Nor. Afr. J. Food Nutr. Res. 2024; 8 (17): 32 – 43

https://doi.org/10.51745/najfnr.8.17.32-43

https://www.najfnr.com

ORIGINAL ARTICLE

Functional and Novel Foods
Food Chemistry, Engineering, Processing and Packaging

Effects of traditional processing techniques on nutritional quality and sensory acceptability of value-added products made from cowpea (*Vigna unguiculata* L. walp.) produced in Ethiopia

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ABSTRACT

Aims: The aim of this study was to ascertain how different traditional processing methods affect the nutritive values and sensory acceptability of two cowpea varieties (Bole and Kenketi) growing in Ethiopia. **Materials and Methods:** A factorial design with two factors was used: cowpea varieties (Bole and Kanketi) and four processing methods (boiling, roasting, dehulling after roasting, and fermentation). **Results:** Moisture content, crude protein, total ash, crude fiber, crude fat, utilizable carbohydrate, and total energy of the raw cowpeas were 8.45%, 28.80%, 5.04%, 4.71%, 1.91%, 51.12%, 336.89 Kcal/100g and 8.91%, 25.32%, 4.71%, 6.60%, 2.12%, 52.34%, 329.72 Kcal/100g, for Bole and Kanketi varieties, respectively. After processing the values of these parameters were 8.00%, 27.44%, 4.81%, 3.61%, 1.75%, 54.39%, 343.03 Kcal/100g and 8.53%, 24.04%, 4.51%, 5.07%, 1.93%, 55.91%, 337.21 Kcal/100g, for Bole and Kanketi varieties, respectively. Fe, Zn and Ca, contents of raw cowpea variety were 15.65, 6.17 and 43.36 mg/100g, for Bole variety and 13.32, 4.99 and 41.91 mg/100g, respectively, for Kanketi variety. After processing, the contents were 13.46, 5.04 and 34.34 mg/100g for Bole variety whereas for Kanketi variety they were 11.65, 4.08 and 33.40 mg/100g, respectively. The anti-nutritional factors; tannin, and phytic acid were 28.43 and 80.37 mg/100g in the raw Bole variety while for Kanketi variety they were 31.23 and 127.99 mg/100g, respectively. After processing, these parameters were reduced to 16.75 and 50.37 mg/100g, respectively, for Bole whereas for Kanketi variety they were 18.42 and 80.05 mg/100g, respectively. The sensory acceptability scores of cowpea food products showed significant ($p<0.05$) differences for most of the quality parameters as affected by different processing methods. The products processed by boiling, roasting, dehulling after roasting and fermentation showed acceptability scores that ranged from 5.97 to 6.68 for appearance, 5.83 to 6.58 for color, 5.30 to 6.57 for flavor, 4.57 to 6.43 for taste, 5.12 to 6.55 for mouthfeel and 5.36 to 6.55 for overall acceptability in scale of 7 points. The results indicated that such processing methods are helpful in improving the nutritional quality of cowpea through the reduction of antinutritional factors. **Conclusion:** Therefore, different processing methods significantly affect the sensory quality of processed cowpea food products and useful for improving the nutritional quality with respect to crude protein, crude fat, crude fibre, total ash, utilizable carbohydrate and mineral bioavailability through reduction of anti-nutritional factors.

Keywords: Antinutritional factors, Cowpea, Nutritional composition, Traditional processing.

ARTICLE INFORMATION

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Received: August 02, 2023
Revised: December 20, 2023
Accepted: December 25, 2023
Published: February 20, 2024

Article edited by:
Pr. Meghit Boumediene Khaled

Article reviewed by:
Pr. Sabrina Zeghichi-Hamri
Dr. Tonderayi Mathew Matsungo

Cite this article as: Gutema, T., and Tolesa, G. N. (2024). Effects of traditional processing techniques on nutritional quality and sensory acceptability of value-added products made from cowpea (*Vigna unguiculata* L. walp.) produced in Ethiopia. *The North African Journal of Food and Nutrition Research, 8* (17): 32 – 43. https://doi.org/10.51745/najfnr.8.17.32-43

1 Introduction

Cowpea [*Vigna unguiculata* (L.) Walp.], also known as black eye pea, is a major annual pulse crop mostly grown in dry tropical areas of Latin America, South Asia, and Africa [1]. Cowpea is farmed in Ethiopia largely for its edible seeds and leaves, which are occasionally utilized as human food in the form of cooked green vegetables, according to Thulin [2]. Cowpea young leaves, pods, and seeds are utilized for human food and animal feed in Southern Ethiopia [3]. Cowpea is a multipurpose crop, according to Pottorff et al. [4], the plant is suitable for both human and animal consumption, while Avanza et al. [5] stated that Cowpea whole grains and decorticated grains are high in protein, carbs, and fiber, and leaves and green pods have substantial vitamins and minerals. Immature pods and seeds are utilized as vegetables, whereas grains are used in many different snacks and main dishes [6].

