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Nutritional and functional characterization of defatted seed cake flour of two Sudanese groundnut (*Arachis hypogaea*) cultivars

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Abstract: Groundnut seed cake of Barberton and Ashford cultivars were used in this study to investigate the nutritional and functional properties of the defatted cake flour, and hence possibility of their application in food system. Significant ($P \leq 0.05$) differences were observed in the seed cake between the two cultivars with respect to protein, fat, ash, fiber and carbohydrates contents. Barberton was high in Ca content (0.38%) while Ashford was high in Fe content (0.31%). Minimum solubility was recorded at pH 4.0 and maximum at pH 10.0 for both cultivars. Both cultivars had good functional characteristics with high water and oil absorption capacities. The emulsifying capacity was 28.10 and 22.90 ml/g for Barberton and Ashford defatted seed cake flour, respectively. The emulsifying activity was 28.33% and 22.90% for the two cultivars, respectively. The emulsion stability was 13.86% for Barberton and 11.36% for Ashford and the foaming capacity was 4.2% and 4.0% for the cultivars, respectively. The foam stability for both cultivars was found to be high. Both cultivars cake had high dispersibility in alkaline and acidic media than the neutral with a bulk density of 0.71 g/ml and average wettability and gelation property.

Keywords: Ashford, barberton groundnut cake, chemical composition, functional properties

Introduction

Food crops have occupied an important place in human nutrition as they remain the major sources of calories and proteins for a large proportion of the world population, particularly, in the developing countries (Singh and Singh, 1991a). The direct consumption of vegetable proteins in food products has been increasing over the years because of animal diseases, global shortage of animal protein, strong demand for wholesome and religious (halal) food, and economic reasons (Asgar *et al.*, 2010). The development of nutritionally balanced protein foods to feed the growing population in such countries is receiving increasing attention of the food scientists and nutritionists. Several international agencies and governmental programs in developing countries are confronted with a challenging task of alleviating the so-called protein calories malnutrition problem (Singh and Singh, 1991a). To overcome this problem, principal raw materials, oil seeds and grain legumes are utilized to manufacture and market high protein foods at reasonably low prices. The increasing importance of legume and oilseed proteins in the manufacturing of various functional food products is due to their high-protein contents (Asgar *et al.*, 2010).

Groundnut, or peanut (*Arachis hypogaea*), is a species in the legume family Fabaceae, native to South America, Mexico and Central America (Gibbon and Pain, 1985). Groundnuts have been known to man as an important food crop for many centuries. However, they acquired economic importance only 130 years ago and even as late as 60 years ago in the developed and developing countries (Demba, 1985). It is a major source of edible oil and protein meal and considered highly valuable for human and animal nutrition especially in the developing world. Presently, because of an increased awareness of the protein shortage existing in the world, the use of groundnuts as a food and cash crop has increased substantially. Groundnut is an important cash crop in the Sudan. In 2007 Sudan produced about 460.000 tonnes of the total world production of groundnut, and ranked number nine in the world (FAO, 2008). It comes first in the Arab countries, both in area and production of groundnut. Groundnut is grown mainly for its oil, protein, plant residue and seed cake. More than half of the world groundnut production is crushed for expulsion of oil, which was diverted mainly as edible oil (Carley and Fletcher, 1995).

Groundnut cake, a by-product of oil extraction, is an excellent livestock feed because of its high protein content. The cake contains 45-60 protein, 22-

