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Comparison and Determination of Selected Essential and Non Essential Metals in the Edible Parts of *Coccinia Abyssinica* and *Plectranthus Edulis* Tuber Crops Cultivated in Abay Chomen District of Oromia Region, Ethiopia

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Abstract – **Coccinia abyssinica and plectranthus edulis are starchy foods widely used in Ethiopia .In the present study the level of selected metals (Mg, K, Ca, Cr, Mn, Ni, Cu, Zn, Cd and Pb,) in coccinia abyssinica and plectranthus edulis sampled from three kebeles of Abay Chomen District, Ethiopia were analyzed. 0.3g powder of coccinia abyssinica and plectranthus edulis samples were digested by Microwave digester using optimized conditions. The contents of the minerals in the digests were analyzed using flame atomic absorption spectrometer (FAAS).The concentration ranges recorded in edible parts of coccinia abyssinica (in mg/kg) were, K (5798.17-5839.55), Mg(1295.5-1305.80), Ca(3155.88-3158.77), Zn(16.67-18.06), Cu(4.23-5.34) and Mn(9.35-11.44) and that of plectranthus edulis were, K(2556.44-2560.04), Mg (332.31-337.43), Ca(280.82-284.92), Zn(12.54-15.62), Cu(4.08-5.29), and Mn(8.77-10.21). The concentrations of Cr, Ni, Pb and Cd in tuber crop samples of all kebeles were found to be below the method detection limit. In coccinia abyssinica, the conetration of K was the highest followed by Ca and Mg while in plectranthus edulis, the concentration of K was the highest followed by Mg and Ca. Among the analyzed trace metals, Zn was found to be highest in both samples. In general, Coccinia abyssinica contained higher concentrations of detected metals compared to that of plectranthus edulis.**

Keywords – **Coccinia Abyssinica, Essential Metals, FAAS, Microwave Digester, Non Essential Metals, Plectranthus Edulis.**

I. Introduction

In many cases, from a livelihoods perspective, root and tuber crops are not minor as they can play important role in livelihood and they are the most important for the world food security. The major tropical root crops of the world are potato (*Solanum tuberosum*), cassava (*Manihot esculenta*), sweet potato (*Ipomoea batatas*), taro (*Colocasia esculenta*), and yams (*Dioscorea rotunda*). The tropical root and tuber crops like *Solanum tuberosum, Manihot esculenta, Ipomoea batatas, Dioscorea rotunda, Colocasia esculenta*, and *Ensete ventricosum* are major sources of food in developing countries with fast population growth and highly urbanization rates (Minaleshewa A., 2007).

Coccinia abyssinica and *plectranthus edulis* are one of the several indigenous tropical root and tuber crops cultivated in Ethiopia (EIAR, 2008). *Coccinia abyssinica* is locally called "anchote" while *plectranthus edulis* is called "Dinicha Oromo" and they have grown principally for their tuberous root (Daba *et al*., 2012). The species recorded in flora of Ethiopia since 1995 and *coccinia abyssinica* is belonging to the *cucurbitaceous* family of best known and *plectranthus edulis* is an ancient Ethiopian tuber crop belongs to *labiatae* family grown in mid and high altitude areas in the south-west of Ethiopia (Mulugeta, 2008 and Allemann *et al*., 2003).


Fig. 1. Tuber crops of coccinia abyssinica


Fig. 2. Tuber crops of plectranthus edulis

Both tuber crops are staple food in the study area, especially in the rainy seasons since the other cereals and legumes are scarce. These tuber crops are also good sources of mineral nutrients for human. For example, they are basic components of human diets (fat, carbohydrate, protein, starch), vitamins (vitamin A, vitamin B_2, vitamin C, thiamin and riboflavin) and good sources of mineral

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nutrients (Nitrogen, sodium, potassium, calcium, magnesium, copper, zinc, phosphorous, and iron) which linked to the maintenance of health for human consumption. Every form of living matter requires these inorganic elements or minerals for their normal life processes (Tamasgen A., 2005 and Ozcan, 2003).

The elements necessary for living organisms can be classified either based on their importance or depending on how they are essential to good health and amount needed by the body. Based on their importance, they can be classified as essential (like K, Mg, Ca, Mn, Fe, Co, Cu, and Zn) and and non essential (like Cd, Pb, As, Cd, Pb, and Hg) (Soetan *et al.*, 2010 and Michael *et al.*, 2009). The essential minerals are also broadly classified as macro (major) or micro (trace) elements. This classification is determined by the amount of the mineral needed by the body, not by how essential it is to good health. The major minerals are required in amounts greater than 100 mg/day and the trace minerals are required in amounts less than 100 mg/day. Many mineral elements occur in living tissues, foods and diets in such small amounts that they are frequently described as traces and mostly essential trace elements are required by man in amounts ranging from 50-20 μg/day (Kathleen *et al*., 2009 and Michael *et al*., 2010).

