Journal of Agricultural Technology 2013 Vol. 9(7):1955-1971
Available online http://www.ijat-aatsea.com
ISSN 1686-9141

Effect of fermentation and/or cooking on protein fractions and sensory characteristics of sorghum supplemented with groundnut flour

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Mardia E. ElHag, Isam A. Mohamed Ahmed, Mohamed M. Eltayeb and Elfadil E. Babiker (2013) Effect of fermentation and/or cooking on protein fractions and sensory characteristics of sorghum supplemented with groundnut flour. Journal of Agricultural Technology 9(7):1955-1971.

Changes in total protein and protein fractions were investigated during fermentation and/or cooking after supplementation of sorghum flour with defatted groundnut flour were investigated. The protein content and fractions were significantly ($p \geq 0.05$) increased after supplementation with defatted groundnut flour. The albumin plus globulin fraction increased significantly ($p \geq 0.05$) during the first 8h of fermentation after supplementation with 20% groundnut flour. Other fraction contents were observed to fluctuate during the fermentation time. Supplementation of the cultivar flour with 20% groundnut flour greatly increased the protein content as well as the albumin plus globulin fraction while other fractions were significantly decreased. Sensory evaluation of locally processed sorghum products (Kisra, Asida and Nasha) before and after supplementation showed no difference between the supplemented samples and the control ones as judged by trained panellists.

Keywords: Fermentation; Groundnut; Protein fractions; Sensory evaluation; Sorghum; Supplementation

Introduction

Sorghum (*Sorghum bicolor* (L.) Moench) is considered to be one of the most important food crops in the world, following wheat, rice, maize and barley (FAO, 1997). Grain sorghum provides the staple food for large populations of Africa, India and the semi-arid parts of the tropics. It is one of the oldest cultivated crops and has been used for centuries in the regions of its origin (Nile

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valley and central India). It is commonly consumed by the poor of many countries and it forms a major source of proteins and calories in the diet of large segments of the populations of India and Africa. Besides being a staple food, it is also used as a feed for animals and it is an industrial raw material; its stalk provides fodder, fuel, shelter and syrup. Grain sorghum is the leader cereal crop in the Sudan. It is the main staple food, prevailing through- out the country and covering more than 60% of the total cultivated cereals area, with an annual production of about 4.0 million tons (FAO, 1997). Processed sorghum seeds or flour are important sources of calories and proteins for the vast majority of the population as well as for poultry and livestock (FAO, 1997). Sorghum proteins are classified, according to solubility, as albumins, globulins, prolamins and glutelins. The prolamin fraction of sorghum (kaffirin) is further divided into α-, β- and γ-kaffirins (Skoch et al., 1970). The nutritional quality of sorghum is poor, due to deficiency in lysine and low quantities of threonine and tryptophan (Au and Fields, 1981). Sorghum grains have low starch and protein digestibilities, due to the presence of certain antinutritional factors which also contribute to poor sensory characteristics of processed sorghum grains. Recently, great efforts have been directed toward improve the nutritional quality of cereal grains, particularly to improve the level of essential amino acids, as well as protein digestibility. Various methods have been proposed to improve lysine content in dishes prepared from germinated and fermented sorghum (Eggum et al., 1983). Fortification with synthetic lysine is very effective, but rather impracticable considering the conditions under which sorghum is processed. Sudanese people consume sorghum as fermented Kisra, Asida or Nasha which provide about 97% of the protein and 75% of the calories in the diet of the people residing in central and western Sudan. Proteins of whey and several beans have better functional properties, such as solubility (Dewit and Kessel, 1996; Patel and Kilara, 1990) over a wide range of pH. Beans protein is a key ingredient in many infant formulas because they contained all the essential amino acids. The albumin plus globulin fraction is reportedly characterized by a high level of lysine (Wu and Wall, 1980). Whey and beans proteins have the potential to improve quality of food products (Kim et al., 1989; Morr and Ha, 1993). Groundnut protein is a high quality protein and a rich source of essential amino acids. Therefore, in this study we investigate the effect of supplementation with defatted groundnut flour and/or fermentation on protein fractions and sensory characteristics of sorghum flour.

