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Effect of Processing Methods on Proximate Composition and Functional Properties of Improved Chickpea (Cicer arietinum L.) Varieties Grown in Ethiopia

Ebisa Olika Keyata[1] Solomon Abera[2] Asnake Fikre[3]
1.Department of Food Science and Nutrition, Wollega University, Shambu Campus P.O. Box: 38, Shambu, Ethiopia
Department of Food Science and Technology, School of Food Science, Postharvest Technology and Process Engineering, Haramaya University, P.O. Box, Haramaya, Ethiopia

Abstract
Chickpea (Cicer arietinum L.) is an important and cheap source of legume protein which can be used as a substitute for animal protein that is limited in supply and expensive. However, the presence of certain antinutritional factors has become a hindrance to the availability of the protein during human consumption. This study was, initiated with the objective of determining the effect of different processing methods on Proximate composition and functional properties of selected improved Chickpea Varieties (Natoli of Desi and Arerti of Kabuli) grown in Ethiopia. The experiment was carried out in a CRD with chickpea variety as the first factor of two levels (Natoli and Arerti) and processing method as a second factor of the five levels (dry roasting, dehulling, soaking, germinating and boiling). The result indicated that the ash, crude protein, crude fiber, crude fat, total carbohydrates and energy of the unprocessed chickpeas were 3.77%, 18.71%, 5.81%, 6.97%, 55.90%, and 361.13 kcal/100g, respectively. After processing the values of these same parameter ranged from 3.21 to 3.67%, 12.51 to 22.62%, 2.43 to 5.32%, 6.94 to 8.48%, 53.34 to 68.52%, and 360.20 to 392.86 kcal/100g, respectively. Bulk density, water absorption capacity, oil absorption capacity, solubility and swelling power were 0.46glcm^3, 1.55 g/g, 2.02g/g, 28.49% and 16.08%, respectively while after processing the values remained between 0.40 to 0.58 g/cm^3, 1.25 to 2.73 g/g, 1.91 to 2.30 g/g, 18.05 to 28.62% and 10.04 to 15.66%, respectively. The results clearly indicated that, among processing methods, dehulling and germination significantly increase the nutritional content while boiling method is best for high water and oil absorption capacity. The present study recommends that dehuling is the best method to increase protein, fat, and energy values and the lower bulk density value in the formulation of complementary foods for children below of two years.
Keywords: Improved Chickpea varieties, proximate composition, Functional properties

INTRODUCTION

Chickpea (Cicer arietinum L.) is one of the world's most important but less-studied leguminous food crop. Among the different legumes, chickpea (*Cicer arietinum L.*) is categorized in *Fabaceae* (*Leguminosae)* family, one of the oldest and most widely consumed legumes in the world and it is a staple food crop particularly in tropical and subtropical areas (Alajaji. and El-Adawy, 2006). Botanically two types of chickpea varieties are usually acknowledged. Kabuli chickpea is large seeded with salmon white testa, grown mainly in the Mediterranean area, central Asia and America and Desi chickpea which is small seeded with a light brown testa, is cultivated mostly in India and East Africa (Rincon et al., 1998). Chickpea is a good and cheap source of protein for people in developing countries (especially in South Asia), who are largely vegetarian either by choice or because of economic reasons. In addition, chickpea was reported as important means of controlling bronchitis, cholera, and constipation and Acids in chickpea seed are supposed to lower the blood cholesterol levels. Also regular pulse consumption such as chickpeas prevents diabetes and reduces risks of heart disease (Jukanti et al., 2012).

In Ethiopia and other African countries, chickpea seeds are consumed as what is known as: Green seed “Eshete”, roasted “Kolo”, flour “Shiro” or mixed with injera and bread, boiled “Nifro” or mixed with vegetables, roasted chick pea with pasta and/or macaroni, etc (Pushpamma and Geervan, 1987). However, presence of antinutritional components restricts its use by interfering with digestion of carbohydrates and proteins. They also interfere with growth, reproduction, or health and reduce protein and carbohydrate utilization when consumed regularly even in normal amounts. Some of these factors include trypsin inhibitors, phytic acid, tannins, saponin and haemagutin activity which can cause adverse physiological responses or diminish the availability of certain nutrients (Urga *et al*., 2005). However, such antinutritional problems can be reduced by processing methods such as dehulling, soaking, boiling, germinating and roasting. The consumption of processed chickpea provides consumers with valuable nutrition and potential health benefits (Gecit, 1991).