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30% carbohydrate, 3.8-7.5% crude fiber and 4-6% minerals (Desai *et al.*, 1999). Defatted groundnut flour (DGF) produced from cake blends easily and enhances or enriches the nutritive value of wheat and other flour (Purohit and Rajyalakshmi, 2011). The DGF is an underutilized by-product of groundnut processing that has potential to be used in food system as low fat groundnut concentrate for extending comminuted meat products, production of beverages, fermented products, composite flours and protein supplementation of bakery products and weaning foods (Tate *et al.*, 1990; Venkataraghavan, 1998). It is also used as shaving cream, metal polish, bleach, ink, soap, shampoo, explosives, paint, rubber, axle grease, paper, wallboard, fireplace logs, cat litter and medicine (Abulude *et al.*, 2006). Despite the fact that DGF has an excellent potential in food formulations because of the high protein content, its uses remain limited. The functional properties of DGF such as whipping properties, emulsification, bulk density, viscosity, and water and oil absorption are also important in food processing and food product formulation (Yu *et al.*, 2007). Functional properties of DGF are rarely studied. Therefore groundnut processors are seeking ways to add value to this by-product through novel utilization. The development of groundnut flour from DGF cake can also provide the food industry with a new cost-effective and high-protein food ingredient for product formulation. This is critically needed in many developing countries where protein-energy malnutrition remains a major health hazard, especially among children. Thus, the objective of the present study was to evaluate the chemical composition, minerals and functional properties of the seed cake of two Sudanese groundnut cultivars namely, Barberton and Ashford.

Materials and Methods

Materials

The groundnut (*Arachis hypogaea*) cakes of Ashford and Barberton cultivars were obtained from Shambat Research Station, Khartoum North, Sudan. Unless otherwise stated all chemicals used in this study were of reagent grade.

Proximate composition

Dry matter, ash, crude protein, fat, fiber and nitrogen free extract (carbohydrates) were determined according to the method of the Association of Official Analytical Chemists (AOAC, 1990).

Energy

The energy content was determined by multiplying the percentages of crude protein, crude fat and CHO by factors of 4, 9 and 4 respectively (Osborne and Voogt, 1987).

Mineral extraction and determination

Minerals of raw samples were extracted according to Chapman and Pratt (1982). Each sample was burned in a muffle furnace at 550°C. The dish which contained the samples was put in a sand bath for 10 minutes after addition of 5 ml HCl. Then the solution was carefully filtered in 100 ml volumetric flask, extracts were stored in bottles at 30°C. The extracted minerals Ca, P and Fe were analyzed at 248 nm by atomic absorption spectrophotometer (AAS - 6800 Shimadzu, Tokyo, Japan) following the methods of AOAC (1995).

Preparation of raw defatted groundnut flour

Groundnut cakes were first cleaned from foreign materials and milled in laboratory miller (IKA LABORTECHNIK, Staufen, Germany) to pass through a 0.8 mm screen. To extract oil from groundnut flour, cold extraction method was used (El Tinay *et al*., 1988). Groundnut flour was placed in a conical flask and mixed with hexane; the mixture was stirred by mechanical shaker for 16 hour and then filtered. The filtrate was washed again with hexane and filtered. The resulting filtrate was dried in an open air at room temperature. The dried flour was then ground to pass a 70 mesh screen and stored at 0°C for further analysis.

Functional properties of defatted groundnut flour

Nitrogen solubility

Nitrogen solubility of defatted groundnut flour was measured by using the method Beuchat *et al*. (1975) at different pH levels. The water soluble nitrogen in the defatted flour was extracted by rotary shaking with distilled water at 1: 10 solute: solvent ratio for an hour at room temperature (26°C). After pH adjustment, the slurry was centrifuged at 3000 × g for 30 min. Nitrogen content of supernatant was determined following micro-Kjeldahl method and expressed as percentage of the total N.

Calculation:

$$\text{Soluble Nitrogen} = \frac{T \times N \times TV \times 14 \times 100}{a \times b \times 1000}$$

Where

T = Titer reading
N = Normality of acid (HCl 0.02N)
TV = Total volume of a liquor extracted
14 = Each ml of HCl is equivalent to 14 mg nitrogen
a = Number of ml of a liquor taken for digestion

b = Number of mg sample flour extracted
1000 = No. of mg in one gram

Water absorption capacity (WAC)

The water absorption capacity (WAC) was estimated by the method of Lin *et al*. (1974) with modification described by Quinn and Beuchat (1975). A 10% suspension (1 g/10ml) was stirred in a centrifugal tube using a glass rod for 2 min at room temperature (26°C). After 20 min equilibration the suspension was centrifuge for 20 min at 4400 × g at room temperature (26°C). The freed water was decanted into a 10 ml graduated cylinder and the volume was recorded. The WAC was recorded as ml water retained by 100 grams materials.