Materials and methods

Materials

Sorghum seed (*Sorghum bicolor*) of Dabar cultivar was obtained from local market, Port Sudan, Sudan, cleaned, freed from foreign seeds and matter, then milled in a laboratory mill to pass 0.4 mm screen, and stored in polyethylene bags, stored at 4^{o}C for further analysis. Groundnut flour was obtained from Emad Oil Factory, Industrial Area, Khartoum North, Sudan, from which oil was extracted with hexane. The flour was milled using house mortar and pistil through, passed through 0.4 mm screen, stored in polyethylene bags at 4ºCfor further analysis.

Natural fermentation

Natural fermentation was carried out by mixing sorghum flour with distilled water (1: 2 w/v). About 250 g of sorghum flour were mixed with 500 ml distilled water in a 750 ml beaker and then incubated in an incubator (Gallenkamp, England) at 37ºC for periods of 0, 4, 8, 12, 16, 20, 24, 28, 32 h. Thereafter, the samples were mixed with a glass rod and transferred to three aluminum dishes (30 cm diameter each) and dried in a hot oven (Heraus UT 5042, Germany) at 70ºC for 3–4 h. Dried samples were then ground to pass a 0.4 mm screen and stored in polyethylene bags at 4ºC for further analysis.

Cooking

Two hundred fifty grams of each sample were put in 600 ml beaker with 500 ml distilled water, stirred with a glass rod, and the beaker was put in water bath for 20 min with continuous stirring. Then the mixture was transferred to three aluminum dished (30 cm diameter each) and dried in a hot air oven (Heraus UT 5042, Germany) at 70^{o}C for 3-4 hours. Dried samples were ground using laboratory mortar to pass 0.4 mm screen and stored at 4^{o}C until analysis.

Processing of sorghum flour before and after supplementation (Kisra, Asida and Nasha)

Kisra bread was prepared from sorghum flour before and after supplementation. The fermented dough, known as ‘‘Ajean’’, was prepared traditionally by mixing samples with water in a round earthen ware container called ‘‘Khumara’’. A small amount of the previously fermented dough was then added to the mixture, which acted as a starter. After thorough mixing, it was baked on a hot steel plate in a process known as ‘‘Aowasa’’, which is a unique Sudanese art in which a small amount of the fermented dough is spread over a hot plate forming a very thin sheet within 1–2 s and then taken out and considered ready for eating. Asida and Nasha preparations differ from that of Kisra; they are prepared as thick and thin pastes, respectively.

Protein fractionation

Nitrogen of a defatted sample was extracted stepwise by series of solvents according to the Landry and Moureaux technique (1970). To obtain salt-soluble globulin, 0.5 M NaCl was added to the sample powder and the mixture was stirred three times for 0.5, 1, and 30 min at 4°C. The residue was extracted with the same volume of distilled water (twice) for 15 min at 4°C to obtain water-soluble albumin. Thereafter, the residue was stirred with 60% ethanol twice for 30 min at 20°C and then at 60 °C for 30 min, followed by extraction with 55% isopropanol (Pr-OH) at 20 °C to obtain alcohol-soluble prolamin. Then the residue was extracted with 60% ethanol plus 0.6% of 2-mercaptoethanol (2-ME) and stirred twice for 30 min (20 °C), then extracted with 55% Pr-OH containing 2-ME (0.6%) at 20 °C (twice) for 30 min to obtain G1-glutelin. While G2- and G3-glutelins were obtained after treatment with 0.0125 M borate buffer (pH 10), 0.6% 2-ME and 0.5 M NaCl and with 0.0125 M borate buffer (pH 10), 0.6% 2-ME and 0.5 M sodium dodecyl sulfate (SDS), respectively. The nitrogen of each of these fractions was determined by the micro-kjeldahl method.

Sensory evaluations

The sensory tests were conducted, using conventional profiling, by a trained panel. Ten judges were selected who had successfully passed standardized tests for olfactory and taste sensitivities as well as verbal abilities and creativity. The panellists were given a hedonic questionnaire to test odour, taste and general acceptability of coded samples of Kisra, Asida and Nasha made from fermented Wad Ahmed as a control, and after supplementation with 5% and 10% whey protein. They were scored on a scale of 1–5 (1 = poor, 2 = fair, 3 = good, 4 = very good and 5 = excellent).

Statistical analysis

Each sample was analyzed in triplicate and the figures were then averaged. Data were compared using analysis of variance (ANOVA)

(Snedecor, 1987) and Duncan's multiple range test at a probability of ($P \leq 0.05$) (Duncan, 1955).

