PJN
ISSN 1680-5194

PAKISTAN JOURNAL OF NUTRITION

ANSInet
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorpjn@gmail.com

Pakistan Journal of Nutrition 9 (10): 1006-1016, 2010
ISSN 1680-5194

Effect of Processing on the Proximate Composition of the Dehulled and Undehulled Mungbean [*Vigna radiata* (L.) Wilczek] Flours

I. Akaerue Blessing and I. Onwuka Gregory
Department of Food Science and Technology, Michael Okpara University of Agriculture, Umudike, Umuahia, Abia State, Nigeria

Abstract: The effects of some processing treatments on the proximate composition of dehulled and undehulled mungbean seeds flours were investigated. The mungbean seeds were subjected to boiling, toasting and sprouting, at different intervals before milling into flour. The flour samples were analyzed for proximate composition using standard methods and the dehulled samples were found to possess better proximate compositions than the undehulled samples, except for crude fiber. Results showed that increase in boiling time (30, 45, 60 and 90 min) did not significantly ($p>0.05$) increase the moisture (10.30-10.65%) and carbohydrate (57.16-65.05%) contents but rather decreased the fat, ash, crude fiber and energy values. The undehulled mungbean boiled for 45 min had the highest crude protein (21.86%), the 30 min boiled sample had the highest fat content (2.20%), while the carbohydrate was highest (66.17%) in the 90min boiled sample. However, the dehulled sample boiled for 30 min had the highest crude protein (26.27%) and fat (2.27%), whereas the dehulled sample boiled for 90 min highest carbohydrate content (65.05%). The 30 min toasted sample had the highest crude protein (19.70%) while the 90 min toasted sample had the highest fat (2.43%) and carbohydrate (69.88%). However, the dehulled sample toasted for 30 min had the highest protein (24.52%) while the 90 min toasted sample had the highest fat (2.07%) and carbohydrate (71.99%). The undehulled sample sprouted for 72h had the highest crude protein (37.17%), while the 24 h sprouted sample had the highest fat (2.32%) and carbohydrate (49.08%). However, for the dehulled sample, increase in sprouting time (24-36 h) increased the moisture (10.43-10.69%) and crude protein (35.90-36.50%) contents but reduced the fat (1.35-1.23%), fiber (2.90-2.83%), carbohydrate (49.02-47.88%) and energy values (351.83-348.59 kcal/g).

Key words: Mungbean seeds, flour, processing, proximate composition

INTRODUCTION

Mungbean (*Vigna radiata* (L.) Wilczek) is one of the lesser known legumes which originated from South East Asia (India) and has been mostly grown in Asian countries like Thailand, Burma, Indonesia and Philippines. It is now widely cultivated in Africa, South America, Australia and the United States (Kay, 1979; Kim *et al*., 2007). It is an important pulse crop, a dicotyledon also commonly referred to as green or golden gram, moong, Ludou (Chinese), green soy and chop bean which belong to the family of Leguminosae or Fabacea and is related to cowpea (Kay, 1979; Charmaine, 1998; Agugo, 2003; Leung, 2007). Opoku *et al*. (2003) reported that about 90% of the world production of mungbean (*Vigna radiata* (L.) Wilczek) is produced in Indo-Burma region while Fery (2002) reported that about 70% of the world production of mungbean is in India. The seed colour is usually dark olive green, bright green skin or yellow and the beans are small, cylindrical or ovoid, globular or oblong in shape, but some cultivars produced brown or speckled black seed (Rubatzky and Yamaguchi, 1997; Anonymous, 2008a). There are 2000 varieties of mungbean, among them yellow, gold and black mungbean (Charmaine, 1998). Structurally, mungbean may consist of 12.1% seed coat, 2.3% embryo and 85.6% cotyledons (Singh *et al*., 1968).

Plate 1: Mungbean seeds

Mungbean [*Vigna radiata* (L) Wilczek] has high nutritional potentials and has been recently introduced

Corresponding Author: I. Onwuka Gregory, Department of Food Science and Technology, Michael Okpara University of Agriculture, Umudike, Umuahia, Abia State, Nigeria

in Nigeria (Agugo, 2003; Mensah and Olukoya, 2007). The consumption of mung proteins can fulfil the essential amino acids requirements with the exception of the sulphur-containing amino acids (Khalil, 2006). Mungbean is rich in dietary fiber, carbohydrates, energy, vitamins, minerals-thiamin, iron, magnesium, phosphorus, potassium, copper and are a good source of folate, however, riboflavin, niacin are found in trace amount (Khalil, 2006; Charmaine, 1998; Anonymous, 2008a). They are also rich in lysine, 5.24-5.85 g/100 g of protein (Adel *et al*., 1980); 1.9 g/100 g of protein (Calloway *et al*., 1994), but deficient in methionine in contrast with the high methionine value observed for rice bean (Andersen, 2007). The high lysine content of mungbeans makes it a good complementary food for rice-based diets, in which lysine is usually the first limiting amino acid (Chen *et al*., 1987). Mungbean has excellent digestibility and freedom from flatulence has made it suitable for infant feed formulation, recuperating patients and the aged people (Kay, 1979; Agugo and Onimawo, 2008). Mungbean has several food uses- It can be eaten alone or combined with rice to make 'Khichari' or combined with vegetables and greens to make hearty soups (Anonymous, 2008a). They are versatile enough to provide a base for sweet making and the paste is used for a variety of sweets, jellies, snacks like cakes, doughnuts and sweet drinks (Weinberg, 2002). Mungbean also has medicinal uses-anti-poisonous, anti-hypertensive, treatment of various ailments like hepatitis, gastritis, heat rash etc. (Leung, 2007; Huijie *et al*., 2003).

The antinutritional factors limit the food applications of mungbean therefore; dehulling the seeds before milling has been used to overcome this problem (Thompson *et al*., 1976; El-Adawy, 2002; Opoku *et al*., 2003). The impacts of traditional processing methods on the nutrients in mungbean were also reported by Bau *et al*. (1997); Bhatty *et al*. (2000); Mubarak (2005) and Agugo and Onimawo (2008). Furthermore, Chau *et al*. (1997); Apata and Ologhobo (1989); Mubarak (2005); Udom (2007) and Agugo and Onimawo (2008) evaluated the effects of processing on the food toxicants in mungbean, throwing some light on the level of reduction in antinutrients achieved by various processing methods. Chau *et al*. (1997); Agugo and Onimawo (2008) reported that cooking improves the protein quality by destruction or inactivation of the heat-labile antinutritional factors. With the increased interest in the exploitation of this mungbean, this present study is designed to evaluate the effect of processing on the proximate composition of dehulled and undehulled mungbean flour.

MATERIALS AND METHODS

The mungbeans (*Vigna radiata* (L.) Wilczek) seeds were obtained from the Crop Science Department of Michael Okpara University of Agriculture, Umudike, Nigeria. All chemical reagents used for the experiment were of analytical grade and were purchased from Joechem Chemical store, Nsukka and Hoslab, Umuahia, Nigeria.

Seeds pretreatment: The dry cleaned mungbean seeds were divided into two sets; one was left undehulled and the other one was dehulled. The undehulled sample was further sub-divided into four sets; one was kept raw (untreated), the second set was boiled, the third set was toasted while the fourth set was germinated (sprouted) as shown in Fig. 1. The dehulled sample was also sub-divided into three sets; one set was kept raw without any further treatment while the other two sets were subjected to boiling and toasting respectively. The fourth set was sprouted and then carefully dehulled as shown in Fig. 2. All these treatments were given to the mungbeans after soaking for 12 h. The mungbean seeds were crushed to smaller fragments with the corona manual grinder after drying in the oven (65^{o}C) and afterwards milled with a blender, using an 80 mesh sieve to sift the flour. All flour samples were stored in air-tight plastic bags until required for analysis.