Fat absorption capacity (FAC)

The fat absorption capacity (FAC) of the sample was measured by a modified method of Lin *et al*. (1974). Four gram of the sample was treated with 20 ml of refined groundnut oil in a 50 ml centrifugal tube. The suspension was stirred in a centrifugal tube using a glass rod for 5 min and the contents were allowed to equilibrate for further 25 min at room temperature (26°C). The suspension was centrifuge for 20 min at 5000 × g at room temperature (26°C). The freed fat was decanted into a 10 ml graduated cylinder and the volume was recorded. The FAC was expressed as ml oil pound by 100 grams materials.

Bulk density (BD)

The Bulk density (BD) was determined by the method of Wang and Kinsella (1976). About 3 grams of material were placed in a 10 ml graduated cylinder and gently packed by tapping the cylinder on the bench 10 times to a reasonable height (approximately 5-8). The volume of the sample was recorded. Bulk density (BD) was calculated as gram per milliliters of material.

Gelation

Least gelation concentration of the sample was measured by the method of Coffman and Garcia (1977) with a slight modification. Appropriate sample suspensions of (2, 4, 6, 8 and 10%) were prepared in 10 ml of distilled water. The test tubes containing these suspensions were then heated for one hour in a boiling water bath followed by rapid cooling under running cold tap water. The test tubes were further cooled for 3 hours at (4°C). The least gelling concentration was determined as that concentration did not fall down or slip when the test tube was inverted.

Foaming properties

The Foam capacity (FC) and foam stability (FS) were determined according to the method of Lawhon *et al*. (1972). Defatted groundnut flour (3 g) was dispersed in 100 ml of distilled water and pH adjusted to 7.0. The contents were transferred to a mixer blender whipped at high speed for 5 min. The contents, along with the foam, were poured into a 250 ml measuring cylinder and the foam volume was recorded after 30 seconds. FC was expressed as percentage increase in volume. After 30 min, the volume of foam was measured and expressed as FS.

$$\text{FC (\%)} = \frac{\text{Volume after whipping} - \text{Volume before whipping}}{\text{Volume before whipping}} \times 100$$

$$\text{FS (\%)} = \frac{\text{Foam volume after (t) time}}{\text{Intial foam volume}} \times 100$$

Emulsification properties

Emulsification capacity (EC) was determined by the method of Beuchat *et al*. (1975). To the defatted flour (1 g), 25 ml of distilled water were added and mixed in a blender at low speed. After complete dispersion, refined groundnut oil was added at a rate of 0.4 ml/s; blending was continued until phase separation was seen. EC was expressed as milliliters of oil emulsified per gram of material.

The emulsification activity (EA) was measured by the procedure of Yasumatsu *et al*. (1972). A bout 0.7 g of material was added to10 ml of distilled water and mixed well before adding to it 10 ml of refined groundnut oil. The mixture was blended in electric blender for 5 min and centrifuged at 2000 × g for 5 min. The supernatant was then poured into 50 ml measuring cylinders and stay a few min until the emulsified layer became stable. EA was expressed as:

$$\text{EA (\%)} = \frac{\text{Height of emulsified layer}}{\text{Height of total content in the tube}} \times 100$$

Emulsion stability (ES) was measured by re-centrifugation followed by heating at 80°C for 30 min, and subsequently cooled to 15°C. After centrifugation the emulsified poured into 50 ml measuring cylinders and stay a few min until the emulsified layer was stable. ES was expressed as the percent of the total volume remaining emulsified after heating.

$$\text{ES (\%)} = \frac{\text{Height of emulsified layer after heating}}{\text{Height of total content in the tube}} \times 100$$

Dispersibility

The dispersibility of flour at selected pH levels (3, 7, and 10) was measured according to the method

of Kullarni *et al*. (1991). Three grams of the flour was dispersed in distilled water in a 50 ml stoppered measuring cylinder and the desired pH was adjusted by addition of drops of dilute HCl and/or NaOH solutions. Then distilled water was added to reach a volume of 30 ml, the mixture was stirred vigorously and allowed to settle for three hours, the volume of settled particles was subtracted from 30 and multiplied by 100 and reported as percentage dispersibility.

