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MINERAL ELEMENTS IN *CANAVALIA ENSIFORMIS*: INFLUENCE OF HYDROTHERMAL PROCESSING TECHNIQUES

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Abstract
Legumes refer to the seeds of leguminous plants belonging to the Leguminousae family. Human consumption of legumes has been on the increase in recent years in many nations of the world especially in developing countries since the seeds are a good source of nutritionally important nutrients such as protein and mineral elements. There are varying concentrations of proteins, carbohydrates, lipids, vitamins and minerals in legumes. This is not unexpected because the Leguminosae are a broad and diverse group of plant resources. There are many species of legumes in Nigeria but some of them remain underutilised. Increasing prevalence of malnutrition due to overdependence on available common legumes results in hike in price. Underutilised legumes that could be used to solve the problem of hunger and malnutrition have limitation in their utilizability because of their "hard-to-cook" status, lack of information on their nutritional composition and the effect of processing methods on their components. Seed of Canavalia ensiformis, a hard-to-cook underutilised legume was subjected to four hydrothermal processing techniques (atmospheric boiling, atmospheric steaming, pressure boiling and pressure steaming) after aqueous soaking to varying hydration levels. Effects of hydrothermal processing techniques on some mineral elements were investigated. All the hydrothermal processing techniques caused significant reduction ($p<0.05$) in the concentrations of mineral elements of the seed. With increase in hydration level, there was better conservation of mineral elements. Leaching of the mineral elements was lowest when the seed was processed by boiling at elevated pressure. The concentrations of the mineral elements during hydrothermal processing were not degraded beyond the normal requirements necessary to meet physiological and nutritional needs.This study seeks to proffer solution to malnutrition through enhancement of the utilisation of this less commonly used legume by producing information on the effect of hydrothermal processing techniques on the mineral elements composition. Provision of such information will increase consumption pattern, encourage increased production, expand market value and encourage other forms of utilisation of the legume.

Keywords: *Canavalia ensiformis*, mineral elements, hydrothermal processing techniques.

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Introduction

In recent years, human consumption of legumes has been increasing since the seeds are regarded as a source of beneficial nutrients. Legumes belongs to the family of *leguminousae* which are a large and economically important family of flowering plants (Gept *et al.*, 2005; Ojo, 2013). They include a large number of domesticated species harvested as crops for human and animal consumption. There are varying concentrations of carbohydrates, protein, lipids, minerals and vitamins in legumes. This is not unexpected because the *leguminousae* are a broad and diverse group of plant resources. Seeds of legumes are used as a source of protein for human and animal nutrition. Legumes seeds are generally low in fat but contain appreciable amount of fibre and minerals. Vitamins are virtually absent in most legumes although some mature dry legume seeds contain some quantity of niacin, folic acid and thiamine. They also contain calcium, phosphorus and iron (FAO, 2007). As part of a diet low in saturated fatty acids and cholesterol, legumes may help to reduce the risk of coronary heart diseases (Graham and Vance, 2003). Moreover, legumes have been reported to reduce the risk of cancer and are of assistance in weight management (Graham and Vance, 2003). Legumes also produce a hypoglycaemic effect when eaten making them a recommended food for diabetics (Gepts, *et al.*, 2005). The increasing awareness of the role of mineral elements in human health and diseases combined with intensifying observation of mineral elements intakes in industrialised populations around the globe under an increasing pattern of worldwide utilisation of processed food items pose the challenge of the potential effects of food processing on mineral element supply to Man.

Canavalia ensiformis is one of the underutilised legumes in Nigeria. The seed coat is light chocolate brown in colour, smooth and glossy while the shape is near elliptical. It is cultivated by local farmers for subsistence purpose, and thus, it is brought out for consumption during dry season when other food crops are out of stock. The presence of antinutrtional components as well as the hard-to-cook nature of this legume have led to the development of processing techniques that could alleviate the problem of prolong cooking. Processing could influence the total mineral content and their bio-availability.