Cowpeas and other legumes are excellent sources of protein and can help with a deficiency in protein and energy. Although cowpeas are an essential source of dietary proteins for humans, their acceptability and utilization have been limited due to the presence of anti-nutritional substances in higher concentrations. Antinutritional components such as phytate and tannins interact with nutrients in gastrointestinal tract and limit their bioavailability, lowering nutritional quality [7].

In Ethiopia, there are numerous methods to prepare and consume legume grains based on cultural traditions and taste preferences. The most widely used home processing techniques include soaking, dehulling, boiling, germination, roasting, and fermentation. These processes in cowpea grain may cause changes in anti-nutritional factors and improve protein, carbohydrate, and mineral bioavailability, and this need to be investigated. The aim of this study was therefore to investigate the effects of traditional processing techniques on the nutritional value and sensory acceptability of two cowpea varieties growing in Ethiopia.

2 Materials and Methods

2.1 Raw materials

Both Bole and Kanketi cowpea varieties weighed 5kg of each were collected from Melkasa Agricultural Research Center (MARC), Ethiopia. The seeds were manually cleaned to remove unwanted foreign material, shriveled and insect-affected seeds, broken or damaged seeds, and unnecessary material. The seeds were treated by boiling, roasting, dehulling after roasting, fermentation, and direct grinding. All materials, including the control, were ground to a sieve size of 730 µm in a laboratory mill (Model 3510 - 011p, Collins, USA) and kept in moisture-proof plastic bags at 4°C until needed for analysis.

2.2 Processing techniques

2.2.1 Unprocessed

One kg of cleaned seeds of each of the two cowpea varieties were directly milled [8].

2.2.2 Boiling

Cleaned 1kg of each of the two cowpea varieties were washed with tap water, rinsed with distilled water, and then cooked for 60 minutes until soft in 2 L of distilled boiling water at 96°C. The boiled samples were then dried in an oven (Model 765, Memmert, Germany) at 50°C for about 48hrs and milled into flour [8].

2.2.3 Roasting

Cleaned 1 kg of each of the two improved cowpea varieties were roasted by hot air oven for 30 minutes at 150°C, a periodic turning with a fork was performed. and turning. The samples were milled into flour after cooling [9].

2.2.4 Dehulled after roasting

Both cleaned cowpea varieties, weighing 1kg each, were roasted in a hot air oven for 30 minutes at 150°C while being turned with a fork. The cooled samples were then dehulled and split using a decorticator, separating the hull, and then milling into flour [10].

2.2.5 Fermentation

In plastic containers, a 1:3 dilutions (w/v) suspension of cowpea flour in tap water was prepared. The flour slurry was left to naturally ferment for 24 hours at room temperature (25°C) using only the microorganisms found on or inside the seeds. The water of fermented samples was decanted and transferred to aluminum dishes after fermentation and dried in an oven (Model 765, Memmert, Germany) at 70°C for 36 hrs. Then dried samples were milled into flour [10].

2.3 Proximate composition

Standard methods of the Association of Official Chemists (2000) were used to determine the amount of moisture (method 925.10), crude fiber (method 962.09), protein (method 960.10), fat (method 4.5.01) and ash (method 923.03) [11]. The difference between 100 and the sum of the percentages of moisture, protein, fiber, fat, and ash was utilized to calculate the carbohydrate content. Using Atwater's conversion factors, the amounts of fat, carbohydrates, and protein were calculated to get the gross energy content (caloric value) [12].

2.4 Mineral analysis

Atomic absorption spectrometry (AAS) (Model 210 VGP Spectrophotometer, Buck Scientific, East Nowalk, CT, USA) was used to determine the amounts of Ca, Fe, and Zn in line with the American Association of Cereal Chemists' standard [13]. The results were reported as dry weight.

2.5 Antinutritional factors

2.5.1 Tannin content

The modified Vanillin-HCl methanol method was used to analyze condensed tannins using the vanillin-HCl methods of Price et al. [14]. An equal volume of 8% concentrated HCl in methanol and 1% Vanillin in methanol was used to make the Vanillin-HCl reagent. 0.2 g of the ground sample was introduced in a small conical flask and mixed with the reagent solution right before use. Subsequently, 10 mL of 1% concentrated HCl in methanol were added. After 20 minutes of continuous shaking in a sealed conical flask, the contents were centrifuged (Model 1020 D.E, U.K) at 3000 rpm for 10 minutes. A test tube containing 5 mL of Vanillin-HCl reagent was filled with 1 mL of the supernatant. After 20 minutes incubation at 300C in a water bath (Model GLS 400, England), absorbance at 450 nm was measured with a spectrophotometer. Additionally, a blank sample was prepared, and its absorbance was taken out of the sample absorbance. Catechin (1 mg/mL) was used to prepare a standard curve. The tannins content was calculated as catechin equivalent, as shown below.

$$\text{Tannin (\%)} = \frac{C*10*100}{200} \quad \ldots\ldots\ldots.. (1)$$

C = Concentration corresponding to the optical density,
10 = Volume of the extract (mL), 200 = Sample weight (mg)

