

# Effect of Processing on Chemical Composition and Antinutritional Factors in Chickpea Flour

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**Abstract:** Nutritional value of pulses is a widely accepted but the presence of antinutritional factors in its composition imposes a restriction in its consumption. Different processing treatments (germination, boiling, pressure cooking and roasting) were employed for reduction of various antinutritional factors (Phytic acid, polyphenols, tannins, saponins, oxalates and trypsin inhibitor activity) in chickpea. Among various treatments employed pressure cooking resulted in maximum reduction of all types of antinutritional factors. Maximum reduction was observed in tannins (93.97%) and polyphenols (87.71%). Processing treatments showed significant effect on protein fraction, fatty acid profile and mineral content of chickpea. The albumins were least affected on processing. Germination increased the linolenic acid to 48.42 percent. Fe and K resulted in increase of 56.89 and 28.6 percent respectively.

**Key words:** Chickpea, pyhtic acid, polyphenols, pressure cooking, fatty acid.

## 1. Introduction

Pulses, including beans and chickpea are one of the most important crops in the world because of their nutritional quality. They are rich sources of complex carbohydrates, protein, vitamins and minerals [1, 2]. Pulses have shown numerous health benefits, e.g. lower glycemic index for people with diabetes [3], increased satiation and cancer prevention as well as protection against cardiovascular diseases due to their dietary fiber content [4]. The seeds of chickpea are large in size, salmon-white in colour and contain high levels of carbohydrate (41.10%-47.42%) and protein (21.70%-23.40%). Starch is the major carbohydrate fraction, representing about 83.9% of the total carbohydrate [5]. Chickpea seed has a high protein digestibility, contains high levels of complex carbohydrates (low glycemic index), is rich in vitamins and minerals and is relatively free from anti-nutritional factors [6, 7]. Chickpea seeds are consumed at raw green, tender stage or as mature dry

seeds in different forms like flour, snack food and supplement in weaning foods [8]. However, presence of antinutritional components restricts its use by interfering with digestion of carbohydrates and proteins. Phyates, oxalates, polyphenols from insoluble complexes with essential dietary components like vitamins, minerals rendering them unavailable to body [9]. Removal of these antinutritional factors *via* genetic amendment may be catastrophic since these compounds have alternative beneficial roles in plants. Hence, removal of antinutritional factors prior to consumption is a better way of handling the problem [10]. Chickpea seed is processed and cooked in a variety of forms depending upon traditional practices and taste preferences. Different domestic processing methods (decortications, soaking, sprouting, fermentation, boiling, roasting, parching frying and steaming) were used to obtain a suitable texture for the consumer, improvement in the nutritional factors and increase the protein digestibility [11, 12]. Heat treatment significantly improves the protein quality in pulses by destruction or inactivation of heat labile anti-nutritional factors. Cooking results

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in significant reductions in phytic acid and tannins in pulses [13]. In the present experimental study various antinutritional factors in chickpea were determined and effect of various processing methods was observed on antinutritional factors and the chemical composition of chickpea.

## 2. Materials and Methods

Chickpea was obtained from the fields of Punjab Agricultural University, Ludhiana, India. The samples were cleaned and subjected to different processing treatments. The processed legumes were stored in airtight containers for subsequent use in the investigation.

### 2.1 Experimental Procedures

#### 2.1.1 Treatments

The chickpea was processed by following treatments to remove the antinutritional factors.

#### 2.1.2 Germination

The chickpea was soaked overnight and then allowed to germinate for two days at room temperature (22 °C). The germinated legume was dried in forced hot air drier at 30 °C-35 °C.

#### 2.1.3 Boiling in Water

The legume was boiled in ratio 1:7 w/v for 10 min. The boiled chickpea was dried to optimum moisture content.

#### 2.1.4 Pressure Cooking

The legume was pressure cooked in a pressure cooker at 15 psi using water ratio 1:2 for 15 minutes followed by drying.

#### 2.1.5 Roasting

Chickpea grains were sand roasted in open pan at 120 °C for 15 min.

### 2.2 Preparation of Samples

The dried legume samples were soaked in sufficient amount of water for 8 hrs. After soaking, the water was drained off. The samples were dried in shade and dehulled in Mini Dal Mill designed by CFTRI Mysore to obtain splits. Processed legumes were then ground

to flour fineness using Buhler Pneumatic Laboratory Mill (MLU-202) and stored in labelled airtight “pet” jars for subsequent use in analysis.