Flour processing

Boiling: Three separate batches of the whole undehulled/dehulled mungbeans (*Vigna radiata* (L) Wilczek) weighing 800 g each were soaked in distilled water (1:3w/v) for 12 h at room temperature (~25^{o}C) according to Mubarak (2005) and Khalil (2006) with slight modification. The seeds were drained and rinsed three times with 600 ml distilled water and then boiled in tap water (100^{o}C) in the ratio of 1:10 (w/v) on a hot plate for 30, 45, 60 and 90 min respectively. The water was drained off after each timing and the seeds dried in the oven at 65^{o}C and cooled in a desiccator. The seeds were then dry milled, sieved and packaged for analysis thereafter.

Dehulling: The hulls were removed manually after soaking the mungbean seeds for 12 h in distilled water (1:10w/v) according to El-Beltagy (1996).

Toasting: Three separate batches of the whole seeds both undehulled and dehulled weighing 800 g each were spread thinly in a pan and oven-dried at a fixed temperature of 120^{o}C for time variables of 30, 45, 60 and 90 min. They were stirred intermittently to maintain uniform heating and then cooled in a desiccator after the toasting. The seeds were milled, sieved and packaged for analysis thereafter (Emenalom and Udedibie, 2005) with slight modification in time.

Sprouting: The germination was carried out by spreading the undehulled seeds soaked in distilled water (1:3 w/v) for 12 h at room temperature (~25^{o}C), weighing 800 g in between jute cloth and allowed to

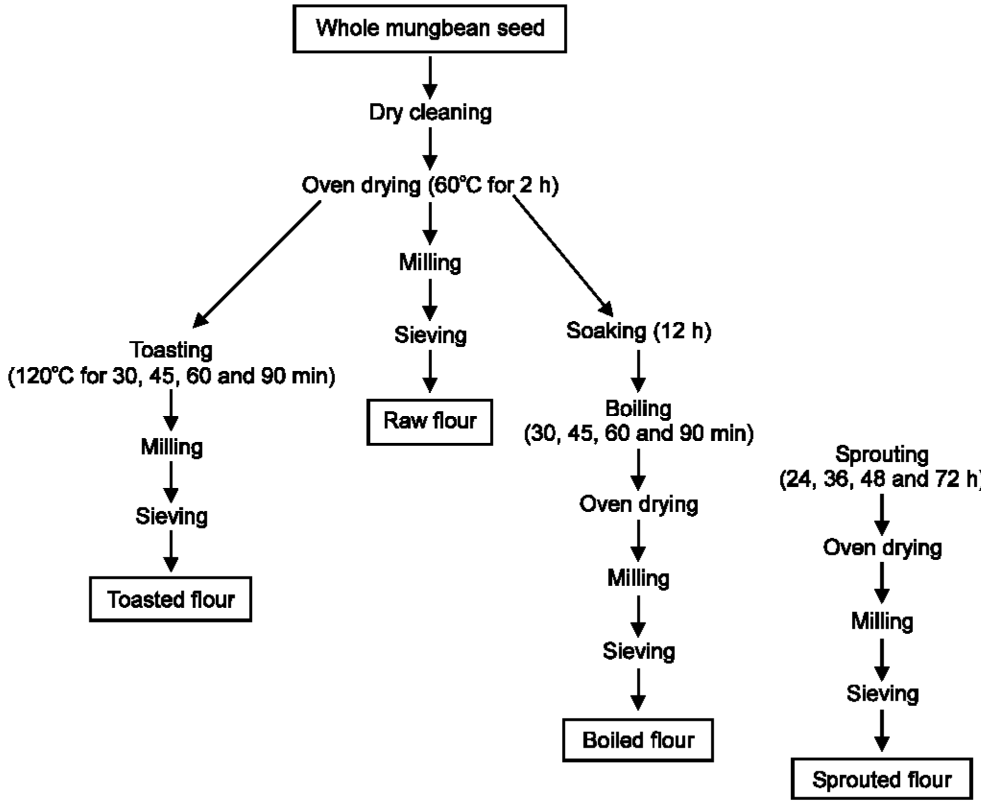

Fig. 1: Flow chart of the undehulled mungbean flour samples

sprout in the dark for 24, 36, 48 and 72 h respectively. The seeds were kept wet throughout germination by spraying them with distilled water every 12 h. The sprouted mungbeans were harvested, rinsed twice in distilled water and oven dried at 65°C for 9 h and cooling followed. The dried seeds were subjected to dry milling and passed through 80 mesh sieve. The flour was cooled and packaged for analysis thereafter in air-tight plastic bags. The dehulled mungbeans were equally germinated under the same conditions for 24 and 36 h, dried, milled and packaged for analysis.

The proximate analysis of the samples for moisture, ash and crude fat determination were done in triplicates using the air oven, dry ashing and soxhlet extraction methods described by AOAC (1990); Nielson (2002); Onwuka (2005). The crude protein (Nx 6.25) was determined by using micro kjeldahl method reported by AOAC (1990); Kirk and Sawyer (1991). The carbohydrate content was determined by difference, a method reported by Onwuka (2005). In this method, carbohydrate content was obtained by calculation having estimated all the other fractions by proximate analysis i.e. % Available carbohydrates = 100 - (% moisture + % ash + % protein + % fiber + % fat).

The energy value was calculated using the Atwater factor method [(9 x fat) + (4 x carbohydrate) + (4 x protein)] as described by Osborne and Voogt (1978); Eneche (1991); Chinma and Igyor (2007) and Nwabueze (2007). The proportion of protein, fat and carbohydrate were multiplied by their physiological fuel values of 4, 9 and 4 kcal, respectively and the sum of the product was taken.

Statistical analysis: The software package used for the statistical analysis was the version 15 of SPSS while all the analyses were carried out in three replicates. The data were evaluated for significant differences ($p<0.05$) in their means using Analysis of Variance (ANOVA). Differences between means were separated using Duncan's Multiple Range Tests (DMRT).

RESULTS AND DISCUSSION

Table 1 presents the effect of processing on the proximate composition of undehulled mungbean seeds flour.