2.5.2 Phytic acid

The modified Vaintraub and Lapteva methods were used to calculate the amount of phytate phosphorus (Ph-P) [15]. Using 12.5 mL of 3% Trichloroacetic acid (TCA), 0.25 g of flour was centrifuged (4000 rpm/10 min) and extracted for 45 min in a water bath with vortex mixing at room temperature (23°C). Phytate estimation was done using the supernatant. Following the addition of 4 mL of $FeCl_3$ to 10 mL of the sample solution, it was centrifuged. 0.2 M of HCl, 20 mL of 3% TCA and 20 mL distilled water were used to retain the precipitate after the clear supernatant was properly decanted. H_2SO_4 and H_2O_2 were used to digest the precipitate (30%). During digestion, Phosphorus is transformed into phosphate. By measuring the absorbance of phosphomolybdate blue produced in addition to ammonium molybdate ($(NH_4)_6Mo_7O_{24}.4H_2O$), the phosphate produced was determined. The stock P solution was made by mixing 250 mL of water with 0.1 mg of KH_2PO_4. For the calibration curve, a sequence of solutions (0, 0.2, 0.4, 0.6, 0.8, 1.0 and 1.2 ppm) were produced from the stock solution. A spectrophotometer is used to measure absorbance at 822 nm. The calibration curve was used to calculate the sample's phosphorus content by subtracting the sample's absorbance from the blank. The amount of phytic acid was estimated by multiplying phytate-phosphorous (db) with 3.55 based on the empirical formula $C_6P_6O_{24}H_{18}$.

2.1 Sensory analysis

Processed products of cowpea boiled (Nufro), roasted (Kolo), dehulled after roasting (Shiro wot) and fermented cowpea (Cookies) were evaluated for their sensory acceptability by a panel of 30 panelists. The panelists were selected randomly among the students and staff of the Haramaya University department of Food Science and Postharvest Technology, and Food Technology and Process Engineering. A list of candidates who agreed to participate in the sensory evaluation activity was drawn at random. Sensory evaluation of processed samples (Kolo, Nufro, Cookies and Shiro wot) was done as soon as processing after cooling. Small salt was added into Nufro sample for taste while other samples were presented as they are. The samples presented in an identical glass bowl were coded for evaluation by panels of judges. In order to rinse their mouths between samples, panelists were provided with glasses of potable water. The panelists were instructed to evaluate each prepared sample using a seven-point hedonic scale ((7 = like very much, 6= like moderately, 5 = like slightly, 4 = neither like nor dislike, 3 = dislike slightly, 2 = dislike moderately and 1 = dislike very much) for appearance, color, flavor, taste, mouthfeel, and overall acceptability.

2.2 Statistical Analysis

In order to examine the proximate composition, mineral content, antinutritional factor and sensory acceptability, analysis of variance (ANOVA) was employed. The statistical software used was SAS version 9.1 Software for Windows (SAS, 2008). Samples statistical differences were examined at $p < 0.05$ and the least significant difference (LSD) was used to compare mean differences. The outcome was presented as the mean ± standard deviation.

3 Results and Discussion

3.1 Effect of processing methods on proximate composition and energy value

Moisture content was significantly ($p < 0.05$) influenced by processing techniques (Table 1). The result showed that moisture content of the boiled and fermented samples increased compared to the raw cowpea and other processed samples. This increase could be attributed to water absorption during these processes and subsequent substrate degradation by fermenting microbes, which released moisture as one of their end products [16, 17]. Whereas, the moisture content of the roasted and dehulled after roasting decreased significantly because dry heat was applied to the sample, leading to water loss. This reduction in moisture is beneficial for the shelf life of roasted cowpea products, such as flour.

Table 1. Influence of processing techniques on the proximate compositions of cowpea seed

Processing methods	MC (%)	Crude protein (%)	Ash (%)	Crude fiber (%)	Crude fat (%)	Utilizable CHO (%)	Energy (Kcal/100g)
Rw	8.68 ± 0.27[c]	27.06 ± 1.91[a]	4.86 ± 0.20[a]	5.66 ± 1.04[a]	2.02 ± 0.12[a]	51.73 ± 0.74[d]	333.28 ± 3.94[d]
Bo	10.09 ± 0.28[a]	24.06 ± 1.69[e]	4.46 ± 0.18[c]	4.67 ± 0.86[c]	1.64 ± 0.09[e]	55.07 ± 0.67[b]	331.31 ± 3.54[e]
Ro	6.54 ± 0.57[e]	25.42 ± 1.80[d]	4.77 ± 0.18[a]	3.88 ± 0.71[d]	1.75 ± 0.09[d]	57.62 ± 0.90[a]	347.91 ± 3.93[b]
DRo	6.81 ± 0.26[d]	26.42 ± 1.89[b]	4.54 ± 0.17[c]	2.59 ± 0.48[e]	1.82 ± 0.10[c]	57.80 ± 1.24[a]	353.31 ± 1.77[a]
Fr	9.20 ± 0.28[b]	25.74 ± 2.05[c]	4.66 ± 0.17[b]	4.90 ± 0.91[b]	1.97 ± 0.11[b]	53.53 ± 0.74[c]	334.79 ± 3.54[c]
CV	2.51	0.86	1.74	2.39	1.95	0.70	0.35
LSD	0.25	0.26	0.10	0.12	0.04	0.47	1.43