### 2.3 Determination of Chemical Composition

Physico-chemical characteristics such as moisture, crude protein, crude fat, fibre and ash of raw and processed legume were determined using AACC [14] methods. For extraction, fractionation and purification of chickpea protein extraction procedure of Basha and Beeven [15] was employed. Fatty acids were transesterified and analysed by standard method developed at lipid chemical Laboratory, Svalof, Sweden. The samples were analysed for different minerals using the atomic absorption, spectrophotometer GBC-902. The organic matter in sample was wet digested with diacid mixture [16]. For estimation of total phosphorous, the molybdc blue micro method of Fischer [17] was used.

### 2.4 Analysis of Antinutritional Compounds

Standard methods were followed for quantification of antinutritional compounds such as phytic acid [18], total polyphenols [19], tannins [14], saponins [20], oxalates [14] and trypsin inhibitor activity [21].

### 2.5 Statistical Analysis

Experiment was carried out in triplicate and data was statistically analyzed by using factorial design [22] and Duncan’s multiple range tests [23] using Minitab.

## 3. Results and Discussion

### 3.1 Effect of Processing on Proximate Composition of Chickpea

Proximate composition of raw and treated chickpea is presented in Fig. 1. The protein content of chickpea (21.88%) showed an increase up to 22 percent on processing. High temperature treatments might have rendered the high digestibility of proteins during processing [15]. However, Alajaji [1] reported 23.64 percent protein in chickpea that showed non-significant

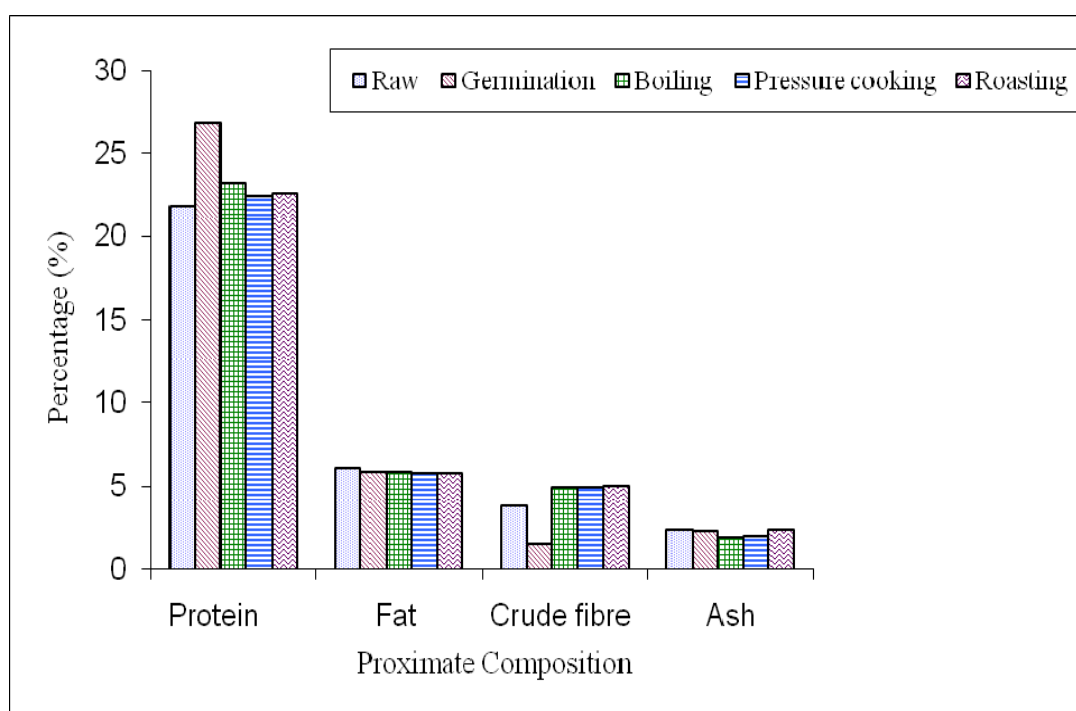


Fig. 1 Effect of processing treatments on proximate composition of chickpea.

effect of cooking treatments on protein content of chickpea. Processing of chickpea decreased the fat and ash content. Leaching effect of fats into the cooking broth at higher temperature is responsible for lower fat content in processed chickpea. Also, as fat serves as store house of energy during embryo development, it again accounts for its reduced levels during germination. The results are in accordance to the reports of Alajaji et al. [8]. Crude fibre increased significantly (30%-32%) in chickpea by various treatments except by germination where it decreased 60.30 percent. The increase may be due to formation of protein-fibre complex [24].

