria

	Samples treatment g 100/g protein					
Amino acids	Peanut	BG	Kh_1	Kh_2	Kh_3	Kh_4
Lysine	3.79	7.13	1.56	1.29	1.56	2.37
Histidine	2.37	3.30	2.08	2.00	2.05	2.12
Arginine	13.32	8.69	5.77	5.78	5.14	5.43
Aspartic acid	10.10	10.96	8.43	8.97	8.52	8.89
Threonine	3.03	3.54	3.46	3.31	3.43	3.49
Serine	4.72	4.05	2.97	3.09	3.02	4.38
Glutamic acid	19.88	21.19	22.58	20.43	21.14	25.14
Proline	6.25	5.48	9.24	10.69	10.87	7.62
Glycine	4.46	2.75	1.57	0.60	0.85	2.07
Alanine	4.57	5.89	10.63	11.01	11.19	8.95
Cystine	0.96	0.69	0.51	0.19	0.21	0.46
Valine	5.11	4.96	6.43	7.00	6.92	5.49
Methionine	0.91	0.92	1.82	1.60	1.63	1.62
Isoleucine	4.23	3.87	4.48	4.83	4.94	3.92
Leucine	7.27	8.25	11.49	11.42	11.70	10.43
Tyrosine	2.96	2.09	1.84	2.39	1.50	2.27
Phenylalanine	6.07	6.24	5.14	5.40	5.33	5.35
Tryptophan	ND	ND	ND	ND	ND	ND

BG: Bambara groundnuts, ND: Not determined

Table 5: Analysis of essential and non-essential amino acids (g/100 protein) of peanut, bambara groundnuts and different types of khemiss-tweria

Amino acids	Peanut	BG	Kh_1	Kh_2	Kh_3	Kh_4
Total non-essential amino acids	53.90	53.10	57.77	57.37	57.30	59.78
Total essential amino acid with His	46.10	46.90	42.23	42.63	42.70	40.22
Total essential amino acid without His	43.73	43.60	40.15	40.63	40.65	38.10
Essential aliphatic amino acids	16.61	17.08	22.40	23.25	23.56	19.84
Essential aromatic amino acids	6.07	6.24	5.14	5.40	5.33	5.35
Total neutral amino acids	39.60	41.35	39.77	37.59	37.95	43.98
Total acid amino acids	29.98	32.15	31.01	29.40	29.66	34.03
Total basic amino acids	19.48	19.12	9.41	9.07	8.75	9.92
Total sulphur amino acids	1.87	1.61	2.33	1.79	1.84	2.08
Cystine (%) in TSAA	51.34	42.86	21.89	10.62	11.41	22.12

BG: Bambara groundnuts, His: Histidine

studied of Yagoub and Ahmed (2012) for peanut cake. Aspartic and glutamic acids contents are the major amino acids in peanut, bambara groundnuts and the different types of khemiss-tweria. Serine, valine, phenylalanine, histidine and lysine contents of developed khemiss-tweria in case of Kh_2 and Kh_3 are higher than that of control sample.

As presented in Table 5, total essential amino acids of peanut, bambara groundnuts, control and different types of khemiss-tweria are (46.10-43.73, 46.90-43.60, 42.23-40.15, 42.63-40.63, 42.70-40.65 and 40.22-38.10) g/100 g protein with and without histidine, respectively improved compared to (30.80 g/100 g protein) as reported by FAO./WHO. (1973). Furthermore, the data are agreement with the results obtained by Aremu *et al.* (2006b) for some Nigerian under-utilized legume flours. Essential aliphatic amino acid was highly concentrated in kh_3 with value of 46.47 g/100 g protein, while the highest value of essential aromatic amino acid was found in peanut (9.03 g/100 g protein). The values of neutral, acidic, basic and sulphur amino acids ranged from (37.59-43.98, 29.40-34.03, 8.75-19.48 and 1.61-2.08 g/100 g protein), respectively. On the other hand, as shown in Table 6, the new types of khemiss-tweria are superior with respect to arginine, isoleucine, leucine, phenylalanine, threonine and valine and meanwhile, supplementation process may be required only for histidine, lysine and methionine. However, the contents of leucine and valine in different types of khemiss-tweria (11.49 and 6.34), (11.42 and 7.0), (11.70 and 6.92) and (10.43 and 5.49) g/100 g protein respectively higher, when compared to (4.80 and 4.20) g/100 g protein as recommended by FAO./WHO. (1973).

Table 6: Recommended FAO/WHO essential amino acid provisional pattern

	Samples treatment (g/100 g protein)						
EAA	FAO/WHO*	Peanut	BG	Kh_1	Kh_2	Kh_3	Kh_4
Arginine	2.00	13.32	8.69	5.77	5.78	5.14	5.43
Histidine	2.40	2.37	3.30	2.08	2.00	2.05	2.12
Isoleucine	4.20	4.23	3.87	4.48	4.83	4.94	3.92
Leucine	4.80	7.27	8.25	11.49	11.42	11.70	10.43
Lysine	4.20	3.79	7.13	1.56	1.29	1.56	2.37
Methionine	2.20	0.91	0.92	1.82	1.60	1.63	1.62
Phenylalanine	2.80	6.07	6.24	5.14	5.40	5.33	5.35
Threonine	2.60	3.03	3.54	3.46	3.31	3.43	3.49
Tryptophan	1.40	ND	ND	ND	ND	ND	ND
Valine	4.20	5.11	4.96	6.43	7.00	6.92	5.49
Total EAA	30.80	46.10	46.90	42.23	42.63	42.70	40.22

*Provisional amino acids pattern recommended by FAO./WHO. (1973), EAA: Essential amino acid, ND: Not determined, BG: Bambara groundnuts, His: Histidine

CONCLUSION

The present study is the first report investigate the utilization of peanut and bambara groundnuts in production of khemiss-tweria. However, the study remarkably developed new types of khemiss-tweria with high contents of crude protein and good shelf life compared to control sample. In addition, the contents of calcium, phosphorus, iron, plamitic and oleic acids of the new products are improved. The amino results indicated that, the new products are superior with respect to arginine, leucine, phenylalanine, threonine and valine when compared to FAO/WHO reference pattern.

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