Where Rw = raw; Bo = boiling; Ro = roasting; Fr = fermentation; DRo = dehulled after roasting; MC = moisture content; CHO = carbohydrate; CV= coefficient of variation; values are Mean ± SD and mean values followed by the same letter in a column are not significantly different at 5% level of significance; LSD = least significance difference

The protein content of the treated flours using the various processing techniques showed statically significant ($p < 0.05$) differences (Table 1). The protein content of the cowpea samples ranged from 24.06% in the boiled cowpeas to 27.06% in the raw cowpeas. The amount of protein in raw cowpeas was lowered by all processing techniques. Compared to other processed samples dehulled after roasted sample scored higher crude protein. This could be because protein is stored in the cotyledons, and its proportion increases when the cover, which contains a minimal quantity of protein, is removed. The decrease of protein content in boiled and roasted samples could be attributed to soluble protein leaking into boiling water and protein denaturation after dry heat treatment [17]. Similar results regarding the loss of protein content through processing techniques like boiling and roasting have been observed for bean types [10, 17-21]. Proteolysis, which produces volatile ammonia as a byproduct of such a process in foods high in protein, may be responsible for the decrease in protein concentration caused by fermentation [22, 23]. Similar results were reported by Dida and Urga [10] and Farinde et al. [17] for chickpea and lima bean, respectively.

Processing techniques had a significant impact on the ash content ($p < 0.05$) (Table 1). The average ash percentage of raw cowpeas (4.86%) was significantly decreased to values between 4.77 and 4.46% as a result of different processing techniques. The reduction of ash content observed in boiled and fermented samples could be attributed to the diffusion of minerals and release into the processing water. It was shown that a significant amount of the water-soluble ash, present in legumes, tended to seep out when the seeds are hydro processed. Similar ash content reduction after processing were reported by Dida and Urga [10].

While the removal of the seed coat of cowpea seed may be responsible for the reduction of ash concentration in dehulled samples following roasting. A decrease in mineral content in grains has been attributed to the loss of the bran or seed coat [24, 25].

The processing techniques had a significant ($p < 0.05$) impact on the crude fiber in cowpeas, as indicated in Table 1. Different processing techniques significantly lowered the mean values of crude fiber content of untreated cowpeas (5.66%) to values between 2.59 and 4.90%. The maximum reduction was found in dehulled after roasting and the minimum goes to fermentation. The most significant reduction in crude fiber may have been achieved by removing the seed cover. Because crude fiber is found mostly in the outer seed testa, its amount is dependent on the seed coat's thickness [25]. The decrease in fiber content during fermentation could be attributed to the partial solubilization of cellulose and hemi-cellulosic material by microbial enzymes [10]. Whereas the lowering of crude fiber in roasted and boiled samples could be attributed to soluble dietary fiber leaking into the cooking water and the breakdown of a long chain of insoluble polysaccharides during heat treatments. Similar results for reduction of crude fiber in different processing methods were reported by Dida and Urga [10] and Farinde et al. [17] in different legumes and pulses.

Processing techniques significantly ($p < 0.05$) influenced crude fat content (Table 1). The level of crude fat in raw cowpeas was reduced by all processing techniques. The raw sample had an average value of 2.02% and was significantly reduced in boiled, roasted, dehulled after roasting and fermented samples with values of 1.64, 1.75, 1.82 and 1.97%, respectively. The reduction in crude fat content in boiled, roasted, and dehulled after roasting samples could be attributable to fat leaching into the processing water, oxidation, and hydrolysis during heat processing.

Table 2. Effect of variety on proximate compositions of processed cowpea seed

Variety	Moisture (%)	Crude protein (%)	Ash (%)	Crude fibre (%)	Crude fat (%)	Utilizable CHO (%)	Energy (Kcal/100g)
Bole raw	8.45 ± 0.12[b]	28.80 ± 0.15[a]	5.04 ± 0.07[a]	4.71 ± 0.08[b]	1.91 ± 0.07[b]	51.12 ± 0.28[b]	336.89 ± 1.12[a]
Kanketi raw	8.91 ± 0.07[a]	25.32 ± 0.06[b]	4.71 ± 0.03[b]	6.60 ± 0.24[a]	2.12 ± 0.05[a]	52.34 ± 0.19[a]	329.72 ± 1.14[b]
CV	1.17	0.42	1.17	3.18	3.02	0.46	0.34
LSD	0.23	0.26	0.13	0.41	0.14	0.54	2.57
Bole processed	8.00 ± 1.47[b]	27.44 ± 1.13[a]	4.81 ± 0.18[a]	3.61 ± 0.90[b]	1.75 ± 0.14[b]	54.39 ± 2.36[b]	343.03 ± 8.67[a]
Kanketi processed	8.53 ± 1.40[a]	24.04 ± 1.01[b]	4.51 ± 0.15[b]	5.07 ± 1.26[a]	1.93 ± 0.15[a]	55.91 ± 2.55[a]	337.21 ± 9.69[b]
CV	2.51	0.86	1.74	2.39	1.95	0.70	0.35
LSD	0.16	0.17	0.06	0.08	0.03	0.29	0.90

Where MC = moisture content; CHO = carbohydrate; CV = coefficient of variation; values are mean ± SD and mean values followed by the same letter in a column are not significantly different at 5% level of significance; LSD = least significance difference ** Correlation is significant at the 0.01 level (2-tailed).