The major minerals includes Ca, K, Mg, Na, Cl and S while the micro or essential trace elements includes Fe, Cu, Zn Cr, Fe, Co, Cu, Zn, Mo, Mn, F, and I. They occur in physiological concentrations, play key roles in living processes, and either an excess or deficit can disturb biochemical functions in both humans and animals. The trace elements mentioned above are widely found in nature, particularly in various mineral deposits, plants, and soils, meaning that they are available to be taken up by plants and animals that serve as food sources for humans (Soetan *et al.*, 2010 and Michael *et al.*, 2009). But, trace amount of non essential metals can affect adult females' in reproduction, ability to sustain pregnancy and cause pregnancy outcomes. Also they can result in miscarriage, low birth weight and pre-term delivery (Naha and Chowdhury, 2005). Like that of adult females, toxic metals can result in decreased sex drive, impotence, and sterility on adult males. Also they can cause risk of lung, pharynx, stomach, and kidney cancer in diverse populations (Jung M., 2008 and Wong *et al.*, 2008)

Each of these mineral nutrients has their own role for a proper body function and health status (WHO and FAO, 2004). Hence, it is worthwhile to look for the presence of any trace toxic metal in these consumable tuber crops which may affect the metabolic system and enzymatic activity in human being. (Kathleen *et al*., 2009 and Michael *et al*., 2010). So that, to ensure individuals health status, it is necessary to address the levels of essential and non essential metals present in *coccinia abyssinica* and *plectranthus edulis* tuber crops **(**Habtamu *et al.*, 1997 and Yeshitila, 2007).

The aim of this study is to determine the selected essential and non essential metals in the edible part of *coccinia abyssinica* and *plectranthus edulis* tuber crops cultivated in Abay Chomen District. Therefore, the findings of this study would provide adequate information about the distribution of essential and non essential metals in the tuber crops of *coccinia abyssinica* and *plectranthus edulis*. Furthermore, the outcome of this research work would ultimately help to ensure the dietary safety of the individual who use these root crops as source of food.

In general, the main objectives of this study were as follows:

- To determine essential (Mg, K, Ca, Mn, Cr, Ni, Cu, Zn) and non essential (Pb, Cd) metals in *coccinia abyssinica* and *plectranthus edulis* tuber crops using flame atomic absorption spectroscopy (FAAS).
- To compare the concentration of essential (Mg, K, Ca, Mn, Cr, Ni, Cu, Zn) and non essential (Pb, Cd) metals in *coccinia abyssinica* and *plectranthus edulis* tuber crops of different kebeles (Chaneni, Boti and Aleku) of Abay Chomen District.

II. Materials and Methods

Instrument and Apparatus

In this research work; closed microwave digester (Buck Scientific, Model BMS 1: USA) was used for the digestion of *coccinia abyssinica* and *plectranthus edulis* samples. A refrigerator (Hitachi, Japan) was used to keep the digested samples till analysis. All the *coccinia abyssinica* and *plectranthus edulis* samples were weighed on a digital analytical balance (ADAM, Model AFP-110L, England) with 120 g loading capacity and ± 0.0001 precision. Flame atomic absorption spectroscopy (Buck Scientific, Model 210VGP AAS, USA) equipped with deuterium background corrector and air-acetylene flame atomizer was used for determination of the selected metals (Mg, K, Ca, Cr, Mn, Ni, Cu, Zn, Pb and Cd) in *coccinia abyssinica* and *plectranthus edulis* samples. Stainless steel knifes (Germany) were used to cut the *coccinia abyssinica* and *plectranthus edulis* samples in to pieces using nartan plastic kitchenware and households for quick drying. Drying oven (Digit heat, J. P. Selecta, Spain) was used for drying the samples placed on porcelain crucibles. DPA-60K Teflon digestion vessels, measuring cylinders (Duran, Germany), pipettes and micro pipettes (Pyrex, USA), were used for measuring different volumes of sample solution, acid reagents and metal standard solutions. Volumetric flasks (25, 50 and 100 ml) were also used during dilution of sample and preparation of metal standard. Ceramic pestle and mortar were used for grinding and homogenizing the *coccinia abyssinica* and *plectranthus edulis* root samples separately.

Chemicals and Reagents

Analytical reagents like concentrated HNO_3 (69%) and H_2O_2 (30%), were used for digestion of *coccinia abyssinica* and *plectranthus edulis* samples. A solution of lanthanum chloride ($LaCl_3$) was used in the determination of Ca and Mg, during the analysis of *coccinia abyssinica* and *plectranthus edulis* samples to avoid interference (for releasing calcium and magnesium from their phosphates or sulphates). Stock standard solutions containing 1000 mg/L of the metals Mg, K, Ca, Cr, Mn, Ni, Cu, Zn, Pd and Cd from which 10 mg/L of intermediate standard obtained were used for preparation of calibration standards of each metal. Deionized water was used for rinsing apparatus prior to analysis, dilution and preparation of all solutions throughout the experiment.