To increase the utilization and consumption of pulses, several researchers have recommended that pulses must be processed into flours and used as ingredients in food product applications. It is necessary to evaluate the functional properties namely (water absorption capacity, oil absorption capacity, bulk density, solubility, swelling power, least gelation concentration, foaming properties and emulsification properties) of the flours to use as ingredients in food product applications (Maskus, 2010).

The materials selected for this study were improved varieties Natoli and Arerti with superior performance at national and regional level in terms of production and productivity, adaptation to both biotic stress (disease, insect and weed) and abiotic stress (particularly terminal drought) and widely adapted by farmers (DZARC and ICRISAT, 2009). Therefore, the objective of this study was to assess the effect of Dry roasting, Dehulling, soaking, germination and boiling on proximate composition and functional properties of improved chickpea varieties grown in Ethiopia.

2. Materials and methods

2.1. Materials

Six kilogram of each Natoli of Desi and Arerti of Kabuli chickpeas were collected from Debrezeit Agricultural Research Centre (DZARC), Ethiopia. The seeds were cleaned manually by removing any foreign material, damaged and broken seeds, shriveled and insect attacked seeds. The seeds were processed by direct grinding (used as control), dehulling, soaking, germinating, boiling and dry roasting. The processed samples except the roasted one were dried in an oven at 50°C for 24 h. All the samples including the control were ground by a laboratory mill (Cyclo sample mill model no.: 3010-081p) to pass through a 75µm sieve and were kept in moisture proof plastic bag placed in air tight tin container at 4^0C. The seed flours of both the control and processed samples were evaluated for nutritional composition, anti-nutritional and functional properties

2.2. Processing methods

2.2.1. Raw (control)

Cleaned seed of 500 g of each of the two chickpea varieties samples were directly ground by a mill (Teklehaimanot *et al*., 1993).

2.2.2. Dehulling

Hulls were removed manually after soaking 600 g clean seeds of the two varieties for 6 h in distilled water at room temperature. Seeds were completely covered by water using seed to water ratio of 1:3 (w/v) (Nestares *et al*., 2003). The dehulled seeds were then dried and milled to flour.

2.2.3. Soaking

Cleaned 500 g each of the two improved chickpea varieties were soaked for 12 h in distilled water at room temperature. Seeds were completely covered by water using seed-to-water ratio of 1:3 (w/v) (Nestares *et al*., 2003)

2.2.4. Dry roasting

Cleaned 500 g seeds each of the two chickpea varieties were roasted by hot air oven for 30 minutes at 150°C. The cooled samples were then milled in to flour, (Suvendu and prakash, 1997).

2.2.5. Germinating

Cleaned 500 g each of the two chickpea varieties were washed and cleaned with tap water. Germinating was done according to the method used by Shimelis and Rakshit, (2005). It was performed at room temperature in a dark room. Washed chickpea varieties were soaked for 12 h in distilled water using seed to water as 1:5(w/v). Soaked seeds were spread on moist filter paper on large plastic screen. The seeds were then covered with filter paper to reduce evaporation. The screen was placed in perforated plastic container and kept in the dark at room temperature for 72 h to germinate. The seeds were splashed every 24 h with running sodium hypochlorite at concentration of 0.01% (w/v) for 10 min to avoid mold contamination. At the end of germination period, non-germinated seeds were discarded and the germinated ones were dried at 50 ^{o}C for 24 h. The dry germinated seeds were milled to flour

2.2.6. Boiling

Cleaned 500 g seeds of the two chickpea varieties were washed under tap water, rinsed with distilled water, placed in 2 L of distilled boiling water at 96°C and cooked for 60 min. (until soft) (Teklehaimanot *et al*., 1993). The boiled samples were then dried and milled.