The decrease in crude fat concentration in the fermented sample could be owing to an increase in lipolytic enzyme activities, which hydrolyze fat into free fatty acids and glycerol during fermentation, preventing the development of protein-lipid or carbohydrate-lipid connections that facilitate oil extraction [19, 20]. The present finding was in agreement with other works reported by Dida and Urga [10] and Farinde et al. [17] in different legumes and pulses.

As indicated in Table 1, the amount of utilizable carbohydrates was significantly ($p < 0.05$) influenced by processing techniques. The present finding shows that, in comparison to the raw sample, the carbohydrate content was considerably ($p < 0.05$) higher after all processing techniques. In roasted and dehulled after roasting samples, maximum values of 57.62 and 57.80%, respectively, were obtained; there was no statically significant variance ($p > 0.05$) between them. The lowest result (51.73%) was produced by the raw sample. The rise in carbohydrate content may be due a significant reduction in other nutrients; therefore, the carbohydrate content was estimated by deducting the other components from 100% [26]. A similar finding was reported by Dida and Urga [10] and Farinde et al. [17] for different legumes and pulses.

Due to the processing techniques in Table 1, there were significant ($p < 0.05$) variations in the gross energy content. The samples that had been dehulled after roasting had statically the highest energy content (353.31 Kcal/100g). The high protein and carbohydrate content may be the cause of this. The sample that undergone boiling, on the other hand, had the lowest energy (331.31 Kcal/100g). This could be explained by sample's increased carbohydrate content, which resulted in significantly lowered levels of fat and protein content.

3.2 Effect of variety on proximate compositions of processed cowpea seed

Significant ($p < 0.05$) difference in moisture content was observed between the two varieties after processing with average values of 8.00% for Bole variety and 8.53% for Kanketi variety (Table 2). These values were lower than those of the raw samples, which averaged 8.45 and 8.91%, respectively.

The crude protein contents of two processed cowpea varieties (Table 2) had a significant ($p < 0.05$) difference between them. After processing, Bole and Kanketi varieties contained average values of 27.44 and 24.04%, respectively. This indicated that Bole variety still contained higher protein than Kanketi. The variation in protein content could be due to differences in the genotypic characteristics of each variety.

The ash content of the two varieties after processing were significantly ($p < 0.05$) different from each other (Table 2). The average values of Bole and Kanketi varieties were 4.81 and 4.51%, respectively. These values are less than those of the raw Bole (5.04%) and Kanketi (4.71%) varieties.

There was a significant difference ($p < 0.05$) in the crude fiber content of processed flour samples due to variety (Table 2). The average crude fiber content after processing were 3.61 and 5.07% for Bole and Kanketi varieties, respectively. The Kanketi variety had higher crude fiber content than Bole variety. The observed differences may be due to varying seed coat thickness. As indicated in Table 2, the average crude fat content of the two cowpea varieties after processing were significantly ($p < 0.05$) different from each other. These values were 1.75 and 1.93% for Bole and Kanketi varieties, respectively. The values of both varieties after processing were slightly lower than those recorded in the raw respective samples with average values of 1.91 and 2.12% (Table 2). The average utilizable carbohydrate contents of two cowpea varieties after processing showed a significant ($p < 0.05$) difference (Table 2). The values of processed Bole and Kanketi varieties were 54.39 and 55.91%, respectively. These values are slightly greater as compared to raw samples with average values of 51.12 and 52.34%, respectively.

The average energy contents of the two evaluated cowpea varieties were significantly ($p < 0.05$) different from each other, with values of 342.98 and 337.44 Kcal/100g for Bole and Kanketi, respectively (Table 2). These values were significantly ($p < 0.05$) higher than those of raw seeds with the average values of 336.89 and 329.72 Kcal/100g, respectively. The source of this energy was protein, fat, and carbohydrate [12].

3.3 Effect of variety on mineral contents of processed cowpea seed

The iron content of processed samples of two cowpea varieties were significantly ($p < 0.05$) different from each other (Table 3). The average values for Bole and Kanketi varieties were 13.46 and 11.65 mg/100g after processing and were lower than that in raw samples (15.65 and 13.32 mg/100g), respectively.