Moisture content: The moisture content of the raw undehulled mungbean flour was 10.25% (Table 1) however; other researchers had earlier reported that raw mungbean had 8.25-10% moisture content (Bhatty *et al.*, 2000). Nevertheless, Mubarak (2005) reported lower value (9.75%). The moisture contents ranged from 10.21% for 30 min boiled sample to 10.55% for the 90 min boiled sample. Increase in boiling time of the mung seeds did not result in any significant ($p>0.05$)

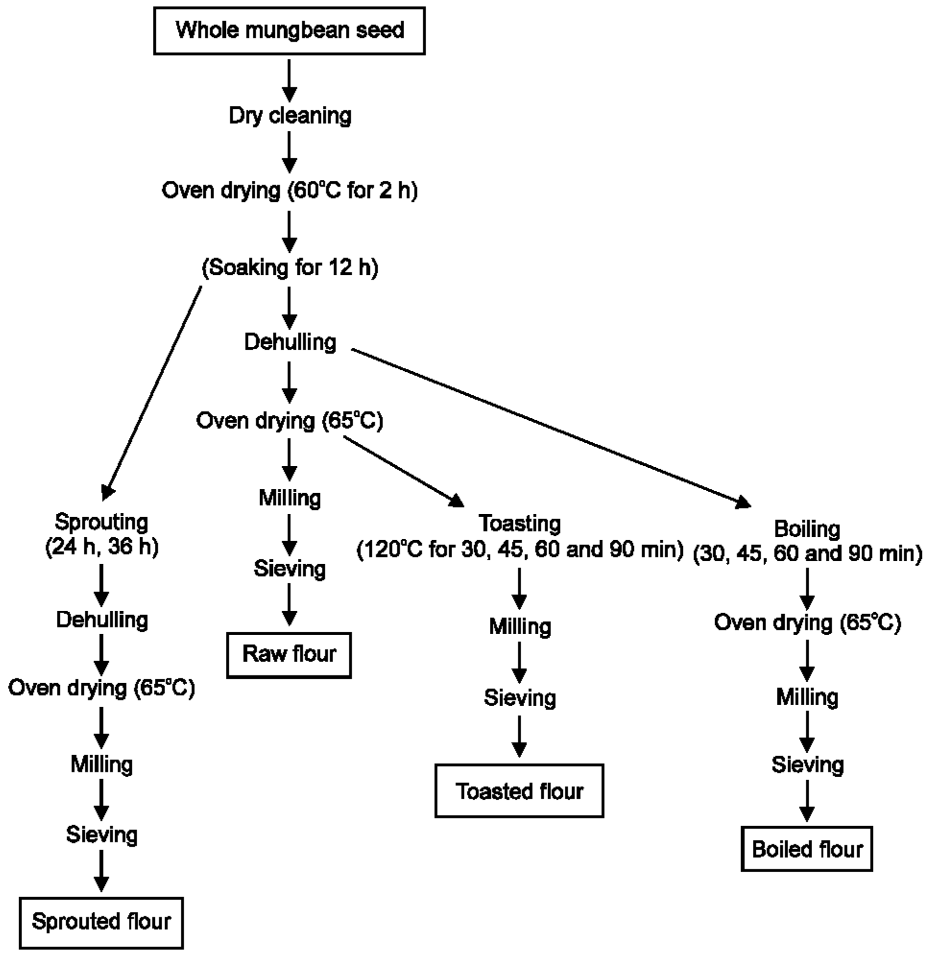

Fig. 2: Flow chart of the dehulled mungbean flour samples

increase in the moisture content of the flours. But generally, boiling was found to slightly increase the flour moisture content. These observations were in agreement with those reported by Bau *et al.* (1997) for soybeans and Mubarak (2005) for mungbeans. Boiling increased the moisture content due to the absorption of water by the seeds during cooking (Mubarak, 2005). There was a slight reduction in the moisture contents of the toasted flour but no significant difference ($p>0.05$) existed among them. The sample toasted for 90 min had the least moisture content of 5.36% which could be as a result of the high temperature and time it was subjected to (120°C and 90 min respectively) and it significantly differed from the moisture content of the raw flour.

The sprouting treatments significantly ($p<0.05$) increased the moisture content of the undehulled flours compared to the raw flour (Table 1), although no marked increase was observed among the samples sprouted for 36, 48 and 72 h (12.33, 12.51 and 12.58% respectively). This increase could be attributed to the hydration of the seeds during soaking, before the germination (Del Rosario and Flores, 1981). Similar report has been made by Mubarak (2005) for germinated mungbean seeds flour.

Crude protein: There were significant ($p<0.05$) differences among the protein contents of the raw and boiled undehulled mungbean flours. The raw flour had 24.08% crude protein which fell between the range 20.97-31.32% reported by Anwar *et al.* (2007).On the contrary, Calloway *et al.* (1994) reported a much lower value of 20.3%. Boiling significantly ($p<0.05$) reduced the protein value of the flour with increase in time. These decreases might be attributed to leaching during boiling. Similar report had been given earlier for boiled soybean and mungbean flour as well as fluted pumpkin seed flour (Kylen and McCready, 1975; Fagbemi, 2007).

Toasting the mungbean seeds reduced the protein from 24.08-19.70% and increase in toasting time significantly reduced ($p<0.05$) the flour protein. The least protein value of 13.13% was observed for the 90 min toasted mung flour (Table 1). This result may be due to the high temperature of toasting, being a dry heat processing

Table 1: Effect of some processing treatments on the proximate composition of the undehulled mungbean (*Vigna radiata* (L) Wilczek) flour

Samples	Moisture	Dry matter	Crude protein	Crude fat	Total Ash	Crude fibre	Carbohydrate	Energy value (kcal/g)
	-------------	-------------	-------------	(%)	-------------	-------------	-------------	
Raw undehulled	10.25^{abc}±0.05	89.75^{bcd}±0.05	24.08^{e}±0.15	1.93^{de}±0.04	3.00^{b}±0.55	5.00^{e}±0.00	55.74^{cde}±0.57	336.65^{i}±0.00
Boiled								
30 min	10.21^{abc}±0.01	89.62^{bcd}±0.29	21.02^{g}±0.40	2.20^{bc}±0.30	1.50^{d}±0.00	3.80^{g}±0.00	61.27^{abc}±0.33	348.96^{b}±0.00
45 min	10.52^{abc}±0.32	89.38^{bcd}±0.18	21.86^{f}±0.15	1.33^{f}±0.20	1.85^{d}±0.00	5.45^{c}±0.05	58.99^{bcd}±0.42	335.37^{k}±0.00
60 min	10.32^{abc}±2.87	89.68^{bcd}±2.87	19.71^{h}±0.30	1.20^{f}±0.03	1.80^{d}±0.00	4.05^{f}±0.05	62.92^{abc}±2.74	341.12^{f}±0.00
90 min	10.55^{abc}±1.66	89.45^{bcd}±1.66	17.34^{i}±0.24	0.53^{h}±0.04	1.50^{d}±0.00	4.10^{f}±0.00	66.17^{ab}±1.64	338.81^{h}±0.00
Toasted (120°C)								
30 min	8.28^{bcd}±0.46	91.72^{abc}±0.46	19.70^{h}±0.10	1.20^{f}±0.03	4.20^{a}±0.00	3.40^{h}±0.00	63.63^{abc}±1.01	344.12^{d}±0.00
45 min	7.56^{cd}±4.91	92.44^{ab}±4.91	17.51^{i}±0.09	1.23^{f}±0.03	4.25^{a}±0.00	4.15^{f}±0.50	65.30^{abc}±5.00	342.31^{e}±0.00
60 min	6.38^{d}±0.08	93.62^{a}±0.08	15.35^{j}±0.16	2.04^{cd}±0.06	4.40^{a}±0.65	5.30^{cd}±0.00	67.23^{ab}±1.56	348.68^{c}±0.00
90 min	5.36^{d}±1.95	94.64^{a}±1.95	13.13^{k}±0.02	2.43^{a}±0.07	4.00^{a}±0.00	5.20^{d}±0.00	69.88^{a}±2.00	353.64^{a}±0.23
Sprouted								
24 h	11.40^{ab}±1.20	88.60^{cd}±1.20	30.65^{d}±0.11	2.32^{ab}±0.29	1.65^{d}±0.00	4.90^{e}±0.00	49.08^{ef}±1.07	339.80^{g}±0.01
36 h	12.33^{a}±0.28	87.67^{d}±0.28	32.56^{c}±0.46	1.76^{e}±0.49	1.80^{d}±0.00	2.03^{i}±0.13	49.52^{def}±0.70	344.16^{d}±0.02
48 h	12.51^{a}±0.35	87.49^{d}±0.35	35.02^{b}±0.05	1.13^{f}±0.03	1.70^{d}±0.00	9.20^{b}±0.00	40.45^{f}±0.28	312.05^{l}±0.00
72 h	12.58^{a}±0.03	87.42^{d}±0.03	37.17^{a}±0.15	0.80^{g}±0.08	2.35^{c}±0.00	13.13^{a}±0.32	44.97^{f}±18.42	335.76^{j}±0.00

Values represent means ± standard deviation of triplicate determinations. Means with the same superscript on the same column are not significantly different (p>0.05)

method, as well as duration of toasting. Similar report was made by Fagbemi (2007) on toasted fluted pumpkin seed flour.