Description of the sampling area

Abay Chomen District is one of the districts in the Oromia Regions of Ethiopia and located in the North East central part of East Wellega zone with an area of 998.7 km^2. The district experiences a temperate (Dega) type of climate. The capital town of the district is Fincha that is found at 280 km from Addis Ababa and 47 km from Shambu which is a capital city of Horro Guduru Wollega zone. The average annual rainfall of Abay Chomen District is about 1350 mm and the average annual temperature of the district lies between 20 ^{0}C and 22 ^{0}C. The altitude of this district ranges from 1500 to 2,400 meters above sea level. Abay Chomen District is situated at 37^0 38' 10" E longitudes and 9^0 34' 54" N latitude.

III. Sampling and Sample Preparation

Depending on the availability of the tuber crops, representative tuber crops of *coccinia abyssinica* and *plectranthus edulis* were collected from three different kebeles of Abay Chomen District in which people are taking these tuber crops orally as a food of high nutritional value. For the sake of sample being representative, *coccinia abyssinica* and *plectranthus edulis* were collected from Chaneni, Boti, and Aleku kebeles of Abay Chomen District. For each kebele three sampling sites were selected and from each site three tubers of *coccinia abyssinica* and six tubers of *plectranthus edulis* with a total of 27 and 54 tubers were collected respectively for each. After collection, the samples were packed into polyethylene plastic container bags, labeled accordingly and transported to laboratory for further experiment.

Both tubers crops of *coccinia abyssinica* and *plectranthus edulis* were collected and kept at room temperature (25-30°C) for 4 days before sample preparations to minimize infection by microorganisms during storage. Both *coccinia abyssinica* and *plectranthus edulis* tubers were thoroughly washed with tap water to remove all the dust particles and afterwards by de-ionized water to make the tubers free from any ions. Then the cleaned tubers of *coccinia abyssinica* were peeled and *plectranthus edulis* without peeling sliced into small pieces with the help of a sharp stainless steel knife for quick drying. Then the sliced samples were kept in an oven and dried at 70 °C for 24 hours to remove major amount of moisture present. The dried samples were grinded and homogenized by using ceramic pestle and mortar, and sieved using a 0.5 mm sieve. The powdered samples were dried again in an oven at 70 °C for 24 hours to remove all moisture until a constant weight is obtained. Then the dried powdered root samples were kept in polyethylene bags until the analysis.

Finally, 0.3 g of the dried powder of the tuber crops were weighed and digested for 25 minutes followed by the addition of reagent mixture 7 ml HNO_3 (HNO_3 68 %) and 2 ml H_2O_2 (30%) for *coccinia abyssinica* and 5 ml HNO_3 and 4 ml H_2O_2 for *plectranthus edulis* samples. Then, the digested sample solutions were then stored in tightly capped polyethylene bottles and kept in refrigerator for further analysis by atomic absorption spectroscopy.

Digestion of reagent blank was also performed in parallel with the root samples keeping all digestion parameters the same. For the analysis of the root samples six reagent blank samples were prepared for each. All the digested blank samples were stored in refrigerator until analysis. The solutions of the digested blank samples were used to determine the concentration of each element by FAAS.

IV. Instrument Operating Conditions and Calibration

In this study a total of ten metals for each root sample were analyzed using flame atomic absorption spectrophotometer with external calibration curve after the parameters such as burner and lamp alignment, slit width and wavelength adjustment were optimized for maximum signal intensity of the instrument. For each metal, the respective hollow cathode lamp was inserted in to the atomic absorption spectrophotometer, and the solution was successively aspirated into the flame.

Nine elements (Mg, Ca, Cr, Mn, Ni, Cu Zn, Cd and Pb) were analyzed by absorption mode of the instrument and one element (K) was analyzed by emission mode of the instrument. The reason for using emission mode is to avoid ionization interference. Three replicate determinations were carried out for each sample. The same analytical procedure was employed for the determination of elements in a total of twelve digested blank solutions for *coccinia abyssinica* and *plectranthus edulis* samples. The operating conditions of the instrument employed for each analyte are shown in table 1.

Table1: Instrumental operating conditions for determination of selected metals in coccinia abyssinica and plectranthus edulis samples using FAAS.