### 3.2 Effect of Processing on Chemical Composition of Chickpea

#### 3.2.1 Protein Fraction

Table 1 illustrates the protein fractions i.e., albumins, legumins and vicilins of raw and processed chickpea. Srivastva et al. [25] reported that albumins accounted for 17.7 percent of the total protein which was lower than the albumin content estimated in this study (18.55%). The processing of chickpea reduced

the protein fractions. Major effect was seen on vicilins where roasting reduced vicilins by 83.68 percent. However, pressure cooking and roasting showed some increasing effect on albumins. Boiling caused minimum losses among various treatments used. Neves and Lourenco [26] reported that globulins and albumin fractions decreased by 19 percent and 20.6 percent, respectively in seeds of chickpea germinated for 6 days.

#### 3.2.2 Fatty Acid Composition

Major saturated fatty acid found in chickpea i.e., palmitic acid and unsaturated fatty acids i.e., oleic, linoleic and linolenic acids are presented in Table 2. Data from Table 2 showed a regular trend of processing on chickpea. 4-16 percent increase was observed in palmitic acid on processing, however, pressure cooking slightly reduced the acid. Linoleic acid showed a decrease on processing of the legume. Germination resulted in 48.42 percent increase in linolenic acid whereas boiling of chickpea eliminated the same. Pressure cooking showed a regular decrease in all four fatty acids on application of various processing treatments.

**Table 1** Effect of processing on protein fractions of chickpea.

Treatment	Protein fractions (% of total extractable proteins)			
	Albumins	Legumins	Vicillins	Other low molecular weight fraction
Raw seed	18.55 <sup>ab</sup>	66.50 <sup>c</sup>	12.20 <sup>d</sup>	2.75 <sup>a</sup>
Germination	17.27 <sup>a</sup> (-6.90)	60.20 <sup>a</sup> (-9.47)	9.20 <sup>c</sup> (-24.59)	13.33 <sup>d</sup> (+384.7)
Boiling	18.20 <sup>ab</sup> (-1.88)	64.48 <sup>b</sup> (-3.03)	10.36 <sup>c</sup> (-15.08)	6.96 <sup>b</sup> (+153.09)
Pressure Cooking	19.44 <sup>b</sup> (+4.79)	65.24 <sup>bc</sup> (-1.89)	6.08 <sup>b</sup> (-50.16)	9.24 <sup>c</sup> (+236.00)
Roasting	18.57 <sup>ab</sup> (+0.10)	66.43 <sup>c</sup> (-0.10)	1.99 <sup>a</sup> (-83.68)	13.01 <sup>d</sup> (+373.09)

Values having same superscript do not vary significantly from each other.

Values in paranthesis shows percent increase (+) or decrease (-) from raw sample.

**Table 2** Effect of processing on fatty acid composition of chickpea.

Treatment	Fatty acid (%)			
	Palmitic	Oleic	Linoleic	Linolenic
Raw seed	9.66 <sup>a</sup>	27.98 <sup>c</sup>	57.26 <sup>c</sup>	1.59 <sup>c</sup>
Germination	11.21 <sup>d</sup> (+16.04)	27.31 <sup>a</sup> (-2.39)	51.94 <sup>c</sup> (-9.29)	2.36 <sup>d</sup> (+48.42)
Boiling	10.82 <sup>c</sup> (+12.00)	33.43 <sup>d</sup> (+19.47)	51.25 <sup>b</sup> (-10.49)	Traces <sup>a</sup> (0.00)
Pressure Cooking	9.57 <sup>a</sup> (-0.93)	27.67 <sup>b</sup> (-1.10)	56.32 <sup>d</sup> (-1.64)	1.56 <sup>c</sup> (-1.88)
Roasting	10.12 <sup>b</sup> (+4.76)	28.18 <sup>c</sup> (+0.71)	50.05 <sup>a</sup> (-12.59)	1.24 <sup>b</sup> (-22.01)

Values having same superscript do not vary significantly from each other.

