Effect of Processing Methods on Mineral Contents of Selected Lentils (Lens Culinuris) Varieties (Derash and Alemaya) Grown in Ethiopia

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Abstract
Mineral contents of legumes showed significant reduction during the process of cooking due to leaching of minerals into cooking water. The aim of this study was to investigate the effects of various processing methods (autoclaving, boiling, dehulling, germinating and soaking) on mineral contents of the two selected lentil varieties (Alemaya and Derash). The present study revealed that processing methods affect the mineral contents of lentils. Germinating process was the least reduction of Zn, Fe and Ca by 4.52, 4.23 and 0.55%, however, dehulling process was the highest reduction by 25.91, 19.14 and 9.56%, respectively.
Keywords: Lentil, Alemaya variety, Derash variety, Mineral contents, Processing methods
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1. Introduction

Lentil is an excellent source of macronutrients (P, K, Ca, Mg, and Na), micronutrients (Fe, Zn, Cu, and Mn), and trace elements (Al, Cr, Ni, Pb, Co, Se, Mo). Red lentils provide three different minerals: calcium, iron and potassium. The iron content of 100 grams of dry, whole red lentils is 7.3 mg, the potassium content is 1,135 mg and the calcium content is 97.3 mg. Dil and Pushparajah, (2011) reported that mineral concentrations in lentils vary with soil mineral content. Comparison of international lentil samples showed high lentil Fe concentrations from Syria (63 mg kg^{-1}), Turkey (60 $mgkg^{-1}$), USA (56 $mgkg^{-1}$), and Nepal (50 $mgkg^{-1}$), and the lower concentrations from Australia (46 $mgkg^{-1}$) and Morocco (42 mg kg^{-1}). The total Fe concentrations in lentils ranged from 73 to 90 mg Fe kg^{-1} and Zn concentrations in lentils ranged from 44-54 $mgkg^{-1}$.

The iron is present in significant quantity in lentils (Padoani *et al*., 2007; Ryan *et al*., 2007). In addition, lentils contain Zn which ranges between 3.2 and 6.3mg/100g. The content of Fe, Ca and Zn in whole lentils were 7.5 mg/100g, 56 mg/100g and 4.8 mg/100g respectively (USDA 2010). Also the Fe, Ca and Zn content of split lentils were 7.6 mg/100g, 41 mg/100g and 3.9 mg/100g respectively.

Mineral contents of legumes also showed significant reduction (18.99-39.50%) during the process of cooking due to leaching of minerals into cooking water (Nuzhat *et al.,* 2008). Soaking cereal and most legume flours (but not whole grains or seeds) in water can result in passive diffusion of water-soluble Na, K, or Mg phytate, which can then be removed by decanting the water (Hotz and Gibson, 2001; Perlas and Gibson, 2002). Wang and Hatcher, (2009) reported that dehulling resulted in a significant increase in K and P however, a significant decrease in Ca, Cu, Fe, Mg and Mn content was observed. Wang and Hatcher, (2009) also reported that cooking lentils in boiling water significantly increased Ca, Cu and Mn content, whereas reduced Fe, K, Mg, P and Zn were observed. However, there is a research gap on the effect of processing methods on lentil varieties produced in Ethiopia. Therefore, the objective of this study was to determine the effect of processing methods on mineral contents of the selected varieties of lentil.

2. Materials and Methods

2.1. Experimental Location

The study was conducted at Haramaya University. Chemical analysis such as crude protein, crude fat, crude fiber, ash content, moisture content and anti-nutritional content, were determined at School of Food Science, Post Harvest Technology and Processing Engineering laboratory. Mineral analysis was carried out at School of Food Science, Post Harvest Technology and Processing Engineering and Soil laboratories.

2.2. Experimental Materials

The samples for investigation i.e 6 kg seed of each of the lentil varieties Derash and Alemaya, were collected from Bishoftu Agricultural Research Centre (BARC)**,** national legumes improvement program.

2.3. Experimental Design

Completely randomized design (CRD) with a 2×6 factorial experiment with three replication was implemented. Two selected lentil varieties, Derash and Alemaya, were tested under five different processing methods (dehulling, soaking, germination, autoclaving, and boiling) with one untreated sample (control) for each variety (Table 1).

Table 1. Experimental plan

Factor-2, Processing	Factor -1, Variety	
	De	Al
Au	AuDe	AuAl
Bo	BoDe	BoAl
Dh	DhDe	DhAl
Ge	Ge De	Ge Al
Ra	RaDe	RaAl
So	SoDe	SoAl

Where Al = Alemaya variety, De = Derash variety, Au = Autoclaving, Bo = Boiling, Dh = Dehulling, Ge = Germinating, Ra = Raw/Control sample, So = Soaking

2.4. Sample Preparation

Samples of each of Derash and Alemaya lentil varieties were cleaned manually by removing any foreign material, damaged and broken seeds. The seeds were processed by dehulling, soaking, germination, boiling and autoclaving. The processed samples including the control sample were dried in an oven at 50°C for about 24 hr. All samples were milled by laboratory miller (cyclo sample mill model no: 3010-081p) and pass through 75 µm sieve. The flours were packed in moisture proof plastic bags and stored in airtight tin containers at 4^{o}C until required for analysis.