Elements	Parameters				
	Wave length (nm)	Slit width (nm)	Lamp current (mA)	Energy (eV)	Instrumental detection limit (mg/l)
Mg	285.2	0.7	1.0	3.717	0.001
K	766.5	0.7	2.0	----	0.010
Ca	422.7	0.7	2.0	3.912	0.010
Cr	357.9	0.7	2.0	2.712	0.040
Ni	341.5	0.2	7.0	2.624	0.020
Cu	324.7	0.7	1.5	3.938	0.005
Zn	213.9	0.7	2.0	3.237	0.005
Mn	279.5	0.7	3.0	3.913	0.030
Pb	283.2	0.7	2.0	2.874	0.040
Cd	228.9	0.7	2.0	3.214	0.010

Calibration curves were prepared to determine the concentration of metals in *coccinia abyssinica* and *plectranthus edulis* sample solutions. For the instrument calibration an intermediate standard solutions containing 10 mg/l were prepared in 100 ml volumetric flask from the standard stock solutions that contained 1000 mg/l of each metal. Then the intermediate standards were diluted with deionized water to obtain four working standards of each metal of interest for calibration purpose. Hence, the instrument was calibrated using four working standards. Wavelengths, concentrations of the intermediate standards, working standards and values of correlation coefficient of the calibration graph for each metal are listed in Table 2.

Table 2: Concentrations of working standards and correlation coefficients of the calibration curves for determination of metals using FAAS

Metals	Wavelength (nm)	Concentration of working standards (mg/l)	Correlation Coefficient (R^2)
Mg	285.2	0.01, 0.10, 0.30, 0.50	0.99977
K	766.5	0.05, 1.0, 2.0, 4.0	0.99957
Ca	422.7	0.05, 1.0, 2.0, 4.0	0.99964
Cr	357.9	0.1, 0.5, 1.0, 2.0	0.99969
Ni	341.5	0.06, 0.2, 0.6, 1.0	0.99955
Cu	324.7	0.006, 0.1, 0.3, 0.5	0.99991
Zn	213.9	0.01, 0.1, 1.0, 2.0	0.99997
Mn	279.5	0.03, 0.1, 0.4, 0.8	0.99957
Pb	283.2	0.05, 0.1, 0.2, 0.3	0.99967
Cd	228.9	0.015, 0.04, 0.06, 0.1	0.99997

Method Detection Limit (MDL)

Method detection limit is the minimum concentration of analyte that can be identified, measured and reported with 99 % confidence that the analyte concentration is greater than zero. Method detection limit is mathematically given by, the analyte concentration giving a signal equal to the blank signal, Y_B, plus three times standard deviations of the blank, S_B: ($Y_B + 3S_B$), where Y_B is mean concentration of the blank and S_B is the standard deviation of the blanks (James H. *et al.*, 2005).

In the present study, to know the method detection limit of each metel, six blank samples were digested and analyzed for both *coccinia abyssinica* and *plectranthus edulis* samples. Then the mean concentration of the blank (Y_B) and the standard deviation of the six blank samples (S_B) were calculated for each metal. Finally, the detection limits were obtained by mean concentration of the blank plus three times of the standard deviation of the reagent blank ($Y_B + 3S_B$). As shown in table 3, the method detection limit of each element is above the instrument detection limit.

Table 3: Method detection limit for metals of interest determined in coccinia abyssinica and plectranthus edulis samples

Metals	MDL for *Coccinia abyssinica* (mg/kg)	MDL for *Plectranthus edulis* (mg /kg)	IDL for selected metals (mg/l)
Mg	1.79	4.92	0.001
K	41.56	35.42	0.010
Ca	67.45	61.96	0.010
Cr	0.32	0.33	0.040
Mn	0.29	0.45	0.020
Ni	0.36	0.34	0.005
Cu	0.72	1.88	0.005
Zn	0.22	2.43	0.030
Pb	0.35	0.34	0.040
Cd	0.27	0.32	0.010

MDL = method detection limit, IDL = Instrument Detection Limit

Method Validation

In this study, since certified standard reference materials were not available in the laboratory, the validity of the analytical procedures and efficiency of atomic absorption spectrophotometer used for sample analysis was tested by spiking experiment and calculating the recovery percent. Spiking experiment was done to evaluate or check the validity of the optimized digestion procedure and efficiency of atomic absorption spectrophotometer used for sample analysis. All the spiked samples were digested in triplicate following the optimal digestion procedure developed for *coccinia abyssinica* and *plectranthus edulis* samples. The digested spiked samples were analyzed for their respective metals content using FAAS.

For spiking of *coccinia abyssinica* sample, 0.3 g of the sample powder was taken in to three different flasks. To the first flask, 120 µL of 1000 mg/L of Ca, Mg and K were spiked, in the second flask, 3 µL of 1000 mg/L of Mn, Zn and Cu were spiked, and in the third flask, 0.105 µL of 1000 mg/L of Ni, Cr, Pb, and Cd were spiked. Similarly for spiking of *plectranthus edulis* sample, 0.3 g of the sample poweder was taken in to four different flasks. To the first flask, 120 µL of 1000 mg/L of K was spiked, in the second flask, 18 µL of 1000 mg/L of Mg and Ca were spiked, in the third flask, 3 µL of 1000 mg/L of Mn, Zn and Cu were spiked and in the fourth flask, 0.105 µL of 1000 mg/L of Ni, Cr, Pb, and Cd were spiked. All the spiked samples were digested in triplicate following the optimal digestion procedure developed for *coccinia abyssinica* and *plectranthus edulis* samples and each recovery test for both samples was performed in triplicates.