Wettability

The wettability was estimated for both samples according to the method of Regenstein and Regenstein (1984). Two grams of the defatted flour were weight in a sieve and transferred to a beaker containing 80 ml distilled water and magnetic without stirring the water. The behavior of the powder was observed on the water surface immediately after adding the sample. After 30 min observation, the material was stirred on the magnetic stirrer sufficiently fast to form a vortex which reached the bottom of the beaker. The stirring continued for one min and after which the grade describing wettability was recorded as excellent, good, and fair or poor according to the time and behavior of the dispersion.

Statistical analysis

Data were analyzed by analysis of variance with Minitab Statistical Software. Where mean differences were determined as significant at $p \leq 0.05$.

Results and Discussion

Chemical composition

The chemical composition of seed cake flour of two Sudanese groundnut cultivars namely, Barberton and Ashford was investigated as shown in Table 1. The data obtained showed that Barberton seed cake had significantly ($p \leq 0.05$) high protein content (50.90%), high oil content (7.76%) and high carbohydrates (19.5%), compared to that of Ashford which contained significantly ($p \leq 0.05$) low protein content (44.51%), low oil content (6.73%) and low carbohydrates (12.7%). The protein contents of partially defatted seed cake of the two cultivars in the present study were slightly lower than that reported for defatted peanut flour (Wu *et al.*, 2009), whereas, they were higher than 43.58% reported for groundnut (Sulieman and Mabrouk, 1999). However, oil content of Ashford and Barberton was lower than that reported by Sulieman and Mabrouk (1999) who found that oil content of groundnut cake was 7.96%. The protein content of partially defatted seed cake of the two cultivars in the present study is within the range (45-60%) reported previously (Desai *et al.*, 1999). The high protein content of partially defatted groundnut seed cakes in the present study suggests that it can be used in food formulations to improve the protein content of the final products.

Table 1. Chemical composition (%) and total energy (Kcal/100 g) of the seed cake flour of two groundnut cultivars

Parameter (%)	Cultivars	
	Ashford	Barberton
Dry matter	95.42 (± 0.16)^a	94.87 (± 0.36)^b
Total ash	14.49 (± 0.30)^a	5.20 (± 0.13)^b
Protein	44.51 (± 1.30)^b	50.90 (± 1.27)^a
Fat	6.73 (± 0.13)^b	7.76 (± 0.27)^a
Crude fiber	16.99 (± 1.84)^a	11.48 (± 0.68)^b
Carbohydrate	12.70 (± 3.21)^b	19.53 (± 1.18)^a
Energy	289.40(± 8.19)^b	352.59(± 3.11)^a

Values are means (± SD) of three independent samples. Values not sharing a common superscript in a column are significantly ($p \leq 0.05$) different.

The ash content of partially defatted seed cake of Ashford was significantly ($p \leq 0.05$) high than that of Barberton and they were found to be 14.49% and 5.20%, respectively. The ash content of both cultivars was significantly higher than that reported by Wu *et al*. (2009) for defatted peanut flour. The ash content of partially defatted seed cake of Barberton cultivar is lower than that reported by Sulieman and Mabrouk (1999), while that of Ashford was higher than that reported by the same authors. The ash content of partially defatted seed cake of both cultivars were higher than that reported by Batal *et al*. (2005) who obtained ash content of 5.0%. This variation may be due to variations in growing location and genotypes.