Values in paranthesis shows percent increase (+) or decrease (-) from raw sample.

### 3.2.3 Mineral Content

Mineral content of chickpea as summarized in Table 3 depicted a significant reduction of minerals in processed chickpea. The minerals leached from the chickpea into the water during cooking treatments [8]. Roasted chickpea showed 5.27 and 2.88 percent increase of K and P, respectively whereas roasting did not show any effect on the Mg content of the studied legume. Interestingly, boiling increased Fe and K in chickpea to 56.89 and 28.6 percent, respectively.

### 3.3 Effect of Processing on Antinutritional Factors

#### 3.3.1 Phytic Acid

Chickpea contained 13.28  $\mu$ mole/g phytate content whereas Alajaji et al. [8] reported 1.21 mg/g in the same. All the processing treatments reduced the phytic

acid content. The breakdown of phytic acid during germination could be due to increase in the activity of endogenous phytase for its use as source of inorganic phosphate during germination [27]. Soaking caused leaching of phytic acid which further added to the losses in phytic acid. Boiling, pressure cooking and roasting of chickpea resulted in 12.34, 13.7 and 3.46 percent loss in phytic acid content, respectively. Duhan et al. [28] showed 7-11 percent phytic acid content in chickpea when unsoaked seeds were cooked. Complete elimination of phytic acid was not observed which may be because of the reduction in the extractability of phytic acid on heat processing [27]. Other reason could be the strong electrostatic force that exists between the oxygen atoms of contiguous phosphate radicals within the phytate structure could impart heat resistance to the

molecule [28].

### 3.3.2 Polyphenols

The study revealed that polyphenol content in raw chickpea was 4.72 mg/g in chickpea (Table 4) that reduced significantly with various processing treatments. Processed chickpea showed more than 80 per cent reduction of polyphenols. Germination resulted in minimum reduction in polyphenol content in chickpea that may be because of the presence of polyphenol oxidase and enzymatic hydrolysis [29]. Reduction of polyphenols content during heat treatment is possibly because of the thermolabile nature of polyphenols. Polyphenols form complexes with other water soluble substances and get discarded with the cooking broth. This loss might be due to the fact phenolic hydrogen bonds between the hydroxyl

group in the phenolics and their receptor groups bid together forming complexes. Several authors have suggested the apparent decrease in polyphenols during cooking is most likely not due to an actual decrease in polyphenols, but to a change in their solubility or chemical reactivity [30].

### 3.3.3 Tannins

Among various antinutritional factors illustrated in Table 4, processing of chickpea showed maximum reduction in tannins. This antinutritional factor is mainly concentrated in the seed coat of the legume, thus preliminary dehulling constitutes the simplest way for their removal. However, among the various treatments applied, germination, boiling and pressure cooking treatment were at par in reduction of tannins up to 93 per cent. The decrease may be attributed to the

**Table 3** Effect of processing on mineral content of chickpea.

Treatment	Minerals (mg/g)				
	K	Fe	Mg	Na	P
Raw seed	6.64 <sup>bc</sup>	0.058 <sup>a</sup>	0.76 <sup>c</sup>	0.11 <sup>c</sup>	2.43 <sup>b</sup>
Germination	6.50 <sup>b</sup> (-2.10)	0.047 <sup>a</sup> (-18.96)	0.69 <sup>b</sup> (-9.21)	0.05 <sup>a</sup> (-54.54)	2.32 <sup>b</sup> (-4.52)
Boiling	8.54 <sup>d</sup> (+28.61)	0.091 <sup>b</sup> (+56.89)	0.67 <sup>a</sup> (-13.43)	0.09 <sup>bc</sup> (-18.18)	0.53 <sup>a</sup> (-78.18)
Pressure Cooking	3.51 <sup>a</sup> (-47.13)	0.048 <sup>a</sup> (-17.24)	0.64 <sup>a</sup> (-15.78)	0.08 <sup>b</sup> (-27.27)	2.33 <sup>b</sup> (-4.11)
Roasting	6.99 <sup>c</sup> (+5.27)	0.045 <sup>a</sup> (-22.41)	0.76 <sup>c</sup> (0.00)	0.05 <sup>a</sup> (-54.54)	2.50 <sup>b</sup> (+2.88)

Values having same superscript do not vary significantly from each other.