Data Analysis

In order to test whether there was a significant difference in metal contents between *coccinia abyssinica* and *plectranthus edulis* samples as well as, to compare the mean concentrations of metals in *coccinia abyssinica* and *plectranthus edulis* root crops from the three kebeles, t-test was performed. Analysis of variance (One way ANOVA) was also used to check whether there was a significant difference in metal contents within *coccinia abyssinica* and *plectranthus edulis* samples of the three kebeles. All mathematical and statistical computations were made made on a computer using Excel 2007 and origin 8 software.

Instrument Calibration

The correlation coefficients of the calibration curve for the entire metals were greater than or equal to 0.999 which assured the linearity of instrumental response for individual analytes. The percentage recovery of the analyte was calculated and provided bellow in table 4 and 5.

As shown in the tables, the results of percentage recoveries for the studied metal nutrients in both *coccinia abyssinica* and *plectranthus edulis* samples lies within the range 90 – 105.7 % and 91 - 105 % respectively, which is in the acceptable range (100 ± 10). This confirms that, the laboratory performance for each analyte is in control and the optimized digestion procedure is valid. Therefore, the optimized digestion procedure was valid for both *coccinia* *abyssinica* and *plectranthus edulis* samples and is believed to remove metal fractions associated with organic matter.

Table 4: Recovery test for the optimized procedure of coccinia abyssinica sample

Elements	[a]Conc. in sample (mg/kg)	Amount added (mg/kg)	[a]Conc. in spiked sample (mg/kg)	[b]Recovery (%)
Mg	1300.50±0.02	400	1700.15± 0.1	99.9± 4.5
K	5821.50±0.13	400	6222.9± 0.4	100.4± 8.7
Ca	3157.68±0.16	400	3556.30± 1.09	99.7 ± 10
Cr	0.0057±0.002	0.0035	0.0091± 0.01	97 ± 9.02
Mn	10.28±0.013	10	20.85 ± 0.02	105.7 ± 0.85
Ni	0.0039±0.02	0.0035	0.0072 ± 0.03	94.3± 4.25
Cu	5.37 ± 0.21	10	15.01 ± 0.05	96.4 ± 8.3
Zn	17.41 ± 0.06	10	26.41 ± 0.4	90 ± 5.7
Pb	0.0045 ± 0.01	0.0035	0.00791 ± 0.02	97.4± 4.6
Cd	0.003 ± 0.001	0.0035	0.00668 ± 0.01	105 ± 0.6

Table 5: Recovery test for the optimized procedure of plectranthus edulis sample

Elements	[a]Concentration in sample (mg/kg)	Amount added (mg/kg)	[a]Concentration in spiked sample (mg/kg)	[b]Recovery (%)
Mg	334.77±0.34	60	389.37±0.43	91 ± 5.28
K	2557.18±0.12	400	2952.03 ± 6.6	98.7 ± 6
Ca	282.50±0.18	60	340.16 ± 0.8	96 ± 1.98
Cr	0.004±0.02	0.003	0.00698 ± 0.04	99.3 ± 4.84
Mn	9.57±0.04	10	18.87 ± 0.43	93 ± 5.6
Ni	0.003±0.01	0.003	0.00615 ± 0.03	105 ± 3.28
Cu	4.66±0.01	10	14.32 ± 0.21	96.6± 9
Zn	13.8±0.06	10	24.17 ± 1.41	103.7± 4.8
Pb	0.005±0.02	0.003	0.00805 ± 0.02	101.7± 7.5
Cd	0.004±0.01	0.003	0.00693 ± 0.01	97.7 ± 2.27

[a] Concentration values are average of three analyzed samples ± standard deviation.
[b] Recovery values are mean ± standard deviation.

V. Results and Discussion

In this research work, the concentration of ten metals, essential (Mg, K, Ca, Mn, Cr, Ni, Cu, and Zn) and non-essential (Pb and Cd) in the *coccinia abyssinica* and *plectranthus edulis* tuber crops were determined by FAAS. Among ten elements, six of them (Mg, K, Ca, Mn, Cu, Zn) were found to be above the method detection limit and are detected and four of them (Cr, Ni, Pb and Cd) were found to be below the method detection limit and are not detected in all samples. The absence of Cr, Ni, Pb and Cd may be due the fact that no commercial fertilizers, pesticides and herbicides are used for *coccinia abyssinica* and *plectranthus edulis* plantation in the study area. In addition, it may be due to the absence of industrial activities in the identified kebeles, which can cause environmental pollution. Hence, the concentrations of the toxic heavy metals are expected to be very low in *coccinia abyssinica* and *plectranthus edulis.*

However, Cd and Pb have no nutritional value for our body; their low concentration is preferable concerning the health of human being. The low levels of the toxic metals might be also an evidence for the absence of the use of some commercial fertilizers and herbicides for production of *coccinia abyssinica* and *plectranthus edulis* tuber crops. Generaly, the results showed that the samples had variable composition of each metal with different concentration range per a kebeles. The average concentration values of the identified metals are shown in table 6 and 7 for *coccinia abyssinica* and *plectranthus edulis* respectively. Furthermore, the distribution pattern of the metals in both *coccinia abyssinica* and *plectranthus edulis* root samples is discussed below.