The results obtained for fiber content of partially defatted seed cake of the cultivars were 11.48 and 16.99% for Barberton and Ashford, respectively and were higher than that reported previously (Desai *et al*, 1999; Sulieman and Mabrouk, 1999; Batal *et al.*, 2005). High fiber content in seed cake of such cultivars is an advantage, and hence this by-product may have potential uses as food supplement. Many researchers have reported an inverse relationship between fiber consumption and the risk for coronary heart disease and several types of cancer (Lattimer and Haub, 2010).

Carbohydrate content of the cultivars was found to be 12.7% and 19.53% for Ashford and Barberton, respectively. The result obtained for Barberton is similar to that (22-30%) reported by Desai *et al*. (1999) compared to that obtained for Ashford. This variation may be due to the variety and location differences. The total energy of partially defatted seed cake of Barberton and Ashford was found to be 352.59 and 289.40 kcal/100 g, respectively. As expected, partially defatted seed cake of Barberton showed higher energy content compared to that of Ashford. It assumed that high energy of Barberton resulted from high carbohydrate content rather than

from fat. The report of the World Health Organization (WHO, 1990) on diet and prevention of chronic diseases recommends that the total fat energy may not exceed 30% of the total energy, whereas total carbohydrate energy may range from 55 to 75%, and energy from protein may range from 10 to 15% of the total energy.

Mineral content of the cultivars is illustrated in Figure 1. The mean Calcium content was found to be 0.38 and 0.14% for Barberton and Ashford, respectively. The results obtained were lower than that reported by Batal *et al*. (2005). Iron content was found to be 0.03 and 0.31% for the two cultivars, respectively. Phosphorus content was 0.43 and 0.35% for the cultivars, respectively. These results are in agreement with those reported by Hulman *et al*. (1977) and are lower than those reported by Sulieman and Mabrouk (1999) and Batal *et al*. (2005). Significant differences ($p \leq 0.05$) were observed in Ca, Fe and P content between the two cultivars. The differences observed could be attributed to cultivar differences and growing conditions.

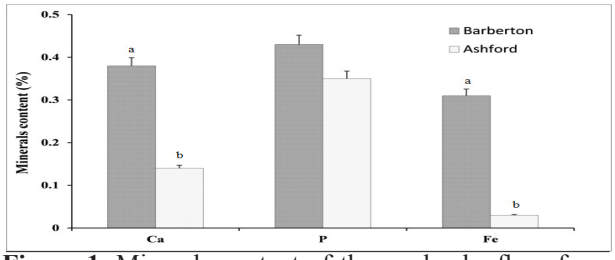

Figure 1. Minerals content of the seed cake flour from two Sudanese groundnut cultivars (Barberton and Ashford). Values sharing different letters in the figures are significantly ($p \leq 0.05$) different

Nitrogen solubility profile

Amongst the functional properties of proteins, solubility is probably the most critical because it affects other properties such as emulsification, foaming and gelation (Kinsella, 1976). The nitrogen solubility characteristics are influenced by many factors such as origin, processing conditions, pH, ionic strength and the presence of other ingredients (Kinsella, 1976). The nitrogen solubility profile of the cultivars (Barberton and Ashford) at different pH levels are illustrated in Figure 2. The pH had a significant effect on the solubility, the minimum nitrogen solubility was observed at pH 4.0 at which it were 5.8 and 3.3% for Barberton and Ashford, respectively. Maximum solubility was achieved at pH 10.0 at which it was 38.9 and 36.4% for the cultivars, respectively followed by acidic pH 2.0 at which it was 35.8% for Barberton and 19.3% for Ashford. At all levels of pH the solubility of Barberton was superior to that of Ashford except at pH 8.0 where the solubility of Ashford is higher than that of Barberton. Similar observations were reported roasted peanut (Yu *et al.*, 2007. The karanja seed proteins were found to vary in solubility (36–90%) with pH change (2–11). The maximum solubility was achieved at pH 10.0, whereas isoelectric precipitation was found at pH 4.0 (Vinay *et al.*, 2008). Good solubility in both acidic and alkaline pH regions was also reported (Idouraine *et al.*, 1991) and is considered as an important characteristic for food and non-food formulations.