The crude protein of the raw sample (24.08%) significantly differed (p<0.05) from that of the sprouted samples and increase in sprouting hours resulted to increased crude protein agreed with the report made by Bau *et al.* (1997) for sprouted soybeans, El-Adawy (2002) germinated chickpea, Mubarak (2005) for germinated mungbean flour, Fagbemi (2007) for germinated fluted pumpkin seeds. Also, Finney *et al.* (1982) had earlier reported an increase in the protein content of whole germinated mungbean seed flour to be 32.89%.

The increase in the protein content of the sprouted flour samples was mainly due to the use of seed components during the germination process (Mubarak, 2005), breakdown of complex proteins into simpler form and breakdown of nutritionally undesirable constituents (Chavan and Kadam, 1989). The metabolic activities of resting seeds increase as soon as they are hydrated during soaking. The complex biochemical changes that occur during hydration and sprouting lead the protein constituents being broken down by enzymes into simple compounds that are used to make new compounds. The increased hydrolytic activities of the enzymes caused by sprouting resulted in improvements in the contents of the total protein due to the disappearance of starch (Anonymous, 2008b). According to Morgan *et al.* (1992), the absorption of nitrate facilitates the metabolism of the nitrogenous compounds from carbohydrate reserves; thus increasing crude protein levels.

Crude fat: The fat content of the raw sample (1.93%) fell within the range (1.85%-2.83%) reported by Bhatty *et al.* (2000) and Mubarak (2005) and it differed significantly (p<0.05) from the boiled samples. Increase in boiling time of the seeds significantly decreased the fat contents of the flour samples except the samples boiled for 45 min (1.33%) and 60 min (1.20%) which had no significant difference (p>0.05) among them. A slight reduction in fat (1.85-1.82%) of cooked undehulled mungbean seeds has been indicated by Mubarak (2005) and the decrease was attributed to their diffusion into cooking water. Furthermore, Ukwuru (2003) observed a reduction in the fat content of cooked soy flour to be due to the leaching into boiling water.

There was no significant difference (p>0.05) between the fat content of the undehulled mungbean flour toasted for 30 and 45 min respectively with the values 1.20 and 1.23%. It was equally observed that these samples had no significant difference (p>0.05) between the fat content of the flour samples boiled for 45 and 60 min respectively with values 1.33 and 1.2% respectively. It was however, observed that toasting for 60 and 90 min significantly (p<0.05) increased the fat content of the undehulled mung flour to 2.04 and 2.43% respectively. This result was in agreement with the report of Fagbemi (2007) for the increased the fat content of the raw flour from 7.56-9.73%.

Sprouting the mungbean seeds for 24 h was observed to increase the fat content of the flour significantly (p<0.05) from 1.93-2.32%. But the 36, 48 and 72 h sprouted seed flours had their fat contents significantly reduced (p<0.05) with values of 1.76, 1.13 and 0.80% respectively. Mubarak (2005) also reported a significant (p<0.05) decrease in the fat content of the germinated mungbean seed flour from 1.85-1.45%. Fagbemi (2007) also reported a significant (p<0.05) reduction in the fat content of germinated fluted pumpkin seed flour. These decreases could be attributed to the use of fat as an energy source to start germination (Mubarak, 2005).

Total ash: The raw sample had ash content (3.0%) close to the value reported by Mubarak (2005) for undehulled mungbean seeds flour (3.76%). However, boiling treatments reduced the ash contents although no marked reduction with increase in boiling time was observed.

Increase in toasting time had no significant ($p>0.05$) difference in the ash contents of the undehulled mungbean flours. Toasting for 30, 45, 60 and 90 min increased the ash contents to 4.2, 4.25, 4.4 and 4.0% respectively. Fagbemi (2007) also observed that toasting increased the ash content of fluted pumpkin seeds flour. Sprouting significantly ($p<0.05$) reduced the ash content of the undehulled mung flour, although no significant difference ($p>0.05$) existed among the ash content of the 24, 36 and 48 h sprouted seed flour. The reduction in ash content was in agreement with those reported by El-Beltagy (1996) for germinated mung seeds flour and El-Adawy (2002) for germinated chickpea flour.

Crude fiber: The fiber content of the raw sample (5.0%) was slightly higher than that reported by Mubarak (2005)- 4.63% and significantly differed from the crude fiber of the boiled samples with 45 min boiled flour having the highest (5.45%).

Increase in toasting time increased the crude fibre content of the undehulled mung flours significantly except for the samples toasted for 60 and 90 min which had no significant difference ($p>0.05$) among them. Similarly, no significant increase was observed in the toasted fluted pumpkin seed flour (Fagbemi, 2007).

The crude fiber content of the 48 and 72 h sprouted seed flour were the highest, 9.2 and 13.13% respectively. The results corresponded with the findings of Chavan and Kadam (1989); Anonymous (2008b) where they reported that germination increases the crude fiber in seeds due to the disappearance of starch. The crude fiber, a major constituent of cell walls increases both in percentage and real terms, with the synthesis of structural carbohydrates, such as cellulose and hemicellulose (Peer and Leeson, 1985); Cuddeford (1989).

Total carbohydrates: The carbohydrates were significantly ($p<0.05$) increased by boiling treatments probably due to the heat involved which reduced the other components as a result of denaturation and leaching, leading to an increase in carbohydrate contents.

Increase in toasting time, increased the total carbohydrate of the undehulled mung flour although no significant difference ($p>0.05$) was observed among them. Toasting for 30, 45, 60 and 90 min resulted in total carbohydrate contents of 63.63, 65.30, 67.23 and 69.88% respectively.

The total carbohydrates of the sprouted undehulled mungbean seeds flour reduced but no significant difference ($p>0.05$) existed between them. This result was in agreement with the findings of Finney *et al.* (1982); Mubarak (2005) which showed that sprouting resulted to a reduction in the carbohydrate content of mungbean.

Energy value: The energy value of the raw undehulled mungbean flour was observed to be 336.65 kcal/g and it significantly differed ($p<0.05$) from the energy values of the boiled flour samples. Calloway *et al.* (1994) had earlier reported the energy value of 306 kcal/g raw mung flour. Increase in boiling time resulted to significant differences ($p<0.05$) in the energy values of the boiled samples and the values obtained were as a result of the protein and fat contents of the flours since they were calculated using the Atwater factor.

However, increase in toasting time resulted to a significant increase in the energy values of the undehulled mung flours (Table 1). Significant differences ($p<0.05$) in energy values also existed among the sprouted samples.