Results and discussions

Effect of supplementation on protein content and protein factions

Protein content of sorghum flour was significantly ($P<0.05$) increased after supplementation with groundnut flour (Fig 1). It was increased from 8.8% in sorghum flour to 15.1% in composite flours. Supplementation of low protein foods with high protein diets results in an increase in protein quantity of the former (Ibrahim *et al*. 2005a; El Tinay *et al*., 1985; Elhag *et al*., 2001). Supplementation is found to cause different changes in protein fractions of sorghum, they either increase, decrease, or remaining unchanged or fluctuated throughout the supplementation process.

Albumin plus globulins of sorghum flour was significantly ($P<0.05$) improved after supplementation with groundnut flour (Fig 1). They were increased from 16.7% in raw sorghum flour to about 64.7 % in composite flour. Similar results was obtained by Ibrahim *et al.* (2005a) who reported that the albumins plus globulin of sorghum increased from 15.2 to 40.9% and 56.7% in composite diets from sorghum supplemented with 5 and 10% whey protein, respectively. This highly significant increase in albumin plus globulin fraction resulted in a considerable improvement of sorghum nutritive value as this fraction is characterized by high level of lysine (Wu and Wall, 1980).

Prolamin which is the predominant fraction in sorghum was significantly ($P<0.05$) decreased in the composite flour compared to control (Fig 1). This result also agreed with that obtained by Ibrahim *et al.* (2005a) who stated that prolamin of sorghum decreased from 30.9% to 21.0% in 5% whey protein supplemented diet and to 17.3% in 10% whey protein supplemented diet. This considerable reduction in sorghum prolamin can be taken as positive point that prolamin fraction is low in the limiting amino acids like lysine, tryptophan therionine and methionine, the poor nutritive value of sorghum is directly attributed to its high level of   in the endosperm (Wall and Blessin, 1969). So since supplementation with defatted groundnut flour resulted in prolamin decrease it improves the nutritive quality of sorghum.

All glutelin fractions G_1, G_2 and G_3 were also decreased with the supplementation level of groundnut flour. The results are in agreement with those of Ibrahim *et al.* (2005b) who stated that G_1 glutelin decreased from 27.80 to 18.9% in 50% whey protein diet to 16.0 in 10% whey protein supplemented diet G_2 glutelin decreased from 3.4 to 2.9 and to 2.8 and G_3-glutelin was decreased from 21.6 to 14.84 and to 12.3% and 10% whey protein supplemented diets, respectively, but the decrease in glutelins is not recommended because it decreases the lysine of the seed that glutelins contain much higher quantities of lysine compared to prolamin (Virupaksha and Sastry, 1968).

The insoluble protein (Fig 1) was significantly ($P<0.05$) decreased with the supplementation. This result disagrees with those obtained by Ibrahim *et al*. (2005b) for sorghum supplemented with whey protein in which supplementation increased insoluble protein from 1.1% for raw sorghum to 1.4% and 1.6% for 5 and 10% whey protein supplemented sorghum, respectively.

Effect of cooking on protein fractions of 20% composite flour

Figure 2 shows the results of cooked sorghum flour supplemented with 20% defatted groundnut flour. Albumin plus globulin fraction was found to be significantly ($P\leq0.05$) decreased as a result of cooking. It was 64.7% for the uncooked raw 20% composite flour and dropped to 58.6% after cooking. Similar result was reported by Nugadalla and El Tinay (1997) for the same fraction for two cowpea cultivars. Moreover, Elfiel *et al*. (2003) reported a reduction in globulin and albumin wet cooked faba beans. Similar result also obtained by Yousif (2000) for dry cooking of rice, Mahamoud (2009) for sickle pod leaves and Elshafie *et al.* (2004) for seven boiled groundnut cultivars. Reduction in globulin due to cooking had an adverse effect on the nutritive value of the composite flour because it reduces the fractions that considered relatively rich in essential amino acids such as lysine (Wu and Wall, 1980).

Prolamin was also significantly ($P\leq0.05$) decreased from 15.0 to 12.0% after cooking (Fig 2). These results are similar to those of Nogdallah and El Tinay (1997) for two varieties of cowpea and with that obtained by Elfiel *et al*. (2002) for faba beans. Also there is an agreement with Suliman (2007) for lentil and with Elshafie *et al.* (2004) for seven boiled groundnut cultivars. Whereas, it disagree with those reported by Yousif (2000) for dry cooked rice. The difference in results may be attributed to many factors that may affect the distribution of the fractions such as fertilizer treatment, others like genotype, soil fertility, water availability, environmental conditions during grain development and temperature.