Table 3. Effect of variety on mineral contents of processed cowpea seed

Variety	Iron	Zinc	Calcium
Bole raw	15.65 ± 0.07^a	6.17 ± 0.04^a	43.36 ± 0.48^a
Kanketi raw	13.32 ± 0.09^b	4.99 ± 0.06^b	41.91 ± 0.38^b
CV	0.55	0.95	1.02
LSD	0.18	0.12	0.98
Bole processed	13.46 ± 1.39^a	5.04 ± 0.76^a	34.34 ± 6.43^a
Kanketi processed	11.65 ± 1.08^b	4.08 ± 0.61^b	33.40 ± 6.09^b
CV	2.28	3.22	0.84
LSD	0.21	0.17	0.21

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

The zinc content of the two studied cowpea varieties were significantly ($p < 0.05$) different from each other after processing as shown in Table 3. The obtained mean values were 5.04 and 4.08 mg/100g for Bole and Kanketi varieties, respectively. These values were lower than those of raw Bole and Kanketi varieties with average values of 6.17 and 4.99 mg/100g, respectively.

There were significant ($p < 0.05$) differences in calcium content between the two varieties after processing (Table 3). The mean values of the Bole and Kanketi varieties were 34.34 and 33.40 mg/100g, respectively. This difference could be attributed to their genetic makeup. The values were significantly ($p < 0.05$) different from those of raw samples with average values of 43.36 and 41.91 mg/100g, respectively.

3.4 Influence of processing techniques on the mineral content of cowpea seed

The mineral content (Fe, Zn, and Ca) of the flours processed using the various processing techniques varied significantly ($p < 0.05$) (Table 4). The raw sample had the highest average value, whereas the sample dehulled after roasting had the lowest. According to Wang et al. [25], dehulling resulted in a considerable reduction in mineral content. This loss might be due to the seed coat being removed since minerals are much more contained in the testa than in the cotyledon [27]. The removal of seed covering following roasting and the oxidation that takes place during the dry heat process may be the causes of the highest reduction in the dehulled after roasting sample. The loss of minerals during roasting and boiling could be the result of oxidation during heat treatment and leaching out into boiling water [28, 29].

Table 4. Influence of processing techniques on the mineral contents (mg/100g) of cowpea seed

Processing methods	Iron	Zinc	Calcium
Raw	14.48 ± 1.28^a	5.57 ± 0.64^a	42.63 ± 0.88^a
Boiling	11.69 ± 0.95^d	4.42 ± 0.54^c	39.58 ± 0.74^b
Roasting	13.10 ± 1.06^b	4.19 ± 0.51^d	30.40 ± 0.12^c
Dehulled after roasting	11.11 ± 0.88^e	3.65 ± 0.44^e	27.90 ± 0.53^e
Fermentation	12.38 ± 0.96^c	4.94 ± 0.57^b	28.83 ± 0.63^d
CV	2.28	3.22	0.84
LSD	0.34	0.11	0.34

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

Fermentation also reduced the mineral content significantly. This might be as a result of leaching into processing water during water decantation following fermentation. This finding agreed with the result reported by Farinde [17] and Dida and Urga [10] on boiling, roasting, and fermentation of lima bean and chickpea, respectively.

3.5 Effect of variety on anti-nutritional factors of processed cowpea seed

As indicated in Table 5, the average tannin contents of the two cowpea varieties were significantly ($p < 0.05$) different from each other after processing. The values were 16.75 and 18.42 mg/100g for Bole and Kanketi varieties, respectively. These values were lower than those of raw samples with mean values of 28.43 and 31.23 mg/100g, respectively.

Table 5. Effect of variety on anti-nutritional factors of processed cowpea seed

Variety	Tannin	Phytic acid
Bole raw	28.43 ± 0.12[b]	80.37 ± 0.15[b]
Kanketi raw	31.23 ± 0.13[a]	127.99 ± 0.14[a]
CV	0.41	0.26
LSD	0.28	0.61
Bole processed	16.75 ± 6.83[b]	50.37 ± 17.67[b]
Kanketi processed	18.42 ± 7.50[a]	80.05 ± 28.18[a]
CV	1.11	0.66
LSD	0.14	0.32

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

The phytic acid content of two varieties showed significance ($p < 0.05$) difference after processing (Table 5). The average values for Bole and Kanketi varieties were 50.37 and 80.05 mg/100g, respectively and are lower than those found in the raw which were 80.37 and 127.99 mg/100g for Bole and Kanketi, respectively.

3.6 Influence of processing techniques on the antinutritional factor of cowpea seed

The finding of this investigation demonstrates that all processing techniques greatly decreased the tannin content (Table 6). Tannin concentration varied from 29.83 mg/100g in raw cowpeas to 9.51 mg/100g in samples that had been dehulled following roasting. The amount of tannin in the cowpea samples used in this investigation is significantly less than the 150 to 200 mg/100g of safe threshold stated by Schiavone et al. [30]. The majority of the tannin is contained in the seed coat, which was removed during dehulling process and due to tannin degradation by heat during the roasting process, which may account for the maximum decrease of tannin in the dehulled after roasting sample (68.11%) [31, 32]. The breakdown and leaching of tannins into the boiling water during the boiling process could be the cause of the tannins loss after boiling. Tannins can be reduced by leaching into boiling water because they are water-soluble phenolic compounds and mostly located in seed covering [29]. Various enzymatic activities could be responsible for the reduction of tannin during fermentation. The enzyme tannase, for example, is well known for breaking down tannins during fermentation [33].