Dry matter: Significant difference ($p<0.05$) existed between the dry matter contents of the raw sample (89.75%), the toasted and the sprouted samples (Table 1). However, toasting at different intervals did not significantly increase the dry matter and also sprouting at different length of time did not markedly reduce the dry matter of undehulled mung flours. The reduction in the dry matter (total solids) could be relatively attributed to the high moisture content of the sprouted samples. However, a decrease in the seeds had been attributed to the increased contents of total proteins, fat, sugars, ß-group vitamins and certain essential amino acids (Anonymous, 2008b).

Table 2 presents the effect of some processing treatments on the proximate composition of dehulled mungbean seeds flour.

Moisture content: The moisture content of the raw dehulled mungbean seeds flour was 10.11%, however, other reports showed mungbean flour to contain 8.78% (Afzal, 1978); 8.25% moisture content (Bhatty *et al.*, 2000); 9.30% (Augustine and Klein, 1989; Agugo and Onimawo, 2008); 10.10% (Mubarak, 2005). The moisture content of the raw flour was observed to qualify for the standard expected of dry legumes, 10.15% as reported by USDA (1999), since moisture content is a quality factor for preservation, stability of products and convenience in packaging. According to Echendu *et al.* (2009), low moisture content enhances keeping quality of flours. Even though boiling slightly increased the moisture content of the dehulled mungbean flour, increase in boiling time did not significantly increase ($p>0.05$) the moisture content of the flour. Mubarak (2005) also reported that boiling had no significant ($p>0.05$) effect on the moisture content of dehulled

Table 2: Effect of some processing treatments on the proximate composition of the dehulled mungbean (*Vigna radiata* (L) Wilczek) flour

Samples	Moisture (%)	Dry matter (%)	Crude protein (%)	Crude fat (%)	Total Ash (%)	Crude fibre (%)	Carbohydrate (%)	Energy value (kcal/g)
Raw dehulled	10.11^{ab}±0.999	89.98^{ab}±0.98	28.38^{c}±0.21	1.89^{c}±0.02	1.20^{e}±0.00	4.05^{c}±0.25	54.47^{e}±0.66	348.41^{j}±0.00
Boiled								
30 min	10.30^{a}±0.06	89.702^{b}±0.06	26.27^{d}±0.03	2.27^{a}±0.01	1.10^{h}±0.00	3.90^{cd}±0.20	57.16^{de}±0.24	354.15^{c}±0.03
45 min	10.91^{a}±0.05	89.09^{b}±0.05	25.36^{e}±0.16	2.24^{a}±0.01	0.20^{h}±0.50	4.005^{c}±0.00	57.29^{de}±0.08	350.16^{f}±0.00
60 min	10.64^{a}±2.08	89.36^{b}±2.08	22.77^{g}±0.04	1.15^{g}±0.02	0.18^{h}±0.30	3.70^{e}±0.00	61.60^{bc}±2.09	347.83^{j}±0.00
90 min	10.65^{a}±2.10	89.35^{b}±2.10	18.83^{i}±0.30	0.76^{h}±0.06	0.90^{f}±0.00	3.81^{de}±0.01	65.05^{b}±2.00	342.36^{k}±0.00
Toasted (120°C)								
30 min	7.66^{ab}±2.70	92.34^{ab}±2.70	24.52^{f}±0.09	1.47^{d}±0.04	1.75^{a}±0.20	4.32^{b}±0.01	60.29^{cd}±2.69	352.47^{d}±0.02
45 min	7.26^{ab}±4.61	92.74^{ab}±4.61	21.00^{h}±0.02	1.52^{d}±0.02	2.10^{a}±0.05	4.95^{a}±0.05	63.18^{bc}±4.60	350.41^{g}±0.00
60 min	6.58^{b}±0.08	93.42^{a}±0.08	17.52^{j}±0.12	2.06^{b}±0.08	1.33^{d}±0.08	2.05^{h}±0.05	71.18^{a}±1.31	373.34^{a}±0.00
90 min	6.45^{b}±0.86	93.55^{a}±0.86	15.33^{k}±0.11	2.07^{b}±0.01	1.45^{c}±0.05	3.40^{f}±0.00	71.99^{a}±1.92	367.91^{b}±0.00
Sprouted								
24 h	10.43^{a}±0.08	89.57^{b}±0.08	35.90^{b}±0.09	1.35^{e}±0.02	0.40^{g}±0.05	2.90^{g}±0.00	49.02^{f}±0.15	351.83^{e}±0.02
36 h	10.69^{a}±2.24	89.31^{b}±2.24	36.50^{a}±0.31	1.23^{f}±0.03	0.88^{f}±0.25	2.83^{g}±0.03	47.88^{f}±2.16	348.59^{h}±0.00

Values represent means ± standard deviation of triplicate determinations. Means with the same superscript on the same column are not significantly different ($p>0.05$)

mungbean flour (10.13%). The slight increase in moisture was due to the water absorbed during dehulling and boiling.

The flour samples toasted at different intervals had comparable moisture content with the raw flour and this could be due to the high temperature of toasting (120°C), which increased the rate of drying. Sprouting treatments did not markedly increase the moisture content of the dehulled mungbean seeds flour and no significant difference ($p>0.05$) existed among the 24 and 36 h sprouted flours (10.43 and 10.69%) respectively. However, Mubarak (2005) reported that germination resulted to an increase in the moisture content of the mung flour from 10.10-11.10%. The increase in moisture could be attributed to hydration of the seeds during soaking and germination (Del Rosario and Flores, 1981).

Crude protein: As shown in Table 2, the crude protein of the raw sample (28.38%) fell within the range observed by other researchers. Dehulled mungbean seeds flour had protein content of 20-27% (Thompson, 1977); 24.95-28.04% (Adel *et al.*, 1980); 22% (Muller, 1988); 23-29% (Augustine and Klein, 1989); 20-25% (Chen, 1990); 24.5% (Calloway *et al.*, 1994); 25% (Bhatty *et al.*, 2000); 27.6% (Mubarak, 2005); 25.09% (Agugo and Onimawo, 2008). All these reports had shown that dehulled mungbean flour contained protein which was higher than or equal to some of the well-known legumes such as bambara groundnuts (18-20.73%), cowpea (22%), peanuts (24.3-27.0%) (Muller, 1988; Sosulski, 1983; Akinjayeju and Francis, 2007); rapeseed (25%), sunflower flour (28.7%), melon seed (*Colocynthis citrullus*) 28.44%; (Akobundu *et al.*, 1982). However, the protein content of the dehulled mungbean seeds flour was lower than that of soybeans (55.56%) (Sosulski *et al.*, 1976); 35.1-36% (Muller, 1988); 45.3-46.8% (Ukwuru, 2003); 38-40% (Rastogi and Singh, 1989).

There were significant reduction ($p<0.05$) among the protein contents of the boiled dehulled mungbean seeds flour with increasing time and the sample boiled for 90 min had the least crude protein (18.83%). A significant reduction ($p<0.05$) in protein content of dehulled mungbean seeds flour (27.6-26.8%) had been reported by Mubarak (2005) to be caused by boiling the seeds. This decrease has been attributed to leaching during boiling, also due to proteases-resistant complex linkage formation and recombination of amino acid residues (Kylen and McCready, 1975; Fagbemi, 2007).