Cooking has no effect on G_2- gluteinine whereas, it significantly ($P\leq0.05$) increased G_1- glutelin and G_3- glutelin. Similar results were obtained by Elshafie *et al.* (2004) for the increment in G_3- glutelin in groundnut and by Nugadallah and El Tinay (1997) for enhancement of G_3- glutelin in two varieties of cowpea as a result of cooking. Where Elshefie *et al.* (2004) reported a slight increase in G_1 and G_2- glutelins of groundnut. Yousif (2000) reported that cooking altered the protein solubility. The difference in results may be due to difference in factors affecting the fractions distribution like fertilization, supplementation rate or anti-nutrients present in the grains (Champ, 2002). There is a slight increase in the insoluble protein due to cooking process the value was insignificantly increased from 0.4 to 0.5% (Fig 2). The result is in disagreement with those of Nugdalla and El Tinay (1997) who reported a high significant increase in the insoluble protein of cowpea as a result of cooking. Also Hamker *et al.* (1986) reported doubling in insoluble protein of sorghum due to cooking process.

Effect of fermentation on protein fractions of 20% composite flour

The effect of fermentation on protein content and fractions of 20% composite flour is depicted in Figure 3. By the end of fermentation a slight improvement of protein quantity of 20% composite flour was observed. The results are similar to that obtained by Ibrahim *et al.* (2005a) and Ibrahim *et al*. (2005b) for sorghum varieties Dabar and Wad Ahmed that was supplemented with 10% whey protein. Fermentation caused significant changes in protein fractions of the composite flour; fractions are increased, decreased or fluctuated throughout the process (Fig 3).

The albumin plus globulin fraction increase gradually from 64.7 h to 64.9, 67.6 and 69.5% for 4, 8 and 12 h, respectively, then dropped to 64.7 and 63.7% after 20 and 24 h, respectively. After that it starts to increase again till reached its maximum value at 32 h of fermentation. The value is very high, especially when compared with that obtained for fermented sorghum alone (16.4%). Thus, fermentation after supplementation highly improved the nutritive value of sorghum qualitatively and expected to solve the problem of lysine deficiency in sorghum as this fraction is known to be rich in lysine (Wu and wall, 1980). Also Elfaki *et al*. (1991) reported a significant increase in sulphur counting amino acids during fermentation of sesame cake.

The prolamin fraction (15.0 at 0 h) was significantly ($P \leq 0.05$) decreased to 13.9, 13.1, 14.9, 14.3% after 8, 12 and 16 h of fermentation, then started to increased slightly to 14.41% after 20 h and sharply at 24 h to 16.0% which was the highest value observed after which it was decreased significantly ($P \leq 0.05$) to 11.6% for 32 h. The result obtained is agreed with those of Ibrahim *et al*. (2005a) and the reduction in this fraction may be attributed to the difference in weight before and after supplementation (Ibrahim *et al.*, 2005a).

Glutelins were found to fluctuate during the fermentation period but at the end of the period G_1- glutelin was decreased significantly ($P \leq 0.05$) , G_2-glutelin was significantly ($P \leq 0.05$) increased and the G_3-glutelin was significantly ($P \leq 0.05$) increased. The detected change was from 1.5 to 2.6% for

G_2- glutelin and from 9.2 to 10.1% for G_3- glutelin. The results are similar to that obtained by Ibrahim *et al*. (2005a) for G_3- glutelin, but against those obtained by the same worker for the G_2- glutelin. The difference of course related to nature of supplemented material in each.

The insoluble proteins were fluctuated throughout the course of fermentation (Fig 3). The results obtained are in agreement with those obtained by Ibrahim *et al.* (2005a); Yousif and El Tinay (2001) and Ibrahim *et al.* (2005b). But the values obtained by these workers are less than those obtained in this study. This difference may be attributed to the fact that residue obtained for the composite flour is small from the beginning of the process.

