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INVESTIGATION OF NUTRITIONAL COMPOSITIONS OF CASSAVA ROOTS OF SELECTED WOREDAS OF JIMMA ZONE, ETHIOPIA

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INVESTIGATION OF NUTRITIONAL COMPOSITIONS OF CASSAVA ROOTS OF SELECTED WOREDAS OF JIMMA ZONE, ETHIOPIA

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Abbreviations / Acronyms

AAS	Atomic absorption spectroscopy
DM	Dry matter
EIAR	Ethiopian Institute of Agricultural Research
FW	Fresh weight
JARC	Jimma Agricultural Research Center
LOD	Limit of Detection
LOQ	Limit of Quantification
LSD	Least Significance Difference
NIRS	Near infrared spectroscopy
RSD	Relative Standard Deviation
SAS	Statistical Analysis Software
SD	Standard Deviation
WHO	World Health Organization

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ABSTRACT

Cassava is a dominant staple food for many developing countries, particularly, in humid and sub-humid tropics. In this study the nutritional composition, mineral, heavy metal and cyanide content of cassava root grown in Jimma Zone, Ethiopia were investigated. Cassava samples were collected from five selected Woredas (Districts) of the Zone, where the plant usually grows. Nutritional compositions such as crude fat, protein and fiber as well as mineral contents were considered in this study. Accordingly, the crude fat, protein and fiber content of the studied cassava root ranging from1.38-3.06%, 1.32-1.90% and 1.58-2.96%, respectively. The concentration of the mineral elements; calcium, magnesium iron, and copper analyzed were ranging from 153-436 ppm, 65-207 ppm, 54.23-427 ppm, and 1.38-7.26 ppm respectively. In addition to the above parameters, the recovery of the mineral and heavy metal determined were between 80.80-120.58%.Wet sample digestion method was used for mineral and heavy metal determination purpose and titration method for cyanide. The results of nutritional composition of analyzed cassava root samples were rich in crude fat, protein, fiber and carbohydrate, as well as in mineral contents. The level of cyanide as compared to the limits set by WHO was low and it may not cause harmful effect on human health.

1. INTRODUCTION

Cassava (*ManihotesculentaCrantz*) is a woody shrub native to South America. The plant is known by its edible starchy tuberous root. It is a drought tolerant, staple food crop grown in tropical and subtropical areas where many people are afflicted to under nutrition, making it a potentially valuable food for developing countries [1].

It is widely used in food security because; its mature edible root can be stored in the ground for up to three years. As a result, it represents a household food bank that can be drawn upon when adverse climatic condition limits the production of other foods. Because of its capability in producing efficient food energy, availability throughout the year, tolerance to extreme stress conditions, and suitability to present farming and food systems in Africa, cassava plays a role to alleviate the African food crisis [2].

Traditionally, cassava roots are processed by various methods into numerous products and utilized in various ways according to local customs and preferences [3]. In some countries, the leaves are consumed as vegetables, and many traditional foods are processed from cassava roots and leaves. It is common to African, as rice to Asian, or wheat and potatoes are to European farmers [3]. These days, it is used as staple food and animal feed in tropical and subtropical Africa, Asia, and Latin America, with an estimated cultivated area greater than 13 million hectares, of which more than 70% is in Africa and Asia [3]. Its mature roots can maintain nutritional value for a long time without water and can grow in areas that receive just 400 mm of average annual rainfall [4, 5].

Cassava is a dicotyledonous plant belonging to the botanical family Euphorbiaceous and has some inherent characteristics which make it attractive to the smallholder farmers [6]. Although its introduction period is not yet known, it is widely grown in south, south west and western part of Ethiopia [7]. Its use as a potential food crop in Ethiopia has been appreciated since 1984 famine [8]. In Ethiopia, cassava is usually consumed by boiling the tuber. Cassava is the third most important source of calories in the tropics and the sixth most important food crop after sugar cane, maize, rice, wheat and potato, in terms of global annual production [9]. Because of its versatile nature, cassava is referred as the drought, war and famine crop to several developing countries. Thus, it is the important crop to improve food security in a time of climate change [10, 11,12]. There are several indigenous cultivated or semi-cultivated root and tuber crops in Ethiopia. These crops have an important place in the diet of the population. Tuberous roots of the plant which can be retrieved from the soil up to three years after maturity. Cassava root is the main consumable part as food product allowing crops to be abandoned during periods of agricultural and social instability. This provides an important form of insurance against social disruption, prolonged droughts, or other periods of stress and unrest. Beside, its production also could not need to use of large amounts of agricultural inputs such as fertilizers, water and pesticides. Cassava is known in Jimma in different names and called as "Muka Furno". For Ethiopians, the consumption of cassava as food is of immense importance and regarded as the food security crop for millions of people. But the nutrient content of cassava roots, which are cultivated in Ethiopia, has not been addressed so far. Currently, some cassava collection, introduction and evaluation productivity works have been initiated by the Ethiopian Institute of Agricultural Research (EIAR) [13]. However, the nutritional composition, mineral and heavy metal as well as cyanide content of the collected and introduced accessions have not been properly evaluated and remains unknown to both consumers and producers. Since the nutritional value of cassava root from different districts of Jimma Zone in location and variety didn't considered; it is necessary to analyze their nutritional values. The present study was, therefore, planned to assess the nutritional composition and level of some selected mineral and heavy metals of cassava in Jimma Zone

1.1 Statement of the Problem

Cassava has nutritional value, drought tolerant crop which can be grown on infertile soils. Its composition depends on the specific tissue and factors, such as geographic location, variety, age of the plant, and environmental conditions. Cassava is the most important tropical root crop and it ranks fourth on the list of major food crops in developing countries, after rice, wheat and maize. It is an important food crop for about 500 million people; in some countries, it provides over 50% of the average daily caloric intake [14]. In Ethiopia, people consume and cultivate the plant without having detailed and enough scientific evidences on the nutritional values of this plant.