2.3. Analytical methods

2.3.1. Proximate Composition

Moisture content, crude protein, crude fat, ash content, and crude fiber of Natoli and Arerti chickpea varieties were determined using AOAC official method 925.09, 979.09. 4.5.01, 923.03, and 962.09, respectively, (AOAC, 2000)

2.3.4. Functional properties of the chickpea flours

2.3.4.1. Bulk density

Bulk density, Solubility and swelling power, Water absorption capacity (WAC,) and Oil absorption capacity (WAC)

Bulk density was determined by the method of Narayana and Narasinga-Rao (1984). An empty calibrated centrifuge tube was weighed. The tube was then filled with a sample to 5 ml by constant tapping until there was no further change in volume. The weight of the tube and its contents was taken and recorded. The weight of the sample was then determined by difference. Bulk density was calculated as weight per unit volume of the sample.

$$\text{Bulk density}, \frac{g}{cm3} = \frac{W_2\_W_1}{\text{Vol. of sample after tapping}}, \quad (4)$$

W_1 - weight of tube, g

W_2 – weight tube with sample, g

2.3.4.2. Solubility and swelling power

The method used by Shimelis *et al*. (2006) was used to determine the solubility and swelling power. About 0.2 g ground sample (< 60 mesh) was suspended in 10 mL of water and incubated in a thermostatically controlled water bath at 95°C in a tared screw cap tube of 15 mL. The suspension was stirred intermittently over 30 min period to keep the starch granules suspended. The tubes were then rapidly cooled to 20°C. The cool paste was centrifuged, at 2200 x g for 15 min to separate jell and supernatant. Then, the aqueous supernatant was removed and poured in to dish for subsequent analysis of solubility pattern. After this, the weight of the swollen sediment was determined. Supernatant liquid (dissolved starch) was poured into a tarred evaporating dish and put in air oven at 100°C for 4 h. Water solubility index was determined from the amount of dried solids obtained the following equation

$$\text{Solubility}(\%) = \frac{w_1 \times 100}{w_s(1 - Mc)} \quad (5)$$

Swelling power was calculated by the following equation

$$\text{Swelling power}(\%) = \frac{W_2\ x100}{W_{dm}(100 - \text{solublity})} \quad (6)$$

$$\text{Dry matter weight, g} = W_s \times (1 - Mc) \quad (7)$$

Where:

W_1 Weight of dissolved solids in supernatant, g

W_2 Weight of centrifuged swollen granules, g

W_s Weight of sample, g

Mc Moisture content of sample, dry basis (decimal), g

W_{dm} Weight of dry matter, g

2.3.4.3. Water absorption capacity (WAC)

Water absorption capacity was determined using the method of Beuchat (1977). One gram of the sample was mixed with 10 ml distilled water for 30 s. The sample was allowed to stand at room temperature for 30 min and then centrifuged at 5000 x g for 30 min, and the freed water was taken into a 10 ml graduated cylinder and the volume was recorded. Water absorption capacity was estimated as the amount of water retained by 100 g materials on dry basis. Density of water was assumed to be 1 g/ml. The mean of triplicate determinations were reported on a dry weight basis.

$$\text{WAC} = \frac{\text{Weight of water bound}}{\text{Weight of sample (dry basis)}} \quad (8)$$

2.3.4.4. Oil absorption capacity (OAC)

Oil absorption capacities were determined using the method of Beuchat (1977). About one gram of the sample was mixed with 10 ml oil for 30 sec in a mixer. The samples was allowed to stand at room temperature for 30min, centrifuged at 5000 x G for 30 min. The freed oil was decanted into a 10 ml graduated cylinder and the volume was recorded. Oil absorption capacity was expressed as the amount of oil bound by 100 grams dry matter. Density of oil was determined to be 0.893 g/ml. The mean of triplicate determinations results is reported on a dry weight basis.