2.5. Processing Techniques

2.5.1. Direct grinding

Cleaned seed of 600 g each of Derash and Alemaya varieties were directly ground by mill.

2.5.2. Dehulling

A 600 g cleaned seed of each of Derash and Alemaya varieties were dehulled by pestle and mortar. The hull was separated using traditional tool (gundoo) from split seeds. The split lentil was milled as indicated above.

2.5.3. Soaking

The 600 g of clean seed each of the two lentil varieties were soaked in distilled water for 12 hr at room temperature (Osama *et al.,* 1985). The soaked samples were drained and rinsed three times with 600 ml distilled water. The samples were oven dried at 50^{o}C for 24 hr. The dried samples were milled and passed through 75 µm sieve. The flours were packed in moisture proof plastic bags and stored in airtight tin containers at 4^{o}C until required for analysis.

2.5.4. Autoclaving

The 600 g cleaned seed each of the two lentil variety were soaked in distilled water (1:10, w/v) for 12 hr at room temperature (25 °C). The soaked samples were drained and rinsed three times with 600 ml distilled water. The rinsed soaked samples were autoclaved at 121°C under 15 lb pressure in distilled water (1:10, w/v) until they became soft when felt between the fingers (35 min) (Hefnawy, 2011) and immediately dried in oven drying at 50°C for 24 hr. The dried sample was milled and passes through 75 µm sieve. The flours were packed in moisture proof plastic bags and stored in airtight tin containers at 4^{o}C until required for analysis.

2.5.5. Germination

The 600 g seed of each of Derash and Alemaya varieties were cleaned and soaked in distilled water at room temperature for 12 hr. The soaked samples were drained and rinsed three times with 600 ml distilled water. The water was drained off and the samples covered in trays lined with absorbent paper and left to germinate for 72 hr (Mashair *et al*., 2008). At the end of the germination process, the samples were oven dried at 50^{o}C for 24 hr, milled and passed through 75 µm sieve. The flours were packed in moisture proof plastic bags and stored in airtight tin containers at 4^{o}C until required for analysis.

2.5.6. Boiling

The 600 g cleaned samples of each of the two varieties were soaked in distilled water (1:10, w/v) for 12 hr at room temperature (25°C). The soaked seeds were drained and rinsed three times with 600 ml distilled water. The samples were then boiled in distilled water in the ratio of 1:10 (w/v) until they became soft when felt between the fingers (90 min) (Hefnawy, 2011) and immediately dried in oven at 50°C for 24 hr. The dried samples were milled and passed through 75 µm sieve. The flours were packed in moisture proof plastic bags and stored in airtight tin containers at 4^{o}C until required for analysis.

2.6. Minerals Analysis

2.6.1. Calcium

The calcium content was determined by atomic absorption spectrophotometer (AACC, 2000). Calcium content was calculated with the following formula

$$\text{Ca (ppm)} = \frac{\text{C} \times 100}{\text{S}} \quad (1)$$

Where: C is the concentration of the sample from plot of absorption in µg/ml and s sample mass (g).

2.6.2. Iron

Iron content was determined by Atomic Absorption Spectrophotometer (AACC, 2000).

$$\text{Fe(ppm)} = \frac{(\mu g/mL) \text{ x } 100}{Sample\ mass(db)} \quad (2)$$

Where: µg/mL is the absorbance reading concentration

2.6.3. Zinc

Zinc content was determined by Atomic Absorption Spectrophotometer (AACC, 2000). Zinc content was calculated by the following formula:

$$\text{Zn (ppm)} = \frac{(\mu g/mL) \text{ x100}}{\text{Sample mass (db)}} \quad (3)$$

Where: µg/mL is the absorbance reading concentration

2.7. Statistical Analysis

Mineral content of the raw and processed samples were statistically analyzed using analysis of variance (ANOVA) and least significant difference (LSD). The statistical package used was (SAS Institute and Cary, NC). Significant differences were determined at the $P \leq 0.05$ level using Fisher LSD to identify significant differences among mean effects of the varieties and processing methods.

3. Results and Discussions

3.1. Mineral contents in Raw Lentil Varieties

Zinc, iron and calcium contents of the two lentil varieties were significantly ($P \leq 0.05$) different from each other (Table 2.). The amount of zinc, iron and calcium were 52.94, 67.16 and 813.26 mg/kg for Alemaya variety and 41.77, 53.94 and 872.59 mg/kg for Derash variety, respectively. Except calcium both minerals in the present study were higher in Alemaya variety than in Derash variety. The values of iron obtained from this finding are less than that reported by El-Adawy *et al*. (2003) in variety Giza 9 which is 85.00 mg/kg. However, the calcium contents obtained were greater than that obtained in Giza 9 lentil variety which is 760.00 mg/kg. Similarly the result of zinc obtained from this finding is greater than that obtained in other different lentil varieties which ranged from 12.8 to 38.9 mg/kg (Ozer and Kaya, 2010).