Table 6: Average concentration (mean ± SD mg/kg, n = 3) of metals in coccinia abyssinica samples from the three kebeles.

Metals	Boti	Chaneni	Aleku
	mean ±SD	mean± SD	mean± SD
Mg	1305.80±1.20	1299.14±1.0	1295.50±0.78
K	5832.76±8.84	5839.55±1.06	5798.17±1.04
Ca	3158.40±0.94	3158.77±1.38	3155.88±1.19
Cr	ND	ND	ND
Mn	9.35±0.1	10.05±0.06	11.44±1.16
Ni	ND	ND	ND
Cu	5.34±0.08	6.55±0.11	4.23±0.31
Zn	18.06±1.3	16.67±0.83	17.50±0.83
Pb	ND	ND	ND
Cd	ND	ND	ND

Table 7: Average concentration (mean ± SD mg/kg, n = 3) of metals in plectranthus edulis samples from three kebeles

Metals	Boti	Chaneni	Aleku
	mean ± SD	Mean ± SD	Mean ± SD
Mg	334.57±0.76	337.43±0.49	332.31±0.69
K	2558.06±3.32	2560.04±1.04	2556.44±0.65
Ca	284.92±1.40	281.77±0.45	280.82 ± 0.44
Cr	ND	ND	ND
Mn	8.77±0.92	10.21±0.35	9.72 ± 0.46
Ni	ND	ND	ND
Cu	4.62±0.92	4.08±0.85	5.29 ± 0.42
Zn	15.62±0.63	13.24±1.96	12.54 ± 1.07
Pb	ND	ND	ND
Cd	ND	ND	ND

ND: Not Detected

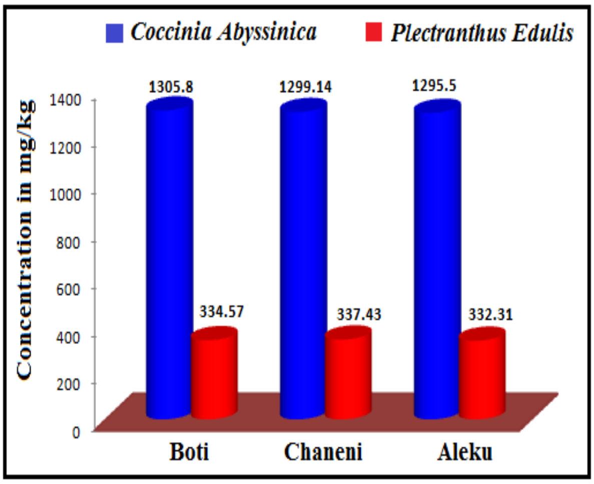
Also in this study, comparative study has been established to correlate the metal levels of *coccinia abyssinica* and *plectranthus edulis*. Both *coccinia abyssinica* and *plectranthus edulis* samples contain highest amount of K, Mg and Ca than Mn, Cu and Zn. But, when the concentration level of the metals in *coccinia abyssinica* is compared with that of in *plectranthus edulis*; except Mn in Chaneni and Cu in Aleku all metals are highly accumulated in *coccinia abyssinica* in all sampling sites.

As can be seen from table 6 and 7, both *coccinia abyssinica* and *plectranthus edulis* samples contain the highest amount of macroelements (K, Mg and Ca) than the microelements (Mn, Cu and Zn). The probable reason for higher accumulation of K, Ca and Mg than Mn, Cu and Zn in both tuber crops may be due to the limited solubility of microelements in soil solution and therefore their uptake by plant was limited. Therefore, microelements in *coccinia abyssinica* and *plectranthus edulis* root crops can be smaller in concentration. Whereas macroelements are highly soluble in soil solution as a result they might be easily taken up by *coccinia abyssinica* and *plectranthus edulis* plants and accumulated in the tuber crops (Jung, 2008).