$$\text{OAC} = \frac{\text{Weight of oil bound}}{\text{Weight of sample (dry basis)}} \quad (9)$$

2.4. Statistical Analysis

The data which were obtained in this experiment subjected to two ways analysis of variance (ANOVA) using SAS 9.1 software. The mean separation values were determined using Least significance (LSD) and Duncan multiple range test (DMRT) and significant differences were defined at $p<0.05$.. The results were presented as mean ± Standard Error

3. RESULTS AND DISCUSSION

3.1. Effect of processing methods on proximate composition and Energy

Processing methods had significant (P<0.05) effect on ash content Table 1. All processing methods resulted in significantly lower ash content as compared to that of raw chickpeas (3.77%). Soaking with 3.67% average ash content gave significantly higher value than germination, boiling, dry roasting and dehulling with values of 3.60, 3.48, 3.44 and 3.21%, respectively. The lowest ash content (3.21%) was recorded for the dehulled chickpeas. The largest ash loss was observed in dehulling process due to the removal of seed coat. Similar ash content reductions after processing such as dehulling, soaking, cooking and germinating were reported in mungbean, and green gram and blue gram (Mubarak, 2004; Kakati *et al*., 2010).

The processing methods had significant (P<0.05) effect regarding the protein content as observed in Table 1. The maximum (22.62%) protein content was recorded for dehulled and the minimum (12.51%) for dry roasted. These values agreed with 19.47 to 21.27% reported by Ihsanullah *et al*. (2008). Dehulling exhibited higher protein percentage due to the removed polysaccharides (cellulose, pectin). Roasting reduced protein content due to denaturation of protein by dry heat. During germination, however, protein content significantly increased in percentage compared to boiling, dry roasting and soaking of chickpea. This apparent increment might be attributed to the utilization of carbohydrates by the seeds as source of energy during germination process.

The crude fiber in the chickpeas was significantly (P< 0.05) affected by processing methods. As shown in Table 1, the average crude fiber content of the unprocessed chickpeas (5.81%) was signinifactly reduced to the values between 2.43% and 5.32% as a result of different processing methods. These values were comparable to those of Egypt chickpea with values ranging between 3.82 to 5.20% after processing by boiling, autoclaving, microwave cooking, and germination as reported by Tarek and EL-Adawy (2000). The highest reduction occurred due to dehulling and the lowest attributed to germination. The significant reduction of CF in dehulled seed (materials) might be due to the removal of non starch polysaccharide (cellulose, pectin, hemicelluloses) in the seed coat. Germination causes breakdown of non starch saccharine to usable form by activation of α-galactosidase while cooking breaks the long chain insoluble polysaccharide to simpler form.

Processing method had significant (P<0.05) effect on crude fat content (Table 1). Dehulling resulted in the highest (8.48%) value and dry roasting in the lowest value (6.94%). Reduction of fat in dry roasting processes might be due to the hydrolysis and oxidation of fat that might have occurred during processing. But, in germination process, the action of activated enzymes might be responsible in converting fat to simple carbohydrate (Finney, 1982)

Table 1, presents average carbohydrate as influenced by processing methods with significant (P<0.05) effect. Processing methods resulted in increased or decreased content of average total carbohydrate. The carbohydrate which was 55.90% for the raw chickpeas increased to 62.24% due to soaking and 68.52% due to dry roasting. It could be attributed to the reduction of the protein content as the result of two process methods which changed the percentage of the carbohydrate. On the other hand it decreased to 54.85% and 53.34% due to germination and boiling, respectively. The loss in carbohydrate during boiling might be due to leaching of soluble carbohydrates like sugars into the soaking and cooking water (Esenwah and Ikenebomeh, 2008). Similar reduction in carbohydrate was reported on grasspea by Gashew *et al.,* (2010). Next to boiling, germination significantly decreased total carbohydrate contents. These decreases could be attributed to its use as an energy source to undergo germination. These results are in agreement with those reported for germinated mung beans by El-Beltagy, (1996).

