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Determination of Levels of Essential and Non-essential Metals and Nutritional Value in Mung Bean Seed (*Vigna radiate* L.) Cultivated in Wolaita Zone, Southern Ethiopia

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ABSTRACT

Background: Mung bean (*Vigna radiate* L.) is an important legume crop grown worldwide from tropical to sub-tropical areas. The experiments were conducted on the mung bean to determine the level of essential and non-essential metals and proximate composition.

Methods: In this study, the levels of selected essential metals and non-essential metal were determined from mung bean (*Vigna radiate* L.) in Kindo Koysha District, Wolaita Zone, Ethiopia. Wet digestion method with a mixture of 6 ml of concentrated HNO_3:$HClO_4$ (5:1 v/v) was used for digestion of the mung bean samples, and a concentrated reagent mixture of 6 mL aqua-regia (3:1 ratio of HCl to HNO_3) and 1.5 mL H_2O_2 was used for digestion of the soil samples.

Result: The results obtained revealed that the concentrations of metals in the mung bean samples in mg/kg dry weight were in the range of Ca (1418.02-1698), Mg (2422-2492.4), Na (88.9-106.7), K (3670-3716.8), Fe (196.2-235.5), Zn (72-103), Mn (51-97.6), Cu (7.8-27.4). The non-essential metal Cr was not detected in mung beans. The proximate composition of mung bean in the range of crude protein (17.86-28.29%), crude fat (1.05-1.49%), ash content (2.9-3.35%) and moisture (5.76-7.57%). Mung bean was found to be an excellent source of essential minerals and protein content and low in fat content.

Key words: Essential metals, Mung bean, Non-essential metals, Proximate composition, Physicochemical properties.

INTRODUCTION

Mung bean belongs to the family Fabaceae, genus *Vigna*, and species *radiata* (Yagoob and Yagoob, (2014). It is used in several ways; seeds, sprouts and young pods are consumed and provide a rich source of amino acids, vitamins and minerals (Somta and Srinives, 2007). The mung bean seed contains 24% protein, 1% fat, 63% carbohydrate and 16% dietary fiber (USDA, 2001). Also, it is an excellent source of vitamins, minerals (Ca, Cu, Fe, Mg, Mn, P, Se, Zn, K) and protein with its essential amino acid profile comparable to that of soybean and kidney bean (Mubarak, 2005). Mung bean has low in calories and rich in fiber, and easily digestible crop without causing flatulence, as happens with many other legumes (Minh, 2014).

In Ethiopia, just as in SSA, approximately 26% of the general population lacks adequate nutrition (FAO, 2014). The Ethiopia Demographic and Health Survey (DHS) in 2005 showed that 47% of children under five in Ethiopia were stunted. Similarly, 27% of all women of childbearing age suffered from chronic energy deficiency. Malnutrition has been a severe obstacle to economic development in Ethiopia. A significant cause is the lack of access to nutritious food products (FDRE, 2008).

Mung beans are a high source of nutrients, including manganese, potassium, magnesium, folate, copper, zinc, and various B vitamins. Because of their high nutrient density, mung beans are considered helpful in defending against several chronic, age-related diseases, including heart disease, cancer, diabetes and obesity (Wongekalak *et al.*, 2011; Gary, 2006).

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Therefore, knowing the essential and non-essential metal contents and nutritional value of these plant seeds is very important to fulfill the dietary requirements and improve individuals' life status and health. However, information on the determination of the essential and non-essential metals and the nutritional value of mung bean seed is scarce in the literature. Thus, the current study aims to determine the essential and non-essential metals and nutritional value in the mung bean, which is grown in the Wolaita Zone, Kindo Koysha districts.

MATERIALS AND METHODS

The study was conducted in the Wolaita Zone, Southern Ethiopia from 2017-2020. The area is located in South Central Ethiopia between 6° 40′-6° 90′N latitude and 37° 40′ 37.80″E longitude.

Mung bean sample collection and preparation

Mung bean seed sample was collected from the Kindo

Koysha district. From four varieties (N-26, NVL, Chinese, and Shewa Robit) 200 g of sample was collected (50 g from each variety). The collected samples were used to determine both proximate composition and level of essential and non-essential metals of a mung bean seed. In both cases, the collected samples were homogenized according to the variety. All collected samples were packed into polyethylene plastic bags, labeled, and transported to the laboratory for further analysis.