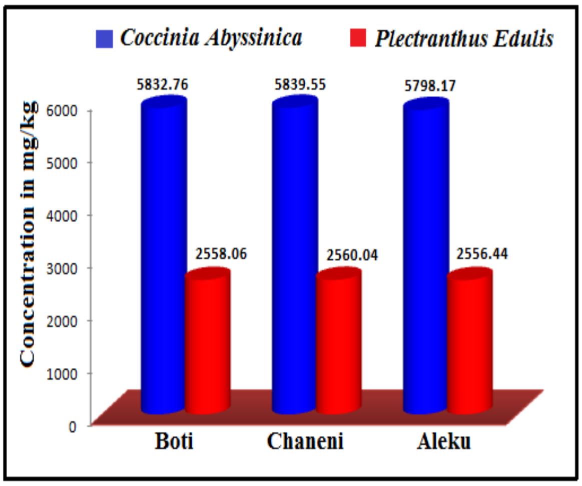
The order of potassium levels in both *coccinia abyssinica* and *plectranthus edulis* samples is: Chaneni > Boti > Aleku. In a similar way, the order of calcium levels in both *coccinia abyssinica* and *plectranthus edulis* samples is: Boti > Chaneni > Aleku.This relation partly verifies that the metal content of the plant may be a function of the metal level in the soil where it has grown. The concentration of the rest four metals (Mg, Mn, Zn and Cu), in *coccinia abyssinica* were varies unproportional to levels of metal in the corresponding *plectranthus edulis* in all sampling areas. For instance, the distribution pattern of Mg followed the trend of Boti > Chaneni > Aleku for *coccinia abyssinica* root sample of three sampling site while the distribution pattern of Mg followed different trend for *plectranthus edulis* as: Chaneni > Boti > Aleku. In a similar manner, the distribution pattern of Mn followed the trend of Aleku > Chaneni > Boti for *coccinia abyssinica* root sample of three sampling site while the distribution pattern of Mn followed different trend for *plectranthus edulis* as: Chaneni > Aleku > Boti.

In general when the concentration of metals in *coccinia abyssinica* is compared with that of in *plectranthus edulis*; there was a large diffirence. Most of the metals are highily accumulated in *coccinia abyssinica* than in *plectranthus edulis* in all sampling sites. While the concentration of Cu and Mn is comparable in *coccinia abyssinica* and *plectranthus edulis* of each single kebele. However, numerically they are different in concentration, t-test was used to check whether their difference was significant or not between *coccinia abyssinica* and *plectranthus edulis* samples of the same kebeles. The statistical t-test result at 95 % (P = 0.05) confidence level reveals that, except for Mn and Cu there was a significant difference in concentration for all metals in *coccinia abyssinica* and *plectranthus edulis* samples from a single kebele.

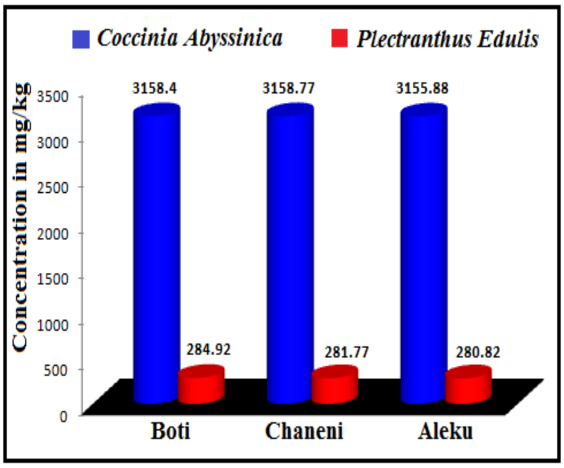
However, the concentration of K, Ca, Mg and Zn in *plectranthus edulis* are not undermined, from this result, it is possible to conclude *coccinia abyssinica* can be used as a good source of these essential mineral nutrients for consumers than that of *plectranthus edulis* . This variation of metal levels in *coccinia abyssinica* and *plectranthus edulis* may be due to the difference in adsorption capacities of these plants. The variation of these nutrients in *coccinia abyssinica* and *plectranthus edulis* within their respective site are shown in fig. 2. The histogram given in this figure is also clearly shows that, among the two samples; *coccinia abyssinica* contains the highest level of Mg, K, Ca and Zn than *plectranthus edulis* sample.



a. Mg in *C. abyssinica* and *P. edulis*



b. K in *C. abyssinica* and *P. edulis*



c. Ca in *coccinia abyssinica* and *P. edulis*

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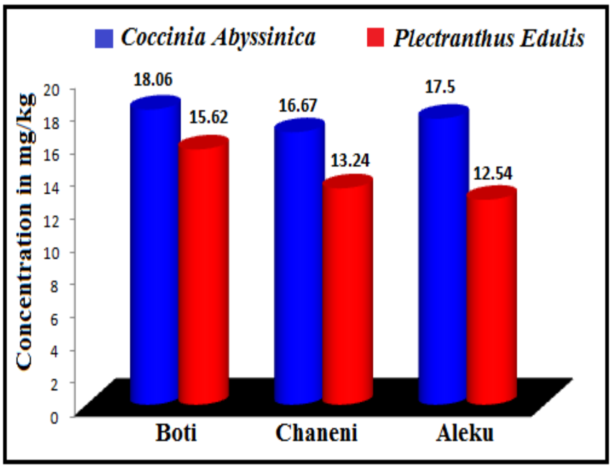

d. Zn in *coccinia abyssinica* and *P. edulis*

Fig.2: Demonistration of comparisons of Mg, K, Ca and Zn between coccinia abyssinica and plectranthus edulis in bar graphs (a,b,c and d respectively).