Significant differences (P<0.05) in the gross energy content were noted due to processing methods in Table 1. Statistically the highest energy (392.86 kcal/100g) was recorded for dehulled chickpeas. This is could be due to high protein and fat content. On the other hand the lowest energy was recorded for samples processed by boiling (360.20 kcal/100g) and for the raw seeds (361.13 kcal/ 100 g). This might be attributed to the relatively lower fat and carbohydrate contents of the two samples as the result of less carbohydrate content

Table: 1. Effect of processing methods on the proximate composition (% in db) and energy

Processing Methods	Proximate composition Ash	Crude protein	Crude fiber	Crude fat	Total CHO	Energy kcal/100g
Raw	3.77 ± 0.04^a	18.71 ± 1.39^c	5.81 ± 0.50^a	6.97 ± 0.20^c	55.90 ± 1.28^{dc}	361.13 ± 2.66^e
Dry roasting	3.44 ± 0.04^e	12.51 ± 1.07^e	3.93 ± 0.22^d	6.94 ± 0.34^c	68.52 ± 1.14^a	386.54 ± 3.38^b
Dehulling	3.21 ± 0.02^f	22.62 ± 0.58^a	2.43 ± 0.16^e	8.48 ± 0.63^a	56.52 ± 1.34^c	392.86 ± 3.24^a
Soaking	3.67 ± 0.03^b	15.15 ± 2.26^d	5.16 ± 0.36^b	7.08 ± 0.36^c	62.24 ± 2.43^b	373.29 ± 3.34^c
Germination	3.60 ± 0.03^c	20.21 ± 0.63^b	5.32 ± 0.42^b	7.39 ± 0.36^b	54.85 ± 0.77^d	366.75 ± 2.95^d
Boiling	3.48 ± 0.03^d	19.91 ± 0.20^b	4.91 ± 0.30^c	7.43 ± 0.27^b	53.34 ± 0.29^d	360.20 ± 3.09^e
CV	0.69	3.55	3.55	2.15	1.97	1.02
LSD	0.04	1.09	0.28	0.27	1.94	6.40

CV= coefficient of variation; values are mean ± MSE and mean values followed by the same letter in column are not significantly different at 5% level of significance.: LSD = least significance difference

3.2. Effect of Processing Methods on Functional properties of improved chickpea varieties

In this study, significance differences were observed in BD of the flours of the processed chickpeas significantly (Table 2). The maximum BD 0.58 g/cm^3 and the minimum 0.40 g/cm^3 were found for flour obtained after soaking and dehulling processes, respectively. The average bulk density of flours of dehulled seeds was significantly reduced as compared to bulk density of those seeds processed by dry roasting, germinating, soaking and boiling. Similar observation of reduced BD of dehulled and germinated chickpeas was reported for popcorn by Steve and Olufunmilayo (2011). The bulk density of dehulled chickpea flour was lower than that of the other flours of chickpeas processed by other methods mainly due to the absence of bulking agents such as cellulose, hemicelluloses, pectin, and lignin which form the bulk of the hull (Fennema, 1996). Decreased bulk density would be an advantage in the preparation weaning food formulations. Among selected processing methods, dehulling and germination are relatively more useful for the preparation food with of low-bulk density in weaning food. (Oladele and Aina, 2007). higher bulk density was found by soaking process methods while dehulling method reduced bulk density as compared to others. Higher value of BD for flour implies that packaging material that will be used for this product shall be stronger than the packaging material used for sample of low bulk density. Low bulk density of flour is used for child feeding formulation (Mulinda *et al*., 2011).