Determination of metal levels in the mung bean samples

Wet digestion methods were used for metal analysis. Metals determined by Flame Atomic Absorption Spectrometry (Demirel *et al*., 2008). Standard solutions and working solutions were prepared. Intermediate (10 mg/L) solutions were prepared from the stock solutions of 1000 mg/L in concentration. Then the concentration of Ca, K, Na, Cu, Fe, Mg, Mn, Zn and Cr were determined with FAAS. Three replicate determinations were carried out on each sample. The metal contents of each sample were calculated as (Paulos, 2009):

Determination of the proximate composition in the mung bean sample

The contents of protein was determined according to Wilson *et al.* (2005). The moisture, ash and fat contents were determined using standard proceures as set in AOAC (2000).

Soil sampling and preparation

Composite soil samples were collected and packaged into transparent plastic bags.The collected samples were dried for three days on the air, crushed, and passed through a 2 mm mesh sieve to remove large debris, stones and pebbles.

Determination of physico-chemical properties of soil

Soil reaction and electrical conductivity were determined using a pH meter and conductivity, respectively (Akinola *et al*., 2008). Soil organic carbon and total N contents in the samples were determined by Walkley and Black method (Allison,1973).

Statistical analysis

The determined data were subjected to analysis of variance (ANOVA) using SAS software version 9.1; these were used to determine whether there was a significant concentration difference within mung bean varieties or not (Bereton, 2003).

RESULTS AND DISCUSSION

Distribution pattern of metals in mung bean varieties

The results showed that potassium, which ranged from 3670.72 to 3716.81 mg/kg, was found to be appreciably highest amount. One-way analysis of variance showed that the mean potassium concentration was significantly different among four mung bean varieties ($p<0.001$). The wide variation, potassium bioavailability in mung beans may be due to various genetic factors. From the study, ShewaRobitis the best variety regarding potassium content because potassium plays a vital role in human metabolism, may affect blood pressure, and can be a factor in general heart health (Aslam *et al*., 2005).

Next to potassium, mung bean varieties have high magnesium (2422-2492.4 mg/kg) concentration. The highest concentration of Mg was recorded in Shewa Robit (2492.4±14.5 mg/kg) followed by China (2473±6 mg/kg), N-26 (2440±38.6 mg/kg) and NVL (2422±23 mg/kg), respectively. The mean concentration of magnesium in ShewaRobit was significantly higher than the mean concentration of magnesium in N-26 and NVL ($p<0.001$). However, the mean magnesium concentrations in ShewaRobit and China were not significantly different. The Mg contents were found to be higher than those reported in an earlier study (Mubarak, 2005), in which Mg contents of raw and differently processed mung beans ranged from 440 to 556 mg/kg. According to USDA (2001), the level of Mg in the current study is greater than the critical level of the standard.

As shown in Table 1, the calcium concentration in mung bean seed varieties ranged from 1418.02±17.7 to 1698±43.76 mg/kg. One-way analysis of variance showed that the mean calcium concentration was significantly different among four mung bean varieties ($p<0.001$). Fisher's combined probability test using the LSD criterion for significance indicated that the mean calcium concentration in NVL was significantly higher than the mean calcium concentration in N-26, China and ShewaRobit with $p<0.001$. According to USDA (2001), the level of Ca in the current study is greater

Table 1: The mean concentration of metals within varieties.

Variety	Metals								
	Ca	K	Na	Mg	Fe	Cu	Mn	Zn	Cr
ShewaRobit	1418.02^{c}	3716.8^{a}	88.9^{a}	2492.4^{a}	208.5^{bc}	10.52^{c}	97.6^{a}	99.4^{a}	ND
China	1470^{bc}	3670^{d}	104.6^{a}	2473^{ab}	196.2^{c}	7.8^{c}	51^{c}	82^{a}	ND
N-26	1532^{b}	3706.4^{b}	96.7^{a}	2441^{bc}	235.5^{a}	17.8^{b}	77^{ab}	72^{a}	ND
NVL	1698^{a}	3690^{c}	106.7^{a}	2422^{c}	227^{ab}	27.4^{a}	67.6^{bc}	103^{a}	ND
LSD	79.9	4	22	44.8	24	4.3	20.7	31	ND
CV	2.77	0.062	11.79	0.968	5.93	14.48	15.04	18.54	ND

* Means with the same letter are not significantly different.

LSD = Least significant difference.

CV= Coefficient variance.

than the critical level (132 mg/100 g), indicating that the mung bean is a good source of nutrients. The mung bean variety N-26 (235.5±2.2 mg/kg) was found to be highest in iron content, while a low amount of iron was present in the sample of China (196.2±6.4 mg/kg) variety. The Fe concentration pattern in mung bean seed was in the order of N-26 > NVL > Shewa Robit > China.