Table 6. Influence of processing techniques on anti-nutritional factors (mg/100g) of cowpea seed

Processing methods	Tannin	Phytic acid
Raw	29.83 ± 1.54[a]	104.18±26.09[a]
Boiling	13.87 ± 0.82[d]	38.30±9.59[e]
Roasting	15.11 ± 0.83[c]	60.07±14.98[c]
Dehulled after roasting	9.51±0.48 [e]	52.82±13.07[d]
Fermentation	19.62±1.00[b]	70.66±17.57[b]
CV	1.11	0.66
LSD	0.23	0.51

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

Processing techniques significantly ($p < 0.05$) decreased the amount of phytic acid (Table 6). The level of phytic acid observed in this study is far lower than the phytic acid content of 10 – 60 mg/g, which could pose a health problem to humans [34]. All the processed treatments reduced the phytic acid contents. The boiled sample had the maximum reduction (63.23%), followed by dehulled after roasting, roasting and fermentation processing methods. A similar reduction of phytic acid was reported by Udensi et al. [32] on the boiled cowpea seeds, which fall in the range of 32.33 to 68.34%.

Dehulling after roasting also decreased the phytic acid concentration of cowpeas by 49.29% (Table 6). The amount of phytic acid in the seeds was significantly ($p < 0.05$) reduced by roasting and dehulling the seeds. According to many authors dehulling and roasting legume seeds significantly reduced the phytic acid level. According to finding reported by some studies [29, 35-37], dehulling lowered phytic acid levels in mung bean by 20.7%, green gram by 19.85 to 23.9%, faba bean by 22.2%, and chickpea by 36.42%. While, the roasting of cowpea, *Adenanthera pavonina L.* (Fabaceae) and chickpea seed as stated by Nwafor et al. [38], decreased the phytic acid content by 51.76 to 62.35%, 32.17% and 16.36 to 47.05%, respectively.

Roasting reduces the phytic acid level by 42.34% (Table 6). Due to phytic acids sensitivity to heat, it's possible that during roasting, its concentration would decrease. In the roasting of chickpeas Sharma et al. [39] found a similar reduction in phytic acid (16.36 to 47.05%).

The amount of phytic acid was significantly ($p < 0.05$) decreased by fermentation by 32.17%. This reduction could be attributed to microorganisms utilized in cowpea processing, which decreased phytic acid to a large extent by producing phytase while simultaneously lowering the pH of the substrate. By increasing phytase activity, phytic acid reduction in legumes is the most effective approach [10].

3.7 Effect of processing techniques on sensory acceptability of cowpea food products

The sensory acceptability ratings of cowpea food products as influenced by various processing techniques are shown in Table 7. The appearance scores were 6.57, 5.97, 6.68 and 6.32 for boiled, roasted, dehulled after roasting and fermented samples of cowpea food products, respectively. The values of the acceptability score for the roasted and fermented cowpea food items were substantially lower than those for the boiled and dehulled after roasting food products. However, it is important to note that these differences were not statistically significant but ($p > 0.05$). All values except roasted one showed an acceptable level above likes moderately.

indicated acceptable levels near to above a moderate degree of liking.

As indicated in Table 7, the flavor scores were 6.35, .30, 6.57 and 6.15 for boiled, roasted, dehulled after roasting and fermented samples of cowpea food products, respectively. All the values were significantly ($p < 0.05$) different from one another and showed acceptable levels above the moderate degree of liking except the roasted sample with the value of 5.30 which showed above a slight degree of liking.

The acceptability score for taste were 6.43, 6.42, 6.28 and 4.57 for boiled, dehulled after roasting, fermented and roasted samples of cowpea food products, respectively (Table 7). With no difference between them, the first three values were considerably ($p < 0.05$) higher than the final one. All values showed acceptable levels above the moderate degree of liking except the roasted sample with the value 4.57 which showed acceptability level of a little bit above the neither like nor dislike. Processing methods affected the sensory acceptability of taste of cowpea food products.

The scores of mouthfeel acceptability were 6.55, 6.33, 5.98, and 5.12 for samples which were dehulled after roasting, boiled, fermented, and roasted respectively (Table 4). The first two scores, which were similar, were significantly ($p < 0.05$) higher than the latter two values, which did differ significantly from each other. All the values showed an acceptable level above likes slightly to above moderate degree of liking.