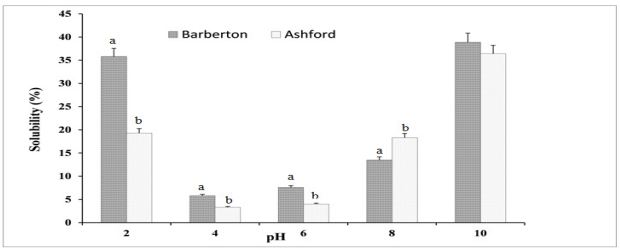

Figure 2. Effect of pH on nitrogen solubility of defatted seed cake flour of Sudanese groundnut cultivars (Barberton and Ashford). Values sharing different letters in the figures are significantly ($p \leq 0.05$) different

Water and oil absorption capacity

Hydration or rehydration is the first and perhaps most critical step in imparting desirable functional properties to proteins in a food system. Interactions of water and oil with flours are very important in food systems because of their effects on the flavor and texture of foods. Intrinsic factors affecting water-binding properties of food flours with relatively high protein contents include amino acid composition, protein conformation and surface polarity/ hydrophobicity (Barbut, 1999). The results of water and oil absorption capacity, bulk density, foaming and emulsifying properties of the two cultivars are shown in Table 2. The defatted seed cake of the cultivars, Barberton and Ashford, had water absorption capacity (WAC) of 303.33 and 306.67 ml H_2O/100 g flour, respectively. These values are higher than those reported by Yu *et al*. (2007) and lower than those of field pea and pigeon pea flour reported by Kaur *et al*. (2006). The difference in protein structure and the presence of different hydrophilic carbohydrates might be responsible for variation in the WAC of the flours. Flours with high WAC have more hydrophilic constituents such as polysaccharides.

Table 2. Mean values of functional properties of groundnut cultivars seed cake flour

Functional property	Ashford	Barberton
Water retention capacity (ml/100g)	306.67 (± 5.77)^a	303.33 (± 5.77)^a
Fat absorption capacity (ml/100g)	286.67 (± 5.77)^a	293.33 (± 5.77)^a
Emulsification capacity (ml/g)	22.90 (± 1.10)^b	28.10 (± 1.10)^a
Emulsifying activity (%)	22.90 (± 1.83)^b	28.33 (± 2.88)^a
Emulsifying stability (%)	11.36 (± 3.18)^a	13.86 (± 1.52)^a
Foam capacity (%)	4.00 (± 0.00)^a	4.20 (± 0.32)^a
Bulk density (g/ml)	0.71 (± 0.00)^a	0.71 (± 0.00)^a

All values are means ± standard deviations of triplicate analyses. Significantly ($p \leq 0.05$) different.

The oil absorption capacity (OAC) of the defatted seed cake of two cultivars were found to be 293.33

and 286.67 ml oil/100 g protein for Barberton and Ashford, respectively (Table 2). The OAC was observed to be higher than that reported for roasted peanut (Yu *et al.*, 2007) and chickpea (Kaur and Singh, 2005). The presence of non-polar side chains which might bind the hydrocarbon side chains of oil among the flours, possibly explains difference in oil binding capacity of the flours (Adebowale and Lawal, 2004). The ability of flours to absorb and retain water and oil may help to improve the binding capacity, enhance flavor retention, improve mouth feel and reduce moisture and fat losses of extended meat products (McWatters and Heaton, 1979). The results obtained in the present study revealed that the seed cake flour of the two cultivars acquired WAC and OAC that are desirable for use in meats, sausages, mayonnaise, salad dressing and breads manufacturing.