One-way analysis of variance showed that the mean concentration of iron was significantly different among four mung bean varieties, $p<0.001$, as shown in Table 1. The mean concentrations of iron in N-26 and NVL were not significantly different. USDA National Nutrient database reported the level of Fe as 6.74 mg/100 g (USDA, 2001); these were lower than the present study result. The permissible limit of Fe set by FAO/WHO in the edible plant was 425.5 mg/kg (FAO/WHO, 2001). Comparing the iron level in this study with the above values, it was lower than the permissible level of iron in edible plants.

The sodium concentration ranged from 88.92 to 106.75 mg/kg in mung bean seeds. The mean sodium concentration was not significantly different among four mung bean varieties ($p>0.001$). USDA National Nutrient database reported the level of Na as 15 mg/100 g (USDA, 2001); these were higher than the present study result.

The highest concentration of Zn was recorded in NVL (103±10 mg/kg) followed by Shewa Robit (99.4±3.2 mg/kg), China (82±8.16 mg/kg) and N-26 (72±30 mg/kg), respectively. One-way analysis of variance showed that the mean zinc concentration was not significantly different among four mung bean varieties, $p<0.001$. Fisher's combined probability test using the LSD criterion for significance indicated that the mean concentration of zinc in all four varieties was not significantly different with $p<0.001$. USDA National Nutrient database reported the level of Zn as 2.68 mg/100 g (USDA, 2001); this was lower than the present study result. The permissible limit of Zn set by FAO/WHO (2001) in the edible plant was 99.4 mg/kg.

The concentration of manganese was found to be higher in ShewaRobit (97.6±18 mg/kg), and its concentration in other varieties was found in order of N-26 (77±10.3 mg/kg), NVL (67.6±1.66 mg/kg) and China (51±7.2 mg/kg) respectively.

The mean manganese concentration was significantly different among four mung bean varieties, $p<0.001$. USDA National Nutrient database reported the level of Mn as 1.035 mg/100g (USDA, 2001); this was lower than the present study result. The permissible limit of Mn set by FAO/WHO (2001) in the edible plant was 500 mg/kg. This amount was higher than those recorded in the present study.

The concentration of copper ranged from 7.8±1.3 to 27.4±2.4 mg/kg in mung bean seeds. The concentration of Cu in mung bean seed was in the order of NVL>N-26> Shewa Robit > China and its mean was significantly different among four mung bean varieties, $p<0.001$. USDA National Nutrient database reported level of Cu was 0.941 ìg/100g (USDA, 2001); these were lower than the present study result. The permissible limit of Cu set by FAO/WHO in the edible plant was 73.3 mg/kg (FAO/WHO, 2001); these were higher than those recorded in the present study.

The proximate composition in the mung bean sample

Crude protein (%)

As shown in Table 2, the average protein contents ranged from 17.86 to 28.29% in different mung bean varieties. Variety NVL exhibited maximum crude protein content (28.29%) followed by N-26 (26.32%), China (24.13%), and ShewaRobit (17.86%).

Crude fat (%)

Crude fat ranged between 1.05% to 1.49 per cent (Table 2). From the varieties, maximum crude fat was found in NVL (1.49%), followed by N-26 (1.28%), ShewaRobit (1.11%), and China (1.05%). Mungbean is not a good source of fat as all the varieties yielded a minimal quantity of crude fat less than 1.5 per cent (Tresina *et al.,* 2010). The mean crude fat content was significantly different among four mung bean varieties, $p<0.001$.

Ash contents (%)

Ash content ranged between (2.9-3.35%). Some researchers like Agugo and Onimawo (2009); Habib *et al.* (2007); Mubarak (2005) and Paul *et al.* (2003) were reported 3.75 to 4% ash content in mung bean, which are relatively higher than those recorded in the present study. However, some

Table 2: Proximate composition (mean S.D.) of mung bean varieties.

Variety	Parameters %			
	Crude protein	Crude fat	Ash	Moisture
ShewaRobit	17.86 ± 0.63^{d}	1.11 ± 0.011^{c}	2.97 ± 0.029^{b}	6.12 ± 0.051^{c}
China	24.13 ± 0.126^{c}	1.05 ± 0.046^{d}	3.35 ± 0.05^{a}	7.57 ± 0.034^{a}
N-26	26.32 ± 0.127^{b}	1.28 ± 0.023^{b}	2.9 ± 0.05^{b}	5.76 ± 0.067^{d}
NVL	28.29 ± 0.253^{a}	1.49 ± 0.006^{a}	2.91 ± 0.029^{b}	7.4 ± 0.034^{b}
LSD	0.660	0.05	0.077	0.091
CV	1.45	2.15	1.34	0.71

Means with the same letter are not significantly different.

LSD = Least significant difference.

CV= Coefficient Variance.

Table 3: The concentration of metals (mg/kg) in mung bean growing soil.