Effect of cooking after fermentation on protein fraction of 20% composite flour

As shown in Figure 4 the protein contents of fermented 20% composite flour were significantly ($P \leq 0.05$) increased as a result of cooking. At 0 h it was 20.1% changed to 21.2, 21.4, 22.1 and 22.7% for 8, 16, 24 and 32 h fermentation, respectively. These results were similar to the findings of Abdel Hady *et al.* (2005) who stated that cooking of maize after fermentation was found to be more effective in increasing protein content and this was attributed to the reduction of anti-nutritional factors (tannin, polyphones and phytic acid) and other water soluble constitutes as a result of cooking . Also the results were in agreement with those of Mahmoud (2009) who reported an increase in protein content of sickle pod leaves from 25.43% to 32.17% as a result of fermentation followed by cooking.

The results (Fig 4) also showed that cooking of fermented 20% composite flour significantly ($P \leq 0.05$) decreased albumin plus globulin from 64.7 to 60.2% (0 h), from 67.6 to 63.6% (8 h), from 68.6 to 65.08% (16 h), from 63.7 to 61.2 (24 h) and from 67.3 to 64.9% (32 h). However, if we compare this reduction with that resulted from cooking alone we can observe considerable improvement in the nutritive value of the composite flour under investigation, that cooking alone caused drop of the fraction from 64.7 to 58.6% only the last value is less than all values obtained from the combination of fermentation and cooking. This result agreed with that reported by Eggnm *et al.* (1983) who stated that fermentation prevents the negative effect of cooking on Sorghum. On the other hand many workers obtain similar results, of them Yousif (2000) in sorghum / maize and rice and Hamaker *et al.* (1986) in sorghum.

Cooking after fermentation significantly ($P \leq 0.05$) reduce prolamin fraction of the 20% composite flour at the end of fermentation period (32 h). Although it was observed that the fraction start to decrease then increased but at the end it was significantly ($P \leq 0.05$) decreased. Same results were obtained by

Hamaker *et al.* (1986) for sorghum and Yousif (2000) for sorghum, maize and rice. This reduction in prolamin (Kafarin) fraction is recommended from a nutritional point of view because this fraction which is the predominant in sorghum flour is responsible for the lower nutritive value, that it's poor in the amino acid lysine. Finally the reduction is attributed to the fact that heat treatment degraded the high molecular weight poly peptides, giving rise to smaller fragments (Semino and Cerletii, 1987) and to the fact that cooking and fermentation both specially when they are in combination cause considerable reduction in anti-nutrients of cereals and legumes (obizoba and Atii, 1991; Abed El Hady *et al.,* 2005).

G_1- glutelin was changed significantly ($P \leq 0.05$) during cooking of fermented composite flour (Fig 4). It decreased at the first 8 h, and then increased reaching it is minimum value at 32 h of fermentation. But if we compare it with the effect of fermentation alone the net reduction (at the end of the period) was of two folds. Similar findings were obtained by Hamaker *et al.* (1986) in cooked and fermented sorghum, and by Yousif (2000) who reported a reduction for the same fraction of the dry cooked fermented sorghum. G_2 and G_3- glutelin would seem to be increased significantly towards the end of fermentation period as a result of cooking (Fig 4). G_2- glutelin increased from 1.5 to 2.2%, 1.3 to 2.0, and then decreased from 2.9 to 2.5% and from 3.8 to 2.8%. This increase if compared with that obtained at the beginning of fermentation by the fermentation process alone is considerably high. Same results were obtained by Yousif (2000) and Hamaker *et al.* (1986) for sorghum. G_{3-} glutelin was significantly ($P \leq 0.05$) increased from 9.2 to 13.7, from 9.4 to 14.2%, from 8.24 to 14.7%, from 6.8 to 16.8% for 0, 8, 16, 24 and 32 h fermented only and fermented cooked, respectively. Also the increase in G_3-glutelin was reported by Nugdalla and El Tinay (1997) for cooked cowpea, Yousif (2000) for fermented cooked sorghum, and Hamaker *et al.* (1986) for wet cooked sorghum. Clark and Switzo (1975) reported that heating a protein at 100^{o}C in SDS solution will completely dissociate all poly peptide chains from one another.