Bulk density (BD)

The bulk density of defatted groundnut seed cake flour of both cultivars Barberton and Ashford was found to be 0.71 g/ml (Table 2). It worth to note that the bulk density reported in the present study for the cake of both cultivars is higher than the previously reported values for various legumes such as field pea (0.541–0.562 g/ml), and pigeon pea (0.471–0.467 g/ml) as reported by Kaur *et al*. (2006) and chickpea flours (0.54 – 0.57 g/ml) as reported by Kaur and Singh (2005). Higher bulk density is desirable since it helps to reduce the paste thickness which is an important factor in convalescent and child feeding (Padmashree *et al.*, 1987). Thus, the defatted groundnut seed cake of the two cultivars could possibly be used in food formulation as supplement for child food.

Emulsifying properties

The emulsifying properties are usually attributed to the flexibility of solutes and exposure of hydrophobic domains. Food emulsions are thermodynamically unstable mixtures of immiscible liquids. The formation and stability of emulsion is very important in food systems such as salad dressing. As shown in Table 2 the defatted groundnut cake flour has an emulsifying capacity of 28.10 and 22.90 ml oil/ g flour for Barberton and Ashford, respectively. These results were lower than those reported for roasted peanut (Yu *et al.*, 2007). Singh and Singh, (1991b) obtained an emulsifying capacity of 24.5 g/g sample for peanut flour. The emulsifying activity results were 28.33 and 22.90% for the two cultivars, respectively, whereas the emulsion stability was 14 and 11.4% for the cultivars, respectively. The results obtained were lower than those reported by Khalid *et al*. (2003) for sesame isolate protein and Suleiman (2007) for lentil protein. The capacity of proteins to enhance the formation and stabilization of emulsion is important for many applications in cakes, coffee whiteners, and frozen desserts. In these products varying emulsifying and stabilizing capacities are required because of different compositions and stresses to which these products are subjected (Elkhalifa and Bernhardt, 2010).

Foaming capacity and foam stability

The foaming capacity (FC) of a protein refers to the amount of interfacial area that can be created by the protein and foam stability (FS) refers to the ability of protein to stabilize against gravitational and mechanical stresses (Fennema, 1996). Foam formation and foam stability are a function of the type of protein, pH, processing methods, viscosity and surface tension. The FC and FS of the groundnut seed cake flour of the cultivars Barberton and Ashford attained no significant differences. The foam produced by legume flours was relatively thick with low foam volume but high foam stability. The results (Table 2) indicated that defatted groundnut cake flour of Barberton and Ashford is not good foaming agent, with a foaming capacity of only 4.2 and 4.0 ml/100 ml water, respectively. Similar observation was reported by Yu *et al*. (2007) for roasted peanut. The results of foam stability of the defatted groundnut cake flour are presented in Figure 3. The defatted cake flour of the two cultivars showed high foam stability and up 120 min only about 4% of the foam loses was observed. Similar observation was reported for field pea flour (Kaur *et al*., 2006). The results obtained suggesting that the native proteins are soluble in the continuous phase (water) are very surface active in groundnut cake flour. Therefore, defatted groundnut cake flours may not be suitable in food system that requires a high percentage of porosity such as cake and ice cream.

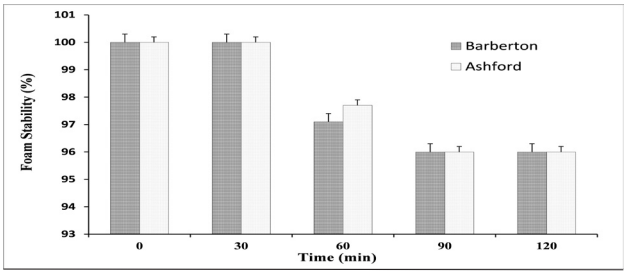

Figure 3. Effect of incubation time on the foam stability of defatted seed cake flour of Sudanese groundnut cultivars (Barberton and Ashford)