In our earlier study, the mineral elements composition of some legumes including *Canavalia ensiformis* has been reported (Ojo, *et al*., 2014). Furtherance to our study on underutilised legumes, efforts have been made in this article to study the effects of soaking followed by different hydrothermal processing techniques on the mineral elements status of *Canavalia ensiformis*. Seeds of *Canavalia ensiformis* are less utilised as a source of mineral elements. Therefore, provision of information on the status of the mineral elements as influenced by processing techniques would be of interest from the point of view of nutritional and food security considerations.

Materials and Methods

Samples and sample preparation

Dry seeds of *Canavalia ensiformis* (Figure 1) were obtained at a local market in Saki, Oyo State, Nigeria. The seeds were cleaned by winnowing. Unwanted materials such as stones, bad and broken seeds were removed. The seeds were kept in a plastic container while some seeds were milled into flour and kept in a cellophane bags at ambient temperature (25±3°C) prior to analysis.

Soaking and determination of soaking time

Soaking and determination of hydration rate of the sample were carried out using the method described by Xu and Chang (2008) with slight modification. The sample (500 g) was cleaned and soaked in 2500 cm^3 of distilled water in a glass jar at ambient temperature 25±3°C for up to 24 h.

Figure 1: *Canavalia ensiformis* (*Sese-nla*)

Water absorption (increase in moisture) of the legume during soaking was measured hourly for the initial 0-6 h and every two hours. The soaked legumes was blotted with a woollen hand towel at appointed time to remove excess water before weighing and returning back into soaking water. Moisture content of the soaked legume was calculated based on weight differences after water absorption. Furthermore, the water absorption curve was plotted to show the kinetic increase of the moisture content with time. The plateau phase of water absorption curve was defined as 100% hydration level. Soaking time of the legume with desired hydration level was calculated through polynomial equation of respective water absorption curve.

For the subsequent boiling and steaming experiments, the legume was pre-soaked to the desired hydration levels of 0, 10, 25, 50, 75 and 100% by controlling soaking time. The soaked seeds were then drained and boiled or steamed by the following methods:

Boiling at atmospheric pressure (BAP)

Atmospheric boiling under normal atmospheric pressure of the sample was done using the procedure described by Xu and Chang (2008). The boiling of each of the legume samples was conducted using a domestic cooker. Pre-soaked samples (500 g) with varying hydration levels were boiled in water. Determination of cooking time for the atmospheric boiling of these samples was conducted by tactile method

(Vindiolla *et al.*, 1996) in which the cooked sample was squeezed between the forefinger and thumb with moderate pressure. A seed was considered to be cooked when it could be squeezed by finger easily. Cooking time was defined as the time duration, in minutes, of at least 90% of seeds subjected to cooking. After boiling treatments the seeds were drained and both the cooking water and the drained seeds were cooled in plastic containers. Subsequently the cooked seeds and cooking water were dried at 45±5°C using cabinet drier. The dried samples were stored in plastic containers prior to analysis.

Boiling at elevated pressure (BEP)

Pressure boiling was performed using a domestic pressure cooker (Binatone PC-5001) at about 80±8 KPa. Five old of distilled water was added to the pre-soaked legume (500 g) at varying hydration levels as described under atmospheric boiling in a glass flask which was covered with aluminium foil. The content of the flask was brought quickly to boiling on a hot plate. The legume samples with boiling water was placed into pre-heated pressure cooker with 2500 cm^3 of boiling water and the lid was locked in place. The cooking time was counted from when steam began to spurt out from pressure lid. Cooking time was determined by tactile method (Vindiolla *et al.*, 1996). When the samples have been boiled under pressure to the desired cooking time, the pressure cooker was then removed from the heat source and the pressure released. Boiling water and the boiled legume samples were cooled to room temperature 25±3°C and dried at 45±5°C using a cabinet drier. The dried samples were then stored in a plastic container before analysis.