Parameter	Analytical result (mg/kg)	Target range	Interpretation
Ca	2524.44	1000-2000	High
Mg	260.93	120-360	Moderate
Na	32.87	69-161	Low Enough
K	449.24	90-190	High
Fe	241.63	80-300	Moderate
Zn	15.00	1.5-10	High
Cu	1.05	3.0-7.0	Low
Mn	241.68	< 20	High

Table 4: Pearson's correlation between the metals in the mung bean seed of China variety and soil samples.

Difrrent varities	Metals							
of mung bean	Ca	Mg	Na	K	Fe	Zn	Cu	Mn
Shewa robit	0.866	0.679	0.500	0.866	0.838	0.693	-0.866	0.903
China	0.762	-0.101	0.930	0.866	0.822	-0.771	-0.866	0.596
N-26	0.748	0.889	0.866	0.981	0.960	-0.894	0.500	0.277
NVL	0.913	0.852	0.993	-0.327	0.755	-0.941	0.960	0.866

other workers namely Blessing and Gregory (2010); Pasha *et al.* (2011); Shaheen *et al.* (2012) and Tresina *et al.* (2010) reported 3.0, 2.97, 2.91 and 3.12% of ash content, respectively, which were in good agreement to those recorded in the present study while Bhatty *et al.* (2000) reported higher ash contents (4.63 g/100g) in green mung bean. The ash contents in mung bean seed was significantly different in four varieties, p<0.001.

Moisture (%)

The data in Table 2 revealed that moisture contents varied from 5.76 to 7.57% in various varieties. The highest Moisture (7.57 %) was found in China, followed by NVL (7.4%), ShewaRobit (6.12%) and N-26 (5.76%). Khatoon and Prakash (2006) reported the mung bean moisture content of 5.25 to 9.3%, agreeing with those recorded in the present study. The pattern of moisture content in mung bean seed was in the order of China > NVL > Shewa Robit > N-26. One-way analysis of variance showed that the moisture content level was significantly different among four mung bean varieties, p<0.001.

Distribution pattern of metals in mung bean growing soils

The concentrations of soil nutrients are good indicators of soil quality and productivity because of their favorable effects on soil's physical, chemical, and biological properties (Cao, 2011). As shown in Table 3, the concentration of K (449.24 mg/kg), Ca (2524.44 mg/kg), Mg (260.93 mg/kg), Fe (241.63 mg/kg), Mn (241.68 mg/kg), Zn (15.00 mg/kg), Cu (1.05 mg/kg) and Na (32.87 mg/kg). In general, the concentration pattern of metals in soil was found as order Ca > K > Mg > Mn > Fe > Na > Zn.

Comparisons of metal levels between mung bean and soil sample

Plants absorb whatever is present in the soil medium. Therefore, the metals are also absorbed and become bioaccumulated in the plant's roots, stems, fruits, grains, and leaves, which may finally be transferred to human in the food chain. The sorption processes of metals by plants is significantly affected by metal level in the soil, soil pH, the presence of competing ligands, the ionic strength of the soil solution, and the simultaneous presence of competing metals (Zubillaga, 2008).

In this work, a comparative study has been established to correlate the metal level of mung bean with the soil where it has grown. As shown in Table 4, for most elements (K, Mg, Ca, Na, Zn, Fe, Cu,) the metal levels of mung bean were directly proportional to the metal levels of soil where it has grown. This relation partly verifies that the metal content of the plant is a function of the metal level in the soil where it has grown. For the rest metal (Mn), the metal levels in the sampling area of mung bean were varied to metal levels in the corresponding soil. This unproportional variation in the level of metals in mung bean and soil may have resulted from the difference in availability of the absorbable form of metals in soil due to differences in soil acidity or the presence of competing ligands (Snober *et al.*, 2011).

CONCLUSION

The level of metals of mung bean in four varieties were in the order of, K (3670-3716.8 mg/kg) > Mg (2422-2492.4 mg/kg) > Ca (1418.02-1698 mg/kg) > Fe (196-235.5 mg/kg) > Na (88.9-106.7 mg/kg) > Zn (72-103 mg/kg) > Mn (51-97.6 mg/kg) > Cu (7.8-27.4 mg/kg). However, the non-essential metal, Cr, was found to be below the method detection limit in mung bean. The ANOVA results at a 99% confidence level suggested a significant difference between the mean concentrations of all metals. Mungbean is rich in protein content and has a poor range of fat.

The soil collected from mung bean cultivated farmland contains high levels of Ca followed by K, Mg, Mn, Fe, Na, Zn, and Cu. It is recommended that the mung bean, due to its high nutritional value and antioxidant potential, could be used in the daily human diet. Further works should be carried out in the mung bean samples to determine the heavy metals level, and anti-nutritional factors.

Conflict of interest: None.

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