The insoluble protein was significantly ($P \leq 0.05$) increase as a result of cooking following fermentation. Similar results were reported by Fageer and El Tinay (2004), Sulieman (2007), Yousif (2000), and Nogdalla and El Tinay (1997) for cereals and legumes residual increment due to cooking of fermented or non-fermented materials. These residues may be un extracted glutelin albumin, associated with starch and cell debris (Wilson *et al.,* 1981) or they may be not extracted because they were linked to cell well or they may be in interaction with lipids, carbohydrates or polyphenols via oxidation process (Landry and Moureax, 1981).

Nevertheless, if we compare these results with those obtained for cooking alone (fig 2) we found that cooking after fermentation had considerably increased protein content from 19.3 to 22.7%, albumin plus globulin from 58.6 to 64.5, decreased prolamin from 12.0 to 10.5% , G_1- glutelin from 18.6 to 4.5, increased G_2- glutelin from 1.5 to 2.8% and G_3- glutelin from 17.1 to 19.8% and insoluble protein form 0.5 to 1.2% for cooked alone and cooked fermented at 32 h 20% composite flour, respectively. This indicate that fermentation had not only improving the nutritive value of composite flour, but also it reduce the bad effect of cooking on the nutritive value of it as early reported by Obizoba and Atti (1991) who stated that combination of boiling in water for 30 min and fermentation for 36 h was found to be the best method for improving nutrient quality and reducing anti-nutritional factors to safe amount in sorghum seeds. Also Yousif (2000) and Abedel Hady *et al*. (2005) stated that the negative effect of cooking on the nutritive value of cereals and legumes could be abolished by fermentation or by adding a reducing agent like sodium bisulphide or ascorbic acid (Hamaker *et al.*, 1987; Arbab and El Tinay, 1997).

Sensory evaluations

Results in Table 1 shows the organoleptic evaluation of the composite flour and some foods prepared from the composite flour. It shows the degrees of acceptability of the 0% supplemented sorghum, 15, 20 and 25% composite flour of sorghum and groundnut defatted flour, also the selected composite flour (20%) was fermented and compared with the raw 20% composite to show the effect of fermentation on its acceptability. All scores were calculated as percentage, so it is clear that the nasha prepared from composite flour was highly acceptable, acceptability increased with the rate of supplementation, but the higher level of supplementation was became less acceptable in term of color, supplementation with defatted groundnut flour to obtain 25% composite flour brought about un recommended dark color, this result is in agreement with the result obtained by CFTRI (Central Food Technological Research Institute – India) where they fortified whole wheat flour (Atta) with edible pea flour, and they were recommended it, but it introduced problems of acceptability as the chapatti (unleavened bread) made using this flour was dark in colour and not soft. Also the results are similar to those of Mensah and Dedeh (1991) who stated that the level of acceptability affected by consistency significantly (ratio of corn to cowpea) and by treatment given to the raw materials. Mohamed *et al.* (1989) studied different substitutes sources for soybean curds and their acceptability and reported that cowpea and peanut curds gave a whiter color than soybean and in term of sensory evaluation they found that peanut curds are the least acceptable compared to other curds (made of soybean, chickpea, mung bean and cowpea). Supplementation with defatted groundnut flour increase percentage of taste and odor acceptability this also in agree with Ahmed *et al.* (1987) who stated that: An addition of 30% edible groundnut flour to sorghum meal was found to produce significant improvement in conventional Kisra bread. Similar results for the higher acceptability of fortified foods with groundnut also reported by Rohini *et al.* (1990) in suggest to improve sattu (a traditional weaning food mix) by adding green gram, soy bean and groundnut, the recipe contained groundnut (two of the flour) obtained higher levels of acceptability while those contained higher soybean were less acceptable. Incorporation of groundnut resulted in an improvement in colour, flavour and taste (Table 1). Also the high acceptability obtained (30% = good, 30% very good and 30% excellent) in a term of odor acceptability may attributed to the fact that groundnut has a recommended pleasant flavour as stated by Singh and Singh (1991) who concluded that, groundnut consumption increased as a result of their pleasant flavour. In case of fermented 20% composite flour it seemed to have high acceptability in term of taste (60% = very good), odour (50% good, 20% very good and 10% excellent) and also better result for colour score were obtained as a result of fermentation (40% very good and 20% excellent). These results are in agreement with those of Alfaki (2004) who reported that fermented sorghum/pigeon pea/groundnut weaning blends has significantly higher acceptability than untreated on malted blends. This is because fermentation in particular is associated with many chemical changes which enhance organoleptic response (Indumadhavi and Agate, 1992) and fermented foods had characteristic flavours and aromas representative as dactyls acetic acid and butyric acid, which make them more appetizing (Van veen and Steinkraus, 1970).