Steaming at atmospheric pressure (SAP)

Steaming and determination of steaming time were carried out at normal atmospheric pressure using steam cooker. The pre-soaked legume samples (500 g by weight) with varying hydration levels were placed on a tray in the steam cooker covered with lid and were steamed over 2500 cm^3 of boiling water. Steaming times were determined by tactile method (Vindiolla *et al.*, 1996). After the steaming process, legumes were cooled and dried at 45±5°C in a cabinet drier. The dried samples were then stored in a plastic container before analysis.

Steaming at elevated pressure (SEP)

Steaming under pressure was performed using a pressure cooker (Binatone PC-5001) at about 80±8 KPa. Pre-soaked samples (500 g by weight) of varying hydration levels were placed on a tray in a pressure cooker and steamed over boiling water under selected high pressure (80±8 KPa). Steamed samples were placed in plastic containers, cooled and then dried at 45±5°C in a cabinet drier. The dried samples were stored in plastic containers before analysis.

Determination of mineral elements

Analyses were carried out for some mineral elements before and after hydrothermal processing using atomic absorption spectrophotometer – Buck 205 (Joslyn, 1970; A.O.A.C, 2005). The mineral elements determined were Potassium (K), Calcium (Ca), Iron (Fe), Magnesium (Mg), Sodium (Na), Phosphorus (P) and Zinc (Zn). The milled sample was weighed and ashed properly in a muffle furnace at 550°C. The ash was dissolved in 100 cm^3 solution of HCl (10% v/v) which was subsequently used in mineral content determination. Its hollow cathode lamp supplied resonance line radiation of each element. Standard calibrations were employed in the analysis.

Statistical analysis

All the analyses were conducted in three replicates and expressed as mean data ± SD (standard deviation). Statistical analysis was performed using SPSS (version 15.0, SAS Institute Inc., Cary, NC). All data were subjected to Analysis of Variance [ANOVA] and the significant differences were determined at $p<0.05$. Duncan's multiple range tests were used to separate the means (SAS, 2005).

Results and discussion

Effect of soaking followed by hydrothermal processing on mineral elements of *Canavalia ensiformis*

The mineral elements composition of *Canavalia ensiformis* at varying hydration levels followed by hydrothermal processing is presented in Table 1.

Table 1: Changes in the mineral elements composition of *Canavalia ensiformis* at varying hydration levels followed by hydrothermal processing