As shown in Table 2, the crude protein content of the raw sample (28.38%) which fell within the range (20-29%) (Augustine and Klein, 1989; Chen, 1990). Increase in toasting time resulted to significant reduction ($p>0.05$) in the protein content of the dehulled mungbean seeds flour with the sample toasted for 90 min having the least protein value of 15.33%. The greater reduction in the protein content of the toasted mungbean flours could be as a result of polymerization of amino acid that occur on roasting (dry heat processing) (Kato *et al.*, 1985) or due to the formation of meladin at high temperature. The crude protein of the sample was significantly ($p<0.05$) increased by 24 and 36 h sprouting (35.9 and 36.5%) respectively. Mubarak (2005) similarly reported a significant ($p<0.05$) increase in crude protein value of germinated mungbean seeds (from 27.6-30.0%). This was in agreement with the report of Anonymous (2008) which attributed the protein increase to protein synthesis during germination or due to inclusion of microbial cells into the flour. Other researchers reported increase in protein for sprouted cowpea (Akinjayeju and Adekanye, 2006) and increase in protein for sprouted bambara nuts (Akinjayeju and Francis, 2007). The increases in crude protein could be due to enzyme hydrolysis of the insoluble protein available (Echendu *et al.*, 2009). It has also been reported that increase in protein during germination was due to the release of free amino acids after enzymatic hydrolysis for the synthesis of new protein (Bliss, 1975).

Fat: The fat content of the raw sample (1.89%) significantly differed ($p<0.05$) from that of the boiled samples. Other researchers presented fat content of raw dehulled mungbean flour to be 2.83% (Bhatty *et al.*, 2000); 0.86-0.96% (Adel *et al.*, 1980); 1.2-1.3% (Chen, 1990); 1.0-1.5% (Savage and Deo, 2000); 1.82% (Mubarak, 2005); 1.45% (Agugo and Onimawo 2008). All these variations could be due to difference in variety or probably the varying extent of dehulling (Bhatty *et al.*, 2000). The fat content of the dehulled mung flour did not differ much from that found in some other legumes except some legumes which are oil seeds like peanuts, soybeans (Sosulski *et al.*, 1976) 11.6%; Ukwuru (2003) 18-19.6%. The low fat levels of legume grains is because its major function is to maintain the integrity of cell wall and other forms of proteins (Chikwendu, 2003). The boiling treatments markedly reduced the fat content with increasing time although no significant difference ($p>0.05$) existed between the fat contents of the mung seeds flour boiled for 30 and 45 min with values of 2.27 and 2.24% respectively. Similar results were obtained by Mubarak (2005); Agugo and Onimawo (2008).

Toasting for 30 and 45 min reduced the fat content significant ($p<0.05$) to 1.47 and 1.52% respectively though there was no marked differences between them. The fat increased in the 60 and 90 min toasted flours to 2.06 and 2.07% respectively. Agugo and Onimawo (2008) reported a reduction in the fat content of toasted mungbean seeds flour while Fagbemi (2007) reported an increase in the fat content of toasted fluted pumpkin seeds flour.

The fat contents of the 24 and 36 h sprouted samples were reduced (1.35 and 1.23%) significantly ($p<0.05$). Similar observation was made by Mubarak (2005) for germinated mungbean seeds which reduced fat content to 1.45%. Furthermore, Fagbemi (2007) observed a significant ($p<0.05$) reduction in fat content of germinated seeds flour. The decreases could be caused by the use of fat as an energy source to start germination (Mubarak, 2005). Contrarily, Chavan and Kadam (1989); Anonymous (2008b) indicated that sprouting increases the fat content of seeds due to disappearance of starch. Akinjayeju and Francis (2007) attributed fat reduction during soaking to hydrolysis of fat to fatty acids and glycerol by lipolytic enzymes.

Ash: The ash content of the raw sample (1.2%) was lower than those obtained by Adel *et al.* (1980), 3.31-4.05%; Bhatty *et al.* (2000), 4.63%; Agugo and Onimawo (2008), 3.43% for mungbean flour and 6.1% (Sosulski *et al.*, 1976); 3.0-4.2% (Ukwuru, 2003) for raw soyflour. Increase in boiling time did not markedly reduce the ash content of the dehulled mung flour.

Significant ($p<0.05$) difference existed among the toasted samples and this result was in agreement with the report of Fagbemi (2007) for the total ash of the toasted fluted pumpkin seeds flour.

The ash was reduced by sprouting treatments which confirms the report of Mubarak (2005) for germinated mungbean seeds flour. Also, Chikwendu (2003) reported an increase in ash content of groundbean germinated for 72 h due to endogenous enzyme hydrolysis of complex organic compounds to release more nutrients leaving antinutrients to leach into the germination medium.

Crude fiber: The crude fiber content of the raw sample (4.05%) which fell within the range 0.57-5.01% reported by Adel *et al.* (1980). However, higher fiber content of mungbean flour was reported by Agugo and Onimawo (2008), 8.95%. The variation observed in the fiber content of raw mungbean was probably due to the varying extent of dehulling (Bhatty *et al.*, 2000). According to Maforimbo (2001), the fiber contents of the dehulled soybean seeds were significantly lower than the whole seeds (undehulled seeds), suggesting that fiber is more concentrated on the outer seed coat (testa) than in the endosperm. Agugo and Onimawo (2008) reported that high fiber content makes mungbean a good digestive food. Raw soybeans flour was reported to have crude fiber content of 3.2% (Sosulski *et al.*, 1976), 4.3-4.5% (Ukwuru, 2003). Boiling treatments did not significantly ($p>0.05$) reduce the crude fiber of dehulled mungbean flour and this result was in agreement with the report of Agugo and Onimawo (2008) for boiled mungbean flour. There were significant difference ($p<0.05$) between the crude fiber contents of the raw and toasted mungbean flour. Also toasting at different length of times resulted to a significant difference ($p<0.05$) among the crude fiber contents of the mungbean flour. Toasting for 30, 45, 60 and 90 min resulted to crude fiber contents of 4.32, 4.95, 2.05 and 3.4% respectively. According to Agugo and Onimawo (2008), toasting increased the crude fiber content of mungbean flour significantly.

The crude fiber was reduced by sprouting treatments which confirms the report of Mubarak (2005) for germinated mungbean seeds flour. However, on the contrary, Peer and Leeson (1985); Cuddeford (1989) stated that sprouting increased the crude fiber contents of seeds. The increase in fiber due to germination might be that the microfloura enzymes hydrolyzed complex carbohydrate to release fiber which subsequently decreased carbohydrate.

Carbohydrate: The carbohydrate content of the raw dehulled mungbean was found to be 54.47%. However, much higher total carbohydrate content have been observed by Mubarak (2005) to be 62.9%; Agugo and Onimawo (2008), 61.47%; Adel *et al.* (1980), 64.15-66.32%. Lower total carbohydrates have been reported by Muller (1988) to be 35%. The variations could be attributed to the processing methods (Agugo and Onimawo, 2008).

Boiling treatments were found to significantly ($p<0.05$) increase the total carbohydrate content of the dehulled mungbean seeds flour especially with increase in boiling time. Boiling for 30, 45, 60 and 90 min increased the total carbohydrates to 57.16, 57.29, 61.60 and 65.05% respectively. These results were in agreement with the findings of Mubarak (2005); Agugo and Onimawo (2008) for boiled mungbean seeds flour.