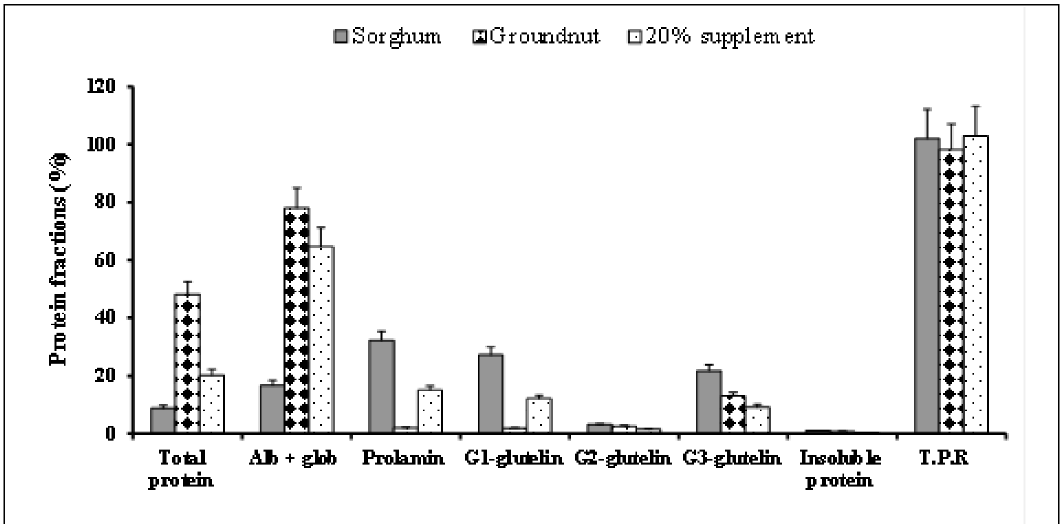

Fig. 1. Effect of supplementation with 20% defatted groundnut flour on protein fractions of sorghum flour.

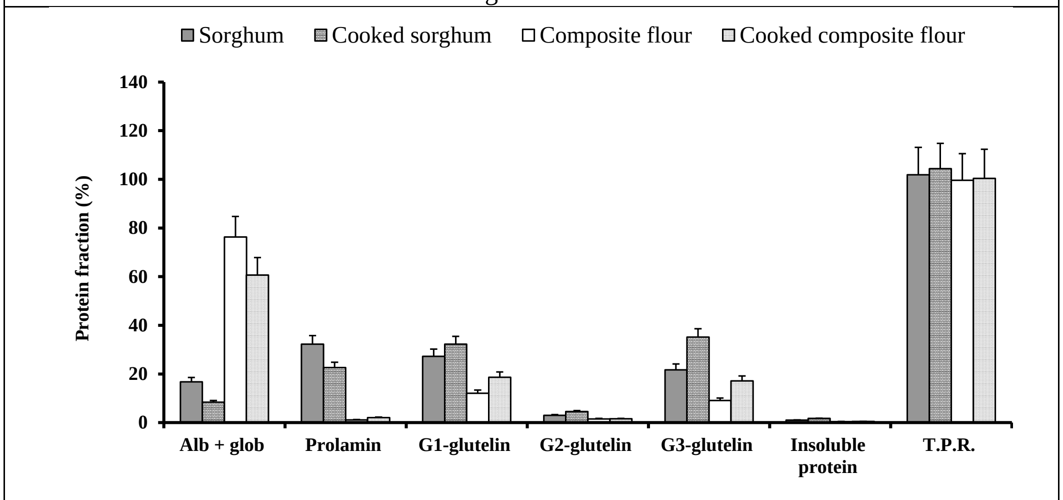

Fig. 2. Effect of cooking on sorghum supplemented with 20% defatted groundnut flour on protein fractions.