Hydration level	Mineral elements (mg/100 g)	RS	BAP	SAP	BEP	SEP
0%	Calcium	131.56e ± 1.20	119.07d ± 0.67 {19.50}	97.74a ± 0.52 { 25.71}	114.29c ± 0.6±2 {13.13}	112.61b ± 0.53 { 14.41}
	Zinc	21.79e ± 0.42	16.04a ± 0.33 { 26.39 }	16.50b ± 0.04 { 24.28 }	19.54d ± 0.31 {10.33 }	18.23 c ± 0.23 { 16.34 }
	Sodium	10.04e ± 0.23	6.74b ± 0.41 {32.87 }	6. 46a ± 0.05 { 40.24 }	7.56d ± 0.03 { 24.70 }	7.08c ± 0.20 { 28.48 }
	Iron	10.42 e ±0.21	7.94b ± 0.05 {23.80 }	7.64a ± 0.51 { 26.68 }	8.90d ± 0.03 { 14.59 }	8.78c ± 0.64 {15.74 }
	Magnesium	116.94e ± 0.81	78.80b ± 0.23 { 32.62 }	75.65a ± 1.40 {35.31 }	108.05d ± 0.50 { 7.60 }	107.68c ± 1.05 { 7.92}
	Phosphorus	325.67e ± 2.31	201.11b ± 0.89 {38.25 }	108.48 a ± 2.00 { 66.69 }	259.58d ± 0.74 {20.29 }	252.13c ± 1.34 {22.58 }
	Potassium	175.e ± 1.02	122.45b ± 0.80 { 30.03 }	120.00a ± 0.88 {31.43 }	158.58d ± 2.05 {9.38 }	158.50 ± 0.85 { 9.43}
10%	Calcium	131.56e ± 1.20	105.91b ± 0.6±7 { 19.50}	97.73a ± 0.43 {25.72}	114.44d ± 0.60 { 13.02}	112.86c ± 0.64 { 14.22}
	Zinc	21.79e ± 0.42	16.05a ± 0.08 { 26.34 }	16.50b ± 0.04 { 24.28 }	19.54c ± 0.26 {10.33 }	18.23d ± 0.22 { 16.34 }
	Sodium	10.04e ± 0.23	6.78b ± 0.31 {32.47}	6.46a ± 0.02 {35.66 }	7.56d ± 0.02 24.70 }	.08 ± 0.20 { 29.48 }
	Iron	10.42e ±0.21	7.94b ± 0.06 { 23.80 }	7.67a ± 0.45 {26.39 }	8.90d ±0.03 { 14.59 }	8.78c ±0.65 { 15.74 }
	Magnesium	116.94e ± 0.81	78.83b ± 0.31 { 32.58 }	75.65a ± 0.67 { 35.31 }	108.05d ± 0.28 { 7.60 }	107.68c ± 1.23 { 7.92 }
	Phosphorus	325.67e ± 2.31	201.34b ± 1.02 { 38.18 }	109.48a ± 1.89 { 66.38 }	259.58d ± 0.82 { 20.29 }	252.13c ± 1.34 { 22.58 }
	Potassium	175.24e ± 1.02	122.45b ± 0.61 {30.12}	120.00a ± 0.72 { 31.52 }	158.58d ± 2.01 { 9.50 }	158.50c ± 0.45 { 9.55 }
25%	Calcium	131.56e ± 1.20	106.25b ± 0.53 { 19.24}	98.66a ± 0.30 { 25.01}	116.09c ± 0.41 {11.76 }	117.03d ± 1.02 { 11.05}
	Zinc	21.79e ± 0.42	17.01b ± 0.06 {21.94 }	16.59a ± 0.03 {23.86 }	19.54d ± 0.16 { 10.33 }	18.68c ± 0.20 { 14.27 }
	Sodium	10.04e ± 0.23	6.78b ± 0.23 { 32.47 }	6.65a ± 0.32 {33.77 }	7.56d ± 0.02 { 24.70 }	7.38c ± 0.18 {26.49 }
	Iron	10.42e ±0.21	7.90b ± 0.14 { 24.18 }	7.77a ± 0.09 { 25.43 }	8.90d ± 0.02 { 14.59 }	8.78c ± 0.52 { 15.74 }
	Magnesium	116.94e ± 0.81	80.01b ± 0.20 { 31.58 }	79.21a ± 0.52 {32.26 }	108.05d ± 0.34 {7.60 }	109.00c ± 0.88 { 6.79 }
	Phosphorus	325.67e ± 2.31	204.58b ± 0.96 {37.18 }	200.02a ± 1.32 { 38.58 }	259.58d ± 1.17 { 20.29 }	255.13c ± 0.77 { 21.66 }
	Potassium	175.24e ± 1.02	122.45b ± 0.72 { 30.12 }	122.40a ± 1.43 { 30.15 }	158.7 ±6d ± 1.54 {9.44 }	158.61c ± 0.55 {9.49 }
50%	Calcium	131.56e ± 1.20	107.90b ± 0.38 { 17.99}	102.38a ± 0.81 { 22.18}	117.71d ± 0.52 {10.5}	117.24c ± 0.73 { 10.89}
	Zinc	21.79e ± 0.42	17.40b ± 0.22 { 20.15 }	16±.59a ± 0.21 { 23.86 }	19.54d ± 0.12 {10.33 }	19.35c ± 0.41 { 11.20 }
	Sodium	10.04e ± 0.23	7.83c ± 0.l42 { 22.01 }	7.20a ± 0.10 { 28.29 }	7.83d ± 0.10 { 22.01 }	7.40b ± 0.15 {26.30 }
	Iron	10.42e ±0.21	8.32b ± 0 0.21 { 20.15 }	7.89a ± 0.09 {24.28 }	8.92d ± 0.05 { 14.40 }	8.90c ± 0.71 { 14.59 }
	Magnesium	116.94e ± 0.81	82.14b ± 0.21 { 29.76 }	82.01a ± 1.21 { 29.76 }	110.12d ± 0.62 { 5.83 }	109.01c ± 0.76 { 6.78 }