Table 2. Mineral composition of selected lentil varieties

Variety	Mineral content (db, mg/kg)		
	Zn	Fe	Ca
Al	52.94 ± 0.08^a	67.16 ± 0.10^a	813.26 ± 0.20^b
De	41.77 ± 0.18^b	53.94 ± 0.03^b	872.59 ± 0.10^a
CV	0.51	0.21	0.03
LSD	0.54	0.28	0.62

Al = Alemaya variety, De = Derash variety, CV = coefficient of variation; LSD = least significant difference; values followed by the same letter in a column are not different at 5% level of significance.

3.2. Effect of Processing Methods on Mineral Contents

3.2.1. Zinc

Processing methods resulted in significant ($P \leq 0.05$) effect on zinc content (Table 3.). The maximum (47.35 mg/kg) average value was found in the raw sample and the minimum (35.08 mg/kg) was found in dehulled sample. According to this finding, the zinc content reduced in dehulled, boiled, autoclaved, soaked and germinated samples by 25.91, 16.56, 13.79, 7.41 and 4.52%, respectively. These reductions may be due to the minerals leached from the lentils' seeds into the distilled water at different rates during soaking, boiling and autoclaving. The reduction of zinc in dehulled samples might be due to the removal of seed coat during processing.

Table 3. Average mineral content of lentil samples processed by different methods

Processing Methods	Zn (mg/kg, db)	reduction (%)	Fe (mg/kg, db)	reduction (%)	Ca (mg/kg, db)	reduction (%)
Au	40.82 ± 2.23[d]	13.79	52.21 ± 4.92[d]	13.77	812.99 ± 12.14[c]	3.55
Bo	39.51 ± 2.93[e]	16.56	54.89 ± 3.99[c]	9.35	802.91 ±16.56[d]	4.75
Dh	35.08 ± 1.76[f]	25.91	48.96 ±5.51[e]	19.14	762.38 ± 20.28[e]	9.56
Ge	45.21 ± 2.76[b]	4.52	57.99 ± 3.52[b]	4.23	838.30 ± 14.18[ab]	0.55
Ra	47.35 ± 2.50[a]	----	60.55 ± 2.96[a]	---	842.93 ± 13.27[a]	---
So	43.84 ± 2.39[c]	7.41	56.47 ± 3.75[bc]	6.74	832.23 ± 14.95[b]	1.27
CV	2.41		3.90		0.81	
LSD	0.69		1.47		4.49	

Au = authoclaving, Bo = boiling, Dh = dehulling, Ge = germinating, Ra = raw, So = soaking
CV = coefficient of variation; LSD = least significance difference; values are mean values followed by the same letter in column are not different at 5% level of significance.

3.2.2. Iron

The result of these finding showed that processing methods had significant (P≤0.05) effect on the iron contents of samples (Table 3). The average values of raw, autoclaved, boiled, dehulled, germinated and soaked samples were 60.55, 52.21, 54.89, 48.96, 57.99 and 56.47 mg/kg, respectively. Processing reduced the content of iron by 19.14, 13.77, 9.35, 6.74 and 4.23% in dehulled, autoclaved, boiled, soaked and germinated samples, respectively. The reduction of iron content might be attributed to leaching during soaking, cooking after soaking and removal of seed coat of lentil samples. These finding agreed with the report of Mubarak, (2005) on the effect of dehulling, soaking, germinating, boiling, autoclaving and microwave cooking of mung bean seeds. However, El-Adawy *et al*. (2003) reported that germination of mung bean, pea and lentil increased the content of iron. Haytowitz and Matthews, (1983) reported that cooking in boiling water caused great losses of Fe (8%). Hatcher, (2009) reported that dehulling (removal of seed coat) resulted in a significant decrease in iron content.

3.2.3. Calcium

Processing method had significant (P≤0.05) effect on calcium content of lentils (Table 3.). Processing decreased the content of calcium from maximum (842.93 mg/kg) to a minimum (762.38 mg/kg) in raw and dehulled sample, respectively. Processing methods reduced the contents of calcium by 9.56, 4.75, 3.55, 1.27 and 0.55% in dehulled, boiled, autoclaved, soaked and germinated samples, respectively. The reduction of calcium due to germination disagreed with the finding of El-Adawy *et al*. (2003) on lentil, mung bean and pea which increased after germination. However, agreed with Mubarak, (2005) who reported on reduction of calcium content during dehulling, boiling, germinating, autoclaving, soaking and microwave cooking in mung bean seeds. The reduction of calcium during germination could be due to leaching during soaking that takes place prior to germination.

4. Conclusion and Recommendation

4.1. Conclusion

The mineral contents of the lentils' samples were reduced in varied degree by all processing methods indicated in this finding. Dehulling process was the highest reduction whereas germinating process was the least reduction of mineral contents.

4.2. Recommendation

The current study observed the effect of different processing methods on mineral contents. This finding recommends that:

- ✓ Instead of dehulling, using germination during lentil processing to different end products.
- ✓ Study on the effect of modern processing techniques on the mineral contents of lentil varieties in Ethiopia.

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