Cassava is resistant to the change of weather conditions and can defend itself from pests. Ethiopia is a country in sub-Saharan region and has been facing series problems in food scarcity, because of natural phenomena such as drought, pests and changes of whether conditions. Thus, crops like cassava can tolerate natural disasters are so important to reduce the persisting food scarcity problem of the country. Cassava is one of the crops cultivated in some areas of south west of Ethiopia, including some Woredas of Jimma Zone. Some studies conducted on this region on the cassava's agronomic and genotype part [13]. However, the nutritional composition of cassava crops cultivated in the region has not yet been investigated. Different cassava varieties that are collected and introduced to the area includes Qulle, Hawassa 1, Chichu and Kello as well as many other varieties are also locally cultivated/ grown in the areas of the Zone has not been yet investigated for their nutritional compositions, essential, heavy metal and toxics like cyanide contents. Therefore, in this study the nutritional composition, heavy metals and cyanide content of cassava grown in selected Woredas of Jimma Zone was studied, to provide scientific evidence for the consumers and as a reference for further studies. In addition, the status of some other constituent of the cassava sample which could harm the consumers health (if beyond the limit), like heavy metals and cyanide level was determined.

1.2 OBJECTIVES OF THE STUDY

1.2.1 General objective

The main objectives of this study was to investigate the nutritional, selected heavy metals and cyanide compositions of cassava roots of Jimma Zone, Oromia Regional State, Ethiopia

1.2.2 Specific objectives

- to investigate the moisture, ash, crude (protien, fiber and fat)content of cassava roots varieties cultivated in the selected woreda's of Jimma Zone
- to determine the level of some selected mineral as well as heavy metals in the cassava varieties of the area
- to analyze the level of cyanide in the varieties
- to compare the variation of nutritional, selected heavy metals and cyanide compositions among the cassava varities as well as with standards

1.3 Significance of the study

With increasing impacts of climate change and frequent droughts, cassava, due to its tolerance to drought, is becoming an invaluable famine reserve. Cassava is particularly important for food security since many tropical areas often experience unfavorable environmental conditions and the crop has been found to have an excellent adaptation and growth performance in different agro-ecologies with productivity variation. The study could enable cassava producers and consumers to know the nutritional, selected heavy metals, and cyanide composition of different cassava varieties of the area. It increases the awareness of the consumers to selectively use the cassava varieties that are rich in nutritional composition, in order to maintain and sustain food security. The finding could also be used as the background information by researchers who wants to undergo further research on nutritional composition of the plant.

2. LITERATURE REVIEW

In tropical regions, cassava is the most important root crop as a source of energy for human consumption. It is a major source of carbohydrate for an estimated 500 million people in tropical Africa**.** Cassava is a major staple food in the developing world, providing a basic diet for over half a billion [15, 16]. It is produced at relatively low cost and more frequently than other staples for sale. It is the third largest source of food carbohydrates in the tropics, after rice and maize [17]. Cassava is referred to as a food security crop which can stay for long period of time. Its roots are very rich in starch and contain significant amounts of calcium and phosphorus (40 mg/100g) [18].

Cassava was introduced to Africa by Portuguese traders from Brazil in the 16th century. Maize and cassava are now important staple foods, replacing native African crops [19]. It is attractive as nutrition source in certain ecosystems because cassava is one of the most drought-tolerant crops, can be successfully grown on marginal soils, and gives reasonable yields where many other crops do not grow well.

Cassava plant is hardy and better able to tolerate drought and poor soil conditions than most other food plants. It can grow in extremely poor, acidic soils because it forms a symbiotic association with soil fungi (mycorrhizae). It is also one of the most productive food plants in terms of carbohydrate production per unit of land, and unequalled in its ability to recover when foliage is lost or damaged by diseases or pests.

2.1 Nutritional Value of Cassava Roots

There is much variation in the nutrient quality of the cassava root [20]. Cassava is an important root crop, is a source of energy in tropical regions and has high calorific value compared to most starchy crops [19]. The starch content of the fresh cassava root is about 30%, and gives the highest yield of starch per unit area of land. Tubers are underground plant stems or shoot bearing tiny leaves whose buds are the eye of the tuber. They are valued for their highly nutritious starch content [21].

The level of minerals in cassava root are appreciable and useful in the human diet. Cassava contains appreciable amounts of iron, phosphorus and calcium, and is relatively rich in vitamin C

[22]. The composition of cassava depends on the specific tissue and on several factors, such as geographic location, variety, age of the plant, and environmental conditions. The nutritional value of cassava root is important because they are the main part of the plant consumed in developing countries [23