Increase in toasting time resulted to significant ($p<0.05$) increase in the total carbohydrates of the dehulled mungbean flour. Toasting for 30, 45, 60 and 90 min gave the total carbohydrate contents of 60.29, 63.18, 71.18 and 71.99% respectively. Similar result was obtained by Agugo and Onimawo (2008) for toasted mungbean flour which showed that toasting significantly increased the total carbohydrate content.

Sprouting treatments were found to significantly ($p<0.05$) reduce the total carbohydrate of the dehulled mungbean seeds flour although, no significant difference existed among the 24 and 36 h sprouted samples(49.02 and 47.88%) respectively. This result corresponded with the report of Mubarak (2005) for germinated samples which showed a significant reduction in the total carbohydrate (from 62.9-61.7%). This could be due to increased starch digestibilities promoted by improved hydrolytic activities of the enzymes during sprouting. Akinjayeju and Francis (2007) reported the carbohydrate by alpha-amylases to simple and more soluble sugars needed by the growing seeds. The decrease in carbohydrate due to germination might also be due to the use of carbohydrate for metabolism by the young seedling (Obizoba and Atu, 1993).

Conclusion: It was noted from this study that, as expected, the dehulled samples had better proximate composition than the undehulled samples because dehulling generally, although not with marked incremental values, improved the proximate compositions of the mungbean flour except the crude fiber values which were much higher in the undehulled mungbean flour. Apparently, boiling treatments increased the moisture and carbohydrate contents but reduced the protein, fat, ash, fiber and energy values. Toasting treatments reduced moisture and protein values but increased carbohydrates and fat contents. However, sprouting treatments increased moisture, crude protein but reduced fat, ash, fiber, energy values and carbohydrates.

REFERENCES

Adel, A., Y. Shehata and M. Thannoun, 1980. Chemical and amino acid composition of Iraqi mungbeans. Zeitschrift fur Lebensmitteluntersuchung und-forschung A., 171: 360-362.

Afzal, E., 1978. Studies on protein supplements for cereal (wheat) based Pakistan diet, Ph.D. Thesis faculty of animal husbandry unit of Agric. Faisalabad. Agriculture, Botswana, pp: 311-322.

Agugo, B.A.C., 2003. Introducing mungbean into the Southeastern Nigeria's humid forest: Overview of potentials. In the Proceedings of 37th Annual Conference of the Agricultural Society of Nigerian held at Calabar, 301-309.

Agugo, U.A. and I.A. Onimawo, 2008. Effect of heat treatment on the nutritional value of Mungbean. M.Sc. project, Department of Nutrition and Dietetic, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria, 5-7, 28, pp: 32-35.

Akinjayeju, O. and O.C. Francis, 2007. Effects of sprouting on the proximate composition of Bambara nut flours. Proceedings of the annual conference/general meeting of NIFST.Oct. 22-25, Abuja, pp: 158-159.

Akinjayeju, O. and Adekanye, 2006. YABATECH. J., 1: 1-10.

Akobundu, E.N.T., J.P. Cherry and J.G. Simmon, 1982. Chemical, functional and nutritional properties of 'egusi' (*Colocynthis citrullus*) seed protein products. J. Food Sci., 47: 828-835.

Andersen Peter, 2007. Report on the Nutritive Value of Rice bean. European Commission 6th Framework Programme, Food Security through Ricebean Research in India and Nepal (FOSRIN). Report 3. Nutritional qualities of rice bean, Bergen, Norway, pp: 1-9.

Anonymous, 2008a. Ayurvedic foods-Mungbeans. Accessed on 3/5/2008.

Anonymous, 2008b. Http://en.wikipedia.org/wiki/sprouting. Nutritional information. Accessed on 23/2/2008.

Anwar, F., S. Latif, R. Przybylski, B. Sultana and M. Ashraf, 2007. Chemical composition and antioxidant activity of seeds of different cultivars of mungbean. J. Clin. Invest., 117: 2486-2495.

A.O.A.C., 1990. Official Methods of Analysis, 15th ed. Washington, D.C.Association of Analytical Chemist 1546.

Apata, D.F. and A.D. Ologhobo, 1989. Trypsin inhibitor and other antinutritional factors in tropical legume seeds. Trop. Sci., 37: 52-59.

Augustine and B.P. Klein, 1989. Nutrient composition of raw, cooked canned, sprouted Legumes. In Legume Chemistry, technology and human nutrition. Edited by R.D. Mattews, Marciel Dekkor, Inc, 32 N.V. AVRDC (1995). Combating micro-nutrients deficiency through vegetables center point, 4: 4-6.

Bau, H.M., C. Villanme, J.P. Nicolas and L. Mejean, 1997. Effect of germination on chemical composition, biochemical constitutes and antinutritional factors of soybean (*Glycine max*) seeds. J. Sci. Food Agric., 73: 1-9.

Bhatty, N., A.H. Gillian and S.A. Nagra, 2000. Effect of cooking and supplementation on nutritional value of Gram (*Cicer arietinum*). Nutr. Resour., 20: 297-307.

Bliss, F.A., 1975. Cowpeas in Nigeria. In: Nutritional improvement of food legumes by breeding. Milner, M. (Ed.). Proceedings of a symposium sponsored by the protein Advisory Group, United Nations System, FAO, Rome in 1972. John Wiley and Sons, New York, pp: 151-158.

Calloway, D.H., S.P. Murphy and S. Bunch, 1994. User's guide to the international minilist nutrient data base. Department of Nutritional Sciences, University of California, Berkey, CA.

Charmaine Solomon, 1998. Encyclopedia of Asian Food, Periplus Editions. New Holland Publishers Pty Ltd. Australia.

Chau, C.F., P.C. Cheung and Y.S. Wong, 1997. Effect of cooking on content of amino acids and antinutrients in three Chinese indigenous legume seeds. J. Sci. Food Agric., 75: 447-452.

Chavan, J. and S.S. Kadam, 1989. Nutritional Importance of cereals by sprouting. Crit. Rev. Food Sci. Nutr., 28: 401-437.

Chen, C.Y., S.C.S. Tsou and H.H. Wang, 1987. Utilization pattern of mungbean in the Chinese diet. In: Shanmugasundaramm (Ed.). Mungbean: Proceeding of the second Intl. symposium. Shanhua, Taiwan: Asian Veg. Research and Development Center, AVDRC Publication No. 88-304, pp: 486-507.

Chen, X., 1990. The 17th International mungbean Nursery trail. Training Report 19th Regional Course in Mungbean production and Research. Kasefart University. Bangkok, Thailand, 1-6.

Chikwendu, N.J., 2003. The effects of germination on the chemical composition and microbial quality of ground bean (*Kerstingiella geocarpa*) flours. Nig. J. Nutr. Sci., 24: 17-20.

Chinma, C.E. and M.A. Igyor, 2007. Micronutrients and anti-nutritional contents of Selected tropical vegetable grown in South East, Nigeria. Nig. Food J., 25: 111-116.

Cuddeford, D., 1989. Hydroponic grass in practice. 11: 211-214.

Del Rosario, R.R. and D.M. Flores, 1981. Functional properties of four types of mungbean flours. J. Sci. Food Agric., 32: 175-180.

Echendu, C.A., I.C. Obizoba and J.U. Anyika, 2009. Effects of germination on chemical composition of groundbean (*Kerstingiella geocarpa* harm) seeds. Pak. J. Nutr., 8: 1849-1854.

El-Adawy, T.A., 2002. Nutritional composition and antinutritional factors of chickpeas (*Cicer arietinum* L.) undergoing different cooking methods and germination. Plant Food Human Nutr., 57: 83-97.