Table 7. Effect of processing methods on sensory acceptability of cowpea food products

Food products	Appearance	Color	Flavor	Taste	Mouthfeel	Overall acceptability
Nufro (Bo)	6.57±0.62a	6.58±0.72a	6.35±0.66 ba	6.43±0.50a	6.33±0.65a	6.45±0.36a
Kolo (Ro)	5.97±0.58c	5.83±0.83b	5.30±0.74c	4.57±0.53b	5.12±0.74c	5.36±0.39c
Shiro wot (DRo)	6.68±0.50a	6.52±0.57a	6.57±0.50a	6.42±0.50a	6.55±0.50a	6.55±0.29a
Cookies (Fr)	6.32±0.57b	6.07±0.86b	6.15±0.78b	6.28±0.78a	5.98±0.72b	6.16±0.48b
CV	8.93	12.03	11.14	9.96	11.04	6.29
LSD	0.20	0.27	0.24	0.21	0.23	0.13

Where Bo = boiling; Ro = roasting; Fr = fermentation; DRo = dehulled after roasting; CV= coefficient of variation; values are Mean ± SD and mean values followed by the same letter in a column are not significantly different at 5% level of significance; LSD = least significance difference

The acceptability, marketability, and healthfulness of foods are frequently correlated with color, which is a crucial quality factor [40]. The average values of acceptability scores of colors were 6.58, 6.52, 6.07 and 5.83 for boiled, dehulled after roasting, fermented and roasted samples of cowpea food products, respectively (Table 7). The former two readings, which did not differ substantially from one another, are significantly ($p < 0.05$) higher than the latter two values, which did not differ significantly from one another. All the values of acceptability scores of colors for the food products

Similarly, the score for overall acceptability exhibited the same trend with the values of 6.55, 6.45, 6.16 and 5.36 for samples dehulled after roasting, boiled, fermented, and roasted, respectively (Table 7). Once more, the values of the dehulled after roasting and boiling samples, which did not differ from each other, were significantly ($p < 0.05$) greater than the values of the fermented and roasted sample, which differed considerably from each other. All the values showed an acceptable level above like slightly to close to like very much degree of liking.

4 Conclusion

The present study was conducted to determine the effect of traditional processing methods on nutritional quality and sensory acceptability of two selected cowpea varieties, Bole and Kanketi. The raw Bole variety had higher values of crude protein; total ash and total energy contents than Kanketi variety while the latter had greater moisture, crude fiber, crude fat, and utilizable carbohydrate than the former. The quantity of all investigated minerals found in Bole variety were higher than those in Kanketi variety. Kanketi variety had a higher level of tannin and phytic acid content than Bole variety. This study revealed that the proximate composition, mineral content, antinutritional components, and sensory acceptability of cowpeas were strongly impacted by traditional processing techniques (boiling, roasting, dehulled after roasting, and fermentation). The processing method changed the proximate composition of cowpea samples. Boiling increased the utilizable carbohydrate content while the ash, crude fiber, crude protein, crude fat, and total energy values were decreased. Roasting, dehulling after roasting and fermentation increased utilizable carbohydrate and total energy value but, decreased crude protein, crude fat, crude fiber and ash contents except that roasting had no significant effect on ash content. The highest reduction of all minerals studied in this work was observed in samples dehulled after roasting. The outcomes also clearly showed the importance of such processing techniques in enhancing cowpea nutritional quality by reducing antinutritional components. Among the processing methods dehulling after roasting and boiling was found to be the best methods to reduce tannin and phytic acid content, respectively. These processing techniques must be promoted in order to solve the issue of zinc and iron deficiency, especially in Ethiopia's rural areas where cereals and pulses make up the majority of diets. Also, all product' average sensory acceptability scores remained above 5 on a scale of 7, which indicates a favorable response. Using suitable and adequate processing methods, cowpea utilization could be improved. Hence, processed cowpeas are a potentially nutrient-rich food ingredient for food formulation.

Limitations of the study

The result of this study indicated that processing cowpea into various food products could offer significant benefits in improving the nutritional quality. However; to acquire a complete interpretation of the cowpea applications in product developments, this study is limited in addressing effects of processing on other quality parameters, including amino acid profiles, functional properties, microbial quality and some anti-nutritional factors, such as trypsin inhibitor, hemagglutinin, saponins, and lectins due to laboratory facilities and expense limitations. Nevertheless, the results of this study will make a valuable contribution to the existing body of research on cowpea and its possible applications.

Source of support: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors
Acknowledgements: The author express his heartfelt thanks to Southern Agricultural Research Institute for granting the corresponding author financial support. The author also deeply thankful to Melkasa Agricultural Research Center for providing him cowpea varieties and Haramaya University (Department of Food Science and Postharvest Technology) and Debrezeit Agricultural Research Center for their good will to use their laboratory space and facilities and to all others who directly and indirectly contributed to the success of this work.
Previous submissions: None.
Authors' Contribution: Gutema T. conceived, designed the study, undertook the literature search, performed the experiment, data acquisition, data analysis, prepared, reviewed, and drafted the manuscript. Moreover, Tolesa G.N. supervised thesis research work, designed the study/experiment, data analysis and reviewed the manuscript draft. Authors approved the final version before submission. Authors have read and agreed to the published version of the manuscript.
Conflicts of Interest: The author declares no competing interests.
Preprint deposit: No

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