Values in paranthesis shows percent increase (+) or decrease (-) from raw sample.

**Table 4** Effect of processing on antinutritional factors in chickpea.

Treatment	Antinutritional factors					
	Phytic acid (μmole/g)	Polyphenols (mg/g)	Tannins (mg/g)	Saponins (%)	Oxalates (%)	Trypsin inhibitor activity (TIU/g)
Whole seed	13.28 <sup>d</sup>	4.72 <sup>d</sup>	5.63 <sup>d</sup>	0.44 <sup>c</sup>	0.39 <sup>d</sup>	107.22 <sup>d</sup>
Germination	12.82 <sup>c</sup> (-3.46)	0.85 <sup>b</sup> (-81.99)	0.38 <sup>a</sup> (-93.25)	0.34 <sup>b</sup> (-22.72)	0.16 <sup>b</sup> (-58.97)	64.58 <sup>b</sup> (-39.76)
Boiling	11.64 <sup>b</sup> (-12.34)	0.64 <sup>a</sup> (-86.44)	0.39 <sup>a</sup> (-93.07)	0.28 <sup>a</sup> (-36.36)	0.22 <sup>c</sup> (-43.58)	66.03 <sup>b</sup> (-38.41)
Pressure cooking	11.46 <sup>a</sup> (-13.7)	0.58 <sup>a</sup> (-87.71)	0.39 <sup>a</sup> (-93.97)	0.42 <sup>c</sup> (-4.55)	0.11 <sup>a</sup> (-71.79)	53.38 <sup>a</sup> (-50.21)
Roasting	12.82 <sup>c</sup> (-3.46)	0.84 <sup>b</sup> (-82.20)	1.12 <sup>b</sup> (-80.10)	0.33 <sup>b</sup> (-25.00)	0.21 <sup>c</sup> (-46.15)	80.88 <sup>c</sup> (-24.56)

Values having same superscript do not vary significantly from each other.

Values in paranthesis shows percent increase (+) or decrease (-) from raw sample.

heat labile and water soluble nature of tannins. Khattab and Arntfield [10] reported reduction of tannins on boiling, autoclaving and microwave cooking of legume.

#### 3.3.4 Saponins

Saponin content was found to be 0.44 percent in chickpea (Table 4). Maximum reduction was observed in boiled chickpea which may be attributed to the leaching of saponins into water [28]. If heat processing of seeds resulted in formation of extractable complex between Saponins and sugar or amino acids was not known. Enzymic degradation is a possible explanation of the saponin lost during germination but this has yet to be established. Similar results were reported by Azza et al. [9] for *J. curcus* seeds where 58.17% reduction in saponins was reported on germination.

#### 3.3.5 Oxalates

Oxalate content was found to be 0.39 per cent in raw chickpea (Table 4) and showed 40%-71% reduction by various treatments given to chickpea in the study. The data showed that maximum effect was observed in pressure cooked chickpea that reduced the oxalates up to 71.79%. The results are in consonance with results of Apata and Ologhobo [31].

#### 3.3.6 TIA (Trypsin Inhibitor Activity)

Trypsin inhibitor activity of raw and processed chickpea as summarized in Table 4 shows a continuous reduction by various processing treatments. Decrease of 50 per cent in Trypsin inhibitor activity was observed in pressure cooked chickpea. Alajaji et al. [8] reported 82.27 per cent reduction by autoclaving in chickpea. Wang et al. [32] reported that steam blanching resulted in higher reduction in TIA than water blanching. Abou-Arab et al. [33] reported that roasting, germination and soaking reduced TIA up to 97.07%, 19.72%, 16.15%, respectively, in *Jatropha* seeds. EL-Adawy [5] found that germination was less effective than other cooking treatments in reducing TIA in chickpea. Reduction in TIA during heat treatments might be due to the heat labile nature of trypsin inhibitors. The reduction in TIA during

germination might be attributed to the mobilization and enzymatic degradation of proteins including trypsin inhibitors of seeds during germination [34].

## 4. Conclusion

All processing treatments were effective in reduction of anti-nutritional factors, however, pressure cooking was found to be best for removal of ANFs. The processing treatments have significant effect on chemical composition, mineral content and free fatty acid profile of chickpea.

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