Significant differences were noted in water absorption capacity among the flours processed by the different methods (Table 2). The water absorption capacity of the flour of boiled chickpea was the highest (2.73 g/g) of the flours processed by other methods and was significantly different from all values which ranged between 1.25 and 1.75 g/g. This values were low as compared to those of the cowpeas with values of 0.9 to 1.2 g/g and relatively similar with those of pigeon peas with values of 1.5 to 2.4 g/g, as reported by Olufunmilola and Rauf (2011). Boiled chickpea had higher WAC as compared to other processing methods which may be due to the higher polar amino acid residues of proteins having an affinity for water molecules (Yusuf *et al*., 2008). Dev and Quensil (1988) reported that protein subunit have more water binding sites (increase in the number of hydrophilic groups which are the primary sites of water binding of protein). Thus, the higher WAC of the boiled samples could be due to the dissociation of the protein subunits during the boiling treatment.

Oil Absorption Capacity of improved chickpea variety was significantly ($P<0.05$) affected by processing methods. As indicated in Table 2, the maximum 2.32 g/g was recorded for the flour of soaked chickpeas and the minimum 1.91g/g was observed for that of germinated ones. Oil binding effect of food components reduces the loss of oil (Gibson and Williams, 2001).

The solubility of improved chickpea flour was significantly ($P<0.05$) affected by processing method (Table 2). The maximum (28.62%) solubility was found for flour of dehulled seeds and the minimum (18.05%) for that of boiled chickpeas. This indicated that boiling reduced solubility of flour due to thermal processing which unfold protein and expose the hydrophobic end of protein which reduces solubility (Maruatona, 2008). Dehulling, dry roasting and soaking with the values of 28.62, 27.33 and 26.17% were not statistically different from 28.49% of the raw samples.

Swelling power values of the flours of the two chickpea varieties obtained by the different processing methods were significantly $P<0.05$ different from each other (Table 2). The maximum swelling power 16.08% was found in raw sample and the minimum (10.04%) was found in boiled. Swelling power of raw chickpea flour was the highest of the flours produced by all processing methods. The order of SP of the different samples direct grinding (16.08%) > germinated (15.66%) > soaked (13.83%) > dry roasted (12.87%) > dehulled (12.61%) >

boiled (10.04%).

Table 2. Effect of processing methods on functional properties of improved chickpea varieties

Processing Methods	BD (g/cm^3)	WAC (g/g,db)	OAC (g/g.db)	Solubility (%, db)	Swelling Power (%.db)
Raw (control)	0.46 ± 0.01[b]	1.55 ± 0.07[cb]	2.02 ± 0.07[b]	28.49 ± 1.59[a]	16.08 ± 1.41[a]
Dry roasting	0.45 ± 0.00[cb]	1.57 ± 0.13[cb]	2.30 ± 0.04[a]	27.33 ± 1.16[a]	12.87 ± 0.74[b]
Dehulling	0.40 ± 0.00[d]	1.25 ± 0.06[d]	2.03 ± 0.07[b]	28.62 ± 2.50[a]	12.61 ± 0.93[b]
Soaking	0.58 ± 0.01[a]	1.51 ± 0.10[c]	2.32 ± 0.06[a]	26.17 ± 1.74[a]	13.83 ± 0.77[b]
Germinating	0.44 ± 0.01[c]	1.75 ± 0.15[b]	1.91 ± 0.09[d]	21.41 ± 0.87[b]	15.66 ± 0.95[a]
Boiling	0.47 ± 0.01[b]	2.73 ± 0.04[a]	2.21 ± 0.13[a]	18.05 ± 1.09[b]	10.04 ± 0.59[c]
CV	3.20	9.88	5.20	10.35	9.36
LSD	0.03	0.29	0.19	4.36	2.13

CV= coefficient of variation; values are mean ± SE and mean values followed by the same letter in column are not significantly different at 5% level of significance. LSD = least significance difference
BD = Bulk density, WAC= Water absorption Capacity, OAC = Oil Absorption Capacity

4. Conclusions

Processing of the two local improved chickpea varieties using processing methods such as dry roasting, dehulling, soaking, and germination and boiling significantly affected the proximate compositions, and functional properties. Processing methods such as dehulling and germination increase the nutritional value while boiling method is best for high water and oil absorption capacity. Among processing methods, dehulling is the best method to increase protein, fat, and energy values and the lower bulk density value in the formulation of complementary foods for children below of two years.

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