Gelation capacity

Gelling capacity is very useful in food systems such as puddings and sauces that require thickening and gelling (Ma *et al.*, 2011). It is an aggregation of

denatured protein molecules. Protein conformations, disulfide linkages, hydrophobicity, have all been reported to play significant roles in gelation (Kain and Chen, 2010). The least gelation concentration (LGC) for defatted cake flour of the Sudanese groundnut cultivars Barberton and Ashford is shown in Table 3. Both cultivars formed a weak gel at 4%, strong gel at 6 and 8% and very strong gel at 10% (w/v). No gel was formed at 2%. The lower LGC, the better is the gelating ability of the protein ingredient (Akintayo *et al.*, 1999). Variations in gelling properties may be ascribed to the ratios of different constituents, such as proteins, carbohydrates and lipids. The least gelation concentration reported for legumes flour was 14% (w/w) for lupin seed proteins (Sathe *et al.*, 1982) and a defatted sesame seed was 6% (Inyang and Nwadimkpa, 1992). Gelation is important in the confectionary products. Thus, the defatted groundnut cake of the cultivars could be used in confectionary products.

Table 3. Least gelation concentration of groundnut cultivars flour

	2%	4%	6%	8%	10%
Ashford	-	+	++	++	+++
Barberton	-	+	++	++	+++

- No gel + Weak gel ++ Strong gel +++ Very strong gel

Dispersibility and wettability

The dispersibility of a mixture in water indicates its reconstitutability (Kullarni *et al.*, 1991). The better temperature, ionic composition, pH and degree of agitation of the solvent are major factors affecting dispersibility (Kinsella, 1976). The results of dispersibility for the defatted cake flour of the cultivars, Barberton and Ashford, at different pH levels are shown in Figure 4. The higher dispersibility of 55 and 55.3% for Barberton and Ashford, respectively, was found at pH 10.0. Whereas, at pH 7.0 the dispersibility was 41.7% for both cultivars and at pH 3.0 it was 48.4 and 53% for the cultivars, respectively. Dispersibility of sesame protein was significantly higher at neutral and alkaline pHs than acidic pHs (Khalid *et al.*, 2003). Sulieman, (2007) reported that lentil protein isolate had a higher dispersibility at pH 7.0. Wettability is an important property when protein powders are dispersed to produce aqueous beverages and batters (Zayas, 1997). Wettability of proteins is affected by surface polarity, topography, texture, area and by the size and microstructure of the protein particles (Hagerdal and Lofqvist, 1978). Wettability grade of groundnut cultivars was good since it wet slightly when it comes in contact with water and after 30 min the wetted sample and the powder sunk to the bottom. Stirring dispersed the sample (data not shown). The findings obtained in this study agree with the observations of Hassan (1994) and Osman (2004) for watermelon protein isolate and chickpea flour, respectively.

Conclusion

The data obtained in this study showed that the varietals differences of groundnut have no significant effect on functional properties of defatted flours. The high protein content of both cultivars indicated that they could be a valuable protein supplement for cereals based food products. Moreover, high solubility of both flours at alkaline pH makes them suitable in beverages. Furthermore, groundnut cake flour of both cultivars had high oil and water absorption capacities as desirable characteristics for use in some foods such as meats, sausages, breads and cakes. Defatted groundnut flours showed high bulk density and would be suitable for use in weaning food. The good wettability of the two cultivars flour makes them suitable for use in textured meats and baked products. Future studies are needed to develop a protein concentrate from groundnut cake from such cultivars.

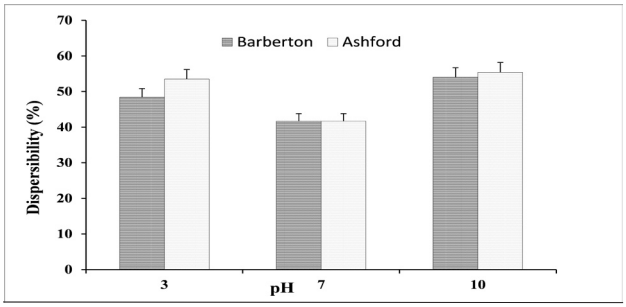

Figure 4. Effect of pH on dispersibility of defatted seed cake flour of two Sudanese groundnut cultivars (Barberton and Ashford)

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