VI. Conclusionand Recommendation

Conclusions

The present study was conducted to determine the concentration of K, Mg, Ca, Mn, Cu, Zn, Ni, Cr, Cd and Pb in *coccinia abyssinica* and *plectranthus edulis* samples collected from Boti, Chaneni and Aleku kebeles of Abay Chomen District using flame atomic absorption spectroscopy. All *coccinia abyssinica* and *plectranthus edulis* samples of the three kebeles contained higher amount of macroelements than microelements. In *coccinia abyssinica*, K was the most accumulated metal in the samples of three kebeles followed by Ca, Mg, Zn, Mn, and Cu. While, K was the most accumulated metal in the samples of three kebeles followed by Mg, Ca, Zn, Mn, and Cu in *plectranthus edulis*. Among the investigated metals, the trace metals (Cr and Ni) and the toxic heavy metals (Pd and Cd) were not detected in all *coccinia abyssinica* and *plectranthus edulis* samples of the three kebeles. Therefore, the *coccinia abyssinica* and *plectranthus edulis* tuber crops cultivated in Abay chomen district are free of contaminants (not affected by toxic heavy metals like Pb and Cd).

Out of the three study kebeles, the highest concentrations for K, Ca, and Cu, were determined in *coccinia abyssinica* tuber crops of Chaneni kebele. Boti *coccinia abyssinica* tuber crops contain the highest amount of Mg and Zn than the tuber crops from the other two kebeles. In a similar manner the highest concentrations for K, Mg, and Mn were determined in *plectranthus edulis* tuber crops from Chaneni kebele. Boti *plectranthus edulis* tuber crops contain the highest amount of Ca and Zn than the tuber crops from the other two kebeles. On the other hand Aleku *coccinia abyssinica* and *plectranthus edulis* tuber crops contain the highest amount of Mn and Cu respectively than the tuber crops from the other two kebeles.

In general, the levels of essential metals in *coccinia abyssinica* and *plectranthus edulis* tuber crops of this study were more or less consistent with the concentrations of metals reported in literature values for different root crops from different parts of the world.

Concentration of metals in both samples of different kebeles was compared using one way ANOVA and t-test. Hence, as the stastistical results of ANOVA and t-test indicates, there was a significant difference in the levels of most metals in *coccinia abyssinica* samples of different kebeles while, there was no significant difference in the levels of most metals within the of *plectranthus edulis* samples of different kebeles. In addition, the metal concentrations in *coccinia abyssinica* samples of all kebeles were higher than that of in *plectranthus edulis* samples of different kebeles. However, their difference is not significant for all identified metals.

The variation in the levels of Mn and Cu between the two samples may be attributed to the difference in metal concentration in the supportive soil and it may be due to the difference in absorption capacities of the two plants. The probable reasons for the significant difference of the indicated metal concentrations in *coccinia abyssinica* samples of different kebeles may be due to the difference in ages (due to age difference between *coccinia abyssinica* of the three kebeles) and verities of sampled *coccinia abyssinica* tuber crops and also it may be due to the significant difference in mineral composition within soils of each kebele. Also it may be attributed to the difference in soil pH, organic and inorganic matter content of the three kebeles.

Recommendations

The result of this study suggests that *coccinia abyssinica* and *plectranthus edulis* tuber crops of Abay Chomen District contain appreciable amounts of macronutrients and micronutrients. Thus the following recommendations could be made from this study.

The present study would give brief information about some mineral contents of *coccinia abyssinica* and *plectranthus edulis* tuber crops in Abay chomen district. *Coccinia abyssinica* and *plectranthus edulis* tuber crops cultivated in Abay chomen district are free of contaminants (not affected by toxic heavy metals like Pb and Cd). Therefore, more awareness should be made by concerned bodies to increase and spread the recognition throughout the countries.

However, the result obtained from this study is relatively small to draw authoritative conclusion about the mineral contents of *coccinia abyssinica* and *plectranthus edulis*, it will give base line for the researcher who intend to conduct similar research on these tuber crops and good awareness for *coccinia abyssinica* and *plectranthus edulis* users as well for those who intend to use. Therefore, to draw strong and ruling conclusion about the mineral content of *coccinia abyssinica* and *plectranthus edulis*, further investigations are needed on mineral contents of the soils parallel to the tuber crops with different methods.

Moreover, use of representative number of *coccinia abyssinica* and *plectranthus edulis* samples from different geographical sources has not been made so far. Thus, it is recommended to the upcoming researchers to use the results of this research as a stepping ladder for further investigation and more elaborative mineral analysis as well other related factors on *coccinia abyssinica* and *plectranthus edulis* tuber crops.

Finally, the agricultural research centers are supposed to work in collaboration with the societies to improve the availability, production and utilization of *coccinia abyssinica* and *plectranthus edulis* in Ethiopia.

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