El-Beltagy, A., 1996. Effect of home traditional cooking on quality aspected of some legumes. MS Thesis, Faculty of Agriculture, Menofiya University, Shibin El-Kom Egypt. In: Nutritional composition and antinutritional factors of mungbean seeds (*Phaseolus aureus*) as affected by some home traditional processes. Mubarak, A.E. (Ed.) 2005. J. Food Chem., 89: 489-495.

Emenalom, O.O. and A.B. Udedibie, 2005. Effect of raw, cooked and toasted *Mucuna pruriens* seeds in the performance of finisher broilers. Nig. J. Anim. Prod., 25: 115-119.

Eneche, E.H., 1991. Biscuit-making potential of millet/ pigeon pea flour blends. Plant Foods Human Nutr., 54: 21-27.

Fagbemi, T.N., 2007. Effect of processing on the nutritional composition of pumpkin (*Telfaira occidentalis*) seed flour. Nig. Food J., 25: 1-22.

Fery, F.L., 2002. New Opportunities in Vigna. In: J. Janick and A. Whipkey (Eds.), Trends in new crops and new uses. ASHS press, Alexandria, VA., pp: 424-428.

Finney, P.L., D. Beguin and J.D. Hubbard, 1982. Effects of germination on Bread-baking properties of Mungbean (*Phaseolus aureus*) and Garbanzo bean (*Cicer arietinum*). Cereal Chem., 59: 520-524.

Huijie, N., C. Nghui Li Yuxhen and K. Wanberger, 2003. The impact of mungbean research in China. Shanhua AVDRC Publication No. 03-350. Working paper, 14: 26.

Kato, A., T. Fujishige, N. Matsudomi and K. Kobayashi, 1985. Determination of emulsifying properties of some proteins by conductivity measurements. J. Food Sci., 50: 56-58.

Kay, D.E., 1979. Food Legumes. Tropical products Institute. London, pp: 273-281.

Khalil, A.A., 2006. Nutritional improvement of Egyptian breed of mungbean by probiotic Lactobacilli. Afr. J. Biotech., 5: 206-212.

Kim, S.H., B.H. Lee, M.Y. Baik, M.H. Joo and S.H. Yoo, 2007. Chemical structure and physical properties of mungbean starches isolated from 5 domestic cultivars. J. Food Sci., 72: C471-C477.

Kirk, R.S. and Sawyer, 1991. Pearson's Composition and Analysis of Foods. 9th Edn., Longman Science and Technology, England, UK.

Kylen, A.M. and R.M. McCready, 1975. Nutrient in seeds and sprouts of AlfaAlfa lentils, mungbeans and soybeans. J. Food Sci., 40: 1008-1013.

Leung Albert, 2007. Better Health with (mostly) Chinese Herbs and Food.Mungbean.http://www.earth power.com. 7/1/2009.

Maforimbo, E., 2001. *In vitro* relative protein digestibility and lipoxygenase activity used as parameters to test and compare quality in five varieties of soybean meals. The J. Food Tech. Afr., 6: 48-52.

Mensah, J.K. and R.T. Olukoya, 2007. Performance of mungbeans (*Vigna mungo* (L.) Hepper) grown in Mid-Western Nigeria. American-Eurasian J. Agric. Environ. Sci., 2: 696-701.

Morgan, J., R.R. Hunter and R. O'Hare, 1992. Limiting factors in hydroponic barley grass production. 8th Int'l Conference on Sioless culture. Hunters' rest, South Africa.

Mubarak, A.E., 2005. Nutritional composition and antinutritional factors of mungbean seeds (*Phaseolus aureus*) as affected by some home traditional processes. J. Food Chem., 89: 489-495.

Muller, H.G., 1988. An Introduction to Tropical Foods Science. Cambridge University Press, Cambridge.

Nielson, S.S., 2002. Introduction to the chemical analysis of foods. CBS Publishers and Distributors, New Delhi, India, pp: 93.

Nwabueze, T.U., 2007. Nitrogen solubility index and amino acid profile of extruded African breadfruit (*T.africana*) blends. Nig. Food J., 25: 23-35.

Obizoba, I.C. and L.N. Atu, 1993. Production and chemical evaluation of some food condiments of Nigeria. Plant Food Hum. Nutr., 44: 249-254.

Onwuka, G.I., 2005. Food Analysis and Instrumentation. Theory and Practice. Naphtali Prints, Lagos, Nigeria, pp: 133-137.

Opoku, A., L. Tabil, J. Sundaram, W.J. Crerar and S.J. Park, 2003. Conditioning and dehulling of pigeon pea and mungbeans. CSAE/SCGR Meeting. Montreal, Quebec., pp: 03-347.

Osborne, D.R. and P. Voogt, 1978. The Analysis of Nutrients in Foods. Academic press, London, pp: 128.

Peer, D.J. and S. Leeson, 1985. Feeding value of hydroponically sprouted barley for poultry and pigs. Anim. Sci. Technol., 13: 183-190.

Rastogi, A. and G. Singh, 1989. Effect of addition of full fat soybean flour of different varieties in quality characteristics and bread making quality of white flour. Bull. Grain Technol., 27: 26, 34.

Rubatzky, V.E. and M. Yamaguchi, 1997. World vegetable Principles, production and nutritive values. 2nd Edn., Chapman and Hall, New York.

Savage, G.P. and S. Deo, 2000. The nutritional value of mungbean and Urd. Bean. Nutr. Abst. Reil.c. (Series A), 599: 66-83.

Singh, S., H.D. Singh and K.C. Sikka, 1968. Distribution of nutrients in the anatomical parts of common Indian pulses. Cereal Chem., 45: 13.

Sosulski, F.W., E.S. Humbert, E.S. Bui and J.I. Jones, 1976. Functional properties of rapeseed flours, concentrates and isolates. J. Food Sci., 41: 134.

Sosulski, F.W., 1983. Rapeseed proteins for food use. In Development in food proteins. vol. 2 (Ed.: Hudson, B.J.F.) Applied Sci. publishers, London. Steikraus, and K.H. (1995). Handbook of indigenous fermented foods. Marcel Dekker, Inc., New York, USA.

Thompson, L.U., L. Hung, N. Wang, V. Rasper and H. Gade, 1976. Preparation of mung bean flour and its application in breadmaking. Can. Inst. Food Sci. Tech. J., 9: 1.

Thompson, L.U., 1977. Preparation and evaluation of mungbean protein isolates. J. Food Sci., 42: 202-206.

Udom, S.D., 2007. Effects of processing on Food Toxicants in Mungbean (*Vigna radiata* (L.) Wilczek) flour. B.Sc. Project Report, Food Science and Tech. Department of Michael Univ. of Agric. Umudike, Abia State, Nigeria, pp 4-8.

Ukwuru, M.U., 2003. Effect of processing on the Chemical qualities, Functional Properties of soy flour. Plant Foods for Human Nutrition. Kluwer Academic Publishers, Netherlands, pp: 1-11.

USDA Nutrient Database for Standard Reference, Release 13, 1999. Food Group 20, Cereal grains and Pasta.

Weinberg, K., 2002. The impact of iron bioavailability enhanced diets on health and nutrition of school children: evidence from bean family in Tamil Nadi Paper presented at the International conference on “why has impact assessment research not made more of a difference” in San Jose, Coasta Rica-February, 4-7.