	Phosphorus	325.67e ± 2.31	211.55b ± 0.6±8 { 35.04 }	208.07a ± 0.98 { 36.11 }	260.39d ± 1.12 { 20.05 }	255.87c ± 2.04 { 21.43 }
	Potassium	175.24e ± 1.02	125.30b ± 0.43 { 28.50 }	123.84a ± 0.56 { 29.33 }	158.76d ± 1.54 {9.40 }	158.70c ± 0.39 { 9.44 }

Table 1 continued

Hydration level	Mineral elements (mg/100 g)	RS	BAP	SAP	BEP	SEP
75%	Calcium	131.56e ± 1.20	119.95b ± 0.54 {14.91}	107.87a ± 1.01 {18.01}	123.03d ± 0.71 {6.35 }	122.91c ± 0.80 {6.58 }
	Zinc	21.79e ± 0.42	17.41a ± 0.30 {20.10 }	17.69b ± 0.56 { 18.81 }	20.06d ± 0.41 { 7.93 }	19.35c ± 0.32 { 11.19 }
	Sodium	10.04e ± 0.23	7.83c ± 0.31 { 22.01 }	7.24a ± 0.15 {27.88 }	7.83c ± 0.03 { 22.01 }	7.58b ± 0.21 { 24.50 }
	Iron	10.42 e ±0.21	8.25b ± 0.05 {20.82 }	8.21a ± 0.10 { 21.20 }	8.95d ± 0.01 { 14.10 }	8.90c ± 0.34 { 14.58 }
	Magnesium	116.94e ± 0.81	82.14b ± 0.40 {29.75 }	82.01a ± 1.21 { 29.87}	110.17d ± 0.13 { 5.78 }	109.24c ± 0.87 { 6.58 }
	Phosphorus	325.67e ± 2.31	211.68b ± 1.12 {35.00 }	210.51a ± 0.69 { 35.36 }	260.39d ± 0.82 { 20.04 }	257.62c ± 1.67 { 20.89 }
	Potassium	175e ± 1.02	125.31b ± 0.51 {28.49 }	124.59a ± 1.02 {28.76 }	160.81d ± 0.96 {8 .23 }	159.43c ± 1.01 {9.02 }
100%	Calcium	131.56e ± 1.20	112.13b ± 0.46 { 14.77}	109.44a ± 0.71 {17.81 }	123.40c ± 0.69 {6.20 }	123.01c ± 0.78 {6.50 }
	Zinc	21.79e ± 0.42	19.15b ± 0.23 {12.12 }	17.98a ± 0.40 { 7.49 }	20.06d ± 0.40 { 7.94 }	19.35c ± 0.37 { 11.19 }
	Sodium	10.04e ± 0.23	8.63c ± 0.31 { 14.04 }	8.38b ± 0.33 { 16.53 }	8.71d ± 0.02 { 13.25 }	8.23a c ± 0.20 { 18.03 }
	Iron	10.42 e ±0.21	8.70b ± 0.10 { 16.51 }	8.34a ± 0.06 {19.96 }	9.30c ± 0.04 { 10.75 }	9.30c ± 0.50 { 10.75 }
	Magnesium	116.94e ± 0.81	85.18b ± 0.32 { 27.16 }	83.11a ± 0.72 { 28.93 }	110.17d ± 0.28 { 5.79 }	110.10c ± 1.06 { 5.85 }
	Phosphorus	325.67e ± 2.31	225.68b ± 1.22 { 30.70 }	210.51a ± 1.44 { 35.36 }	260.39d ± 1.00 { 20.04 }	258.40c ± 1.20 { 20.66 }
	Potassium	175.e ± 1.02	130.43b ± 0.37 {25.57}	210.59a ± 0.81 {16.79}	160.81d ± 1.00 {8.23 }	160.80c ± 1.12 {8.24 }