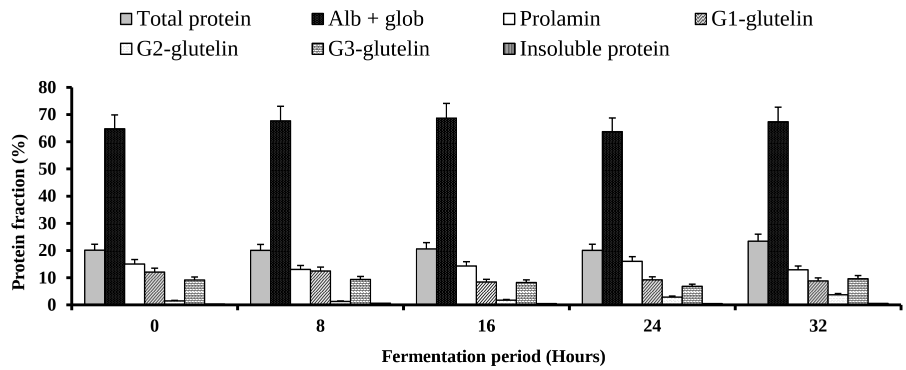

Fig. 3. Effect of fermentation on sorghum supplemented with 20% defatted groundnut flour on protein fractions.

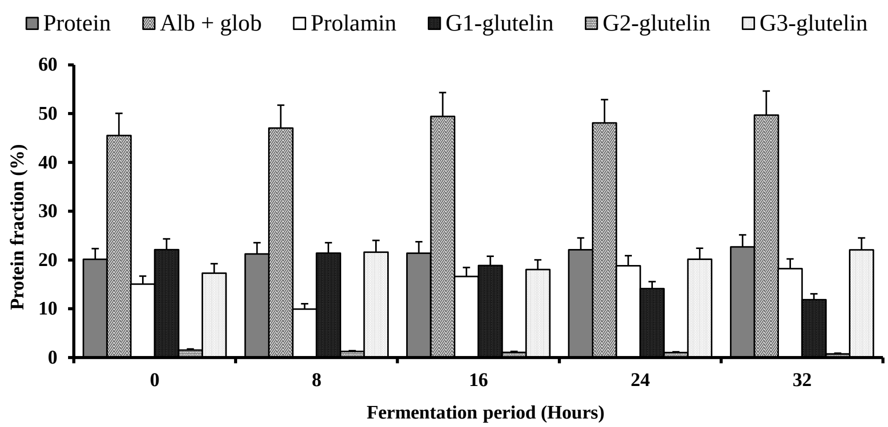

Fig. 4. Effect of fermentation followed by cooking on sorghum supplemented with 20% defatted groundnut flour on protein fractions.

Table 1. Effect of supplementation and fermentation on sensory quality of processed sorghum

	Taste acceptability		Odor acceptability		Colour acceptability		General acceptability	
	Scale	(%)	Scale	(%)	Scale	(%)	Scale	(%)
0% sorghum nasha	1	10	1	30	1	30	1	10
	2	60	2	50	2	10	2	30
	3	20	3	10	3	20	3	40
	4	10	4	10	4	20	4	20
	5	10	5	0	5	10	5	0
15% composite flour	1	10	1	20	1	30	1	10
	2	10	2	20	2	20	2	20
	3	30	3	30	3	30	3	40
	4	30	4	20	4	20	4	20
	5	20	5	10	5	0	5	10
20% composite flour	1	0	1	0	1	0	1	0
	2	10	2	10	2	10	2	10
	3	20	3	30	3	30	3	30
	4	40	4	30	4	40	4	30
	5	30	5	30	5	20	5	20
25% composite flour	1	0	1	20	12	30	1	20
	2	20	23	20	2	20	2	20
	3	40	3	40	3	40	3	20
	4	20	4	10	4	10	4	20
	5	20	5	10	5	0	5	10
Fermented 20% sorghum flour composite flour	1	0	1	10	1	0	1	10
	2	0	2	10	2	10	2	20
	3	20	3	50	3	30	3	20
	4	60	4	20	4	40	4	30
	5	20	5	10	5	20	5	20

Conclusion

Supplementation of sorghum flour with defatted groundnut flour was found to improve the nutritive value in terms of quantity and quality as well as acceptability of sorghum flour and its products (in particular nasha). Fermentation was found to considerably improve the nutritive value of sorghum and its composite flour (20%) in terms of protein content, albumin plus globulin, G3-glutelin fractions. On the other hand cooking was found to significantly decrease the nutritive value of sorghum and its composite flour. Nevertheless fermentation followed by cooking was significantly reducing the negative effect of cooking on sorghum and its composite flour.

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(Received 15 October 2013; accepted 22 December 2013)