Values are means ± standard deviation (n=3) on dry basis; means with different letters on the same row are significant (p<0.05).
Values in parenthesis represent percentage change in concentration after processing.
RS =raw dried sample; BAP=boiling at normal atmospheric pressure; SAP=steaming at normal atmospheric pressure; BEP=boiling at elevated pressure; SEP=steaming at elevated pressure.

The raw sample of *C. ensiformis* that was not subjected to soaking was represented as 0% hydration level. For each of the hydrothermal processing methods as shown in Table 1, values in parenthesis represent the percentage change in the concentration of the mineral elements after processing. The specific effects of processing on mineral element contents depend on the methods of processing.

C. ensiformis is a good source of phosphorus containing 325.67 mg/100g. Boiling at atmospheric pressure at the hydration level of 50% induced percentage reduction of 35.04%. Pressure boiling of the seeds at 100% hydration level caused the percentage of phosphorus to be lower – 20.05%. Thus, boiling at elevated pressure resulted in a product of higher concentration of phosphorus compared with other hydrothermal processing methods. The recommended dietary allowance of 1250 mg phosphorus is allowed for children of 9 – 18 years while 700 mg is recommended for people above 18 years (Gordon, 1999). Phosphorus helps to regulate the absorption of fat. Also adenosine diphosphate (ADP) is necessary for storing and releasing energy according to body needs (Sunetra, 2009). Magnesium is another nutritionally important mineral element detected at the concentration of 116.94 mg/100g in the raw legume seeds. The recommended dietary allowance for magnesium is 350 mg for women and 420 mg for men (Gordon, 1999). Magnesium is present in the intracellular fluid and helps in the transmission of nerve impulses, muscular contractions and regulation of heartbeat. At atmospheric pressure and at 100% hydration level, boiling of *C. ensiformis* seeds resulted in a reduction of this mineral element by 27.16%. There was further reduction in the concentration of magnesium by 28.93% when the seeds were processed with steam at atmospheric pressure. However, 100% at hydration level, pressure boiling reduced the percentage reduction by 5.79%.

All the hydrothermal processing techniques significantly affected ($p<0.05$) the concentration of zinc in the legume seeds. Zinc is required in the human diet for proper functioning of insulin, healing of wounds as well as normal formation of hair and skin. Deficiency symptoms of this mineral elements in humans would result in stunted growth and mental retardation (Sunetra, 2009). The percentage reduction in the concentration of zinc in *C. ensiformis* ranged from 10.35 for BEP to 26.39 for BAP. These results agree with the study of Schmitt and Weaver (2002) who observed 19.7% loses in zinc for bush beans and 23.0% for kale during thermal treatment. Canning of soybean also caused a loss of 28.8% zinc (Toma and Tabekhia, 1997). A daily intake of 22 mg of zinc has been suggested with the provision that growing children, pregnant and lactating mothers would need more (NRC, 1989). The calcium content of the raw sample of *C. ensiformis* before processing was 131.56 mg/100g. Without soaking, boiling and steaming at normal atmospheric pressure reduced the content of calcium by 19.50 and 25.71%, respectively while boiling and steaming at elevated pressure reduced it by 13.13 and 14.41%, respectively. Hydration of the legume seeds at 10% did not induce much change in the concentration of this mineral compared with the sample processed without soaking.

Iron content of the seeds also experienced leaching after processing. The raw dried seeds contained 10.42 mg/100g of iron. Iron unlike water soluble electrolytes such as potassium is less prone to leaching during thermal processing. When cooking time was short as in the case of boiling at elevated, there was better retention of iron. The iron content of the seeds decreased by 8.82% after boiling at elevated pressure at 100% hydration level. Thus, the seeds were found to be good sources of non-heam iron even after hydrothermal processing. Similar result was obtained when the seeds of *Cassia occidentalis* was processed by boiling. Iron content of *C. occidentalis* seeds which was 59.06 mg/kg decreased by 20.30% after boiling. Iron helps to build up blood cells. For a normal healthy person, daily intake of iron lies between 10 – 18 mg (Robert, 1981).

Table 2 shows the computed mineral weight ratios for the seed of *Canavalia ensiformis.* The Ca/P and Ca/Mg ratios of the raw sample were low compared with those of the processed samples. This could be due to the presence of antinutritional components. Antinutritional components such as phytic acid can form complexes with mineral ions rending them unavailable for absorption (Lopez *et al*., 2002). Each of the hydrothermal processing techniques caused improvement in the values of Ca/P and Ca/Mg. This increase in the weight ratios was probably due to the reduction in the level of phytic acid. As presented in Table 2, the Ca/Mg weight ratio ranged from 1.05 for SEP and 1.51 for BAP. These ratios were generally low when compared with the recommended ratio of 2.2 (NRC, 1989). The raw sample as well as samples processed by the hydrothermal methods have low Ca/P ratio compared with the recommended value of 1.0 (NRC, 1989). Ca/Mg and Ca/P are important in the formation of bones and teeth as well as in controlling the level of Calcium in the blood of animals (Fagbemi, 2007).

Table 2: Computed mineral weight ratios for the seed of *Canavalia ensiformis* at 0% hydration level

Mineral ratio	RS	BAP	SAP	BEP	SEP
K/Na	17.43b±0.24	18.57a±0.04	20.00c±0.18	20.98d±0.02	22.39e±0.01
Ca/P	0.40a±0.03	0.59b±0.01	0.90c±0.00	0.44a±0.06	0.45a±0.07
Ca/Mg	1.13a±0.04	1.51c±0.02	1.29b±0.07	1.06a±0.04	1.05a±0.04
K/[Ca+Mg]	0.70b±0.00	0.62a±0.03	0.69b±0.01	0.71b±0.01	0.72b±0.02

Values with different letters in the same row are significantly different (p<0.05).

Considering the macro nutrients such as potassium, phosphorus, calcium and magnesium, this legume is a good source of these mineral elements in spite of the fact that the hydrothermal processing techniques caused varying degree of leaching. High amount of potassium, calcium and magnesium have been reported to reduce high blood pressure (Ramhotra *et al.*, 1998). Thus, frequent intake of this legume may lower blood pressure significantly. In general, cooking at higher hydration level caused better retention of mineral elements. This was probably due to the fact that the seeds with higher hydration level required less time for cooking. Moreover, the degree of cell wall damage can be assumed to affect the degree of leaching of mineral elements from the seeds during hydrothermal processing. This degree of cell wall damage is time dependent during processing thereby making the sample cooked at relatively shorter time, as in the case of boiling at elevated pressure, have a better retention of nutritionally important mineral elements.

Conclusion

Hydrothermal processing could influence the total content of mineral elements. Although there was leaching of mineral elements during hydrothermal processing, the concentrations of the elements were not degraded beyond the normal requirements necessary to meet physiological and nutritional needs. The concentration of the mineral elements in this legume after hydrothermal processing justifies the need to promote its adoption in human diet to meet up with daily nutritional requirements. Moreover, the traditional practice of throwing away cooking water in some localities should be discouraged for the maximum benefit of the mineral elements. Adaptation of this underutilised legume will widen the scope of consumption and strengthen healthy eating habit thereby making critically important nutrients available for the teeming population in developing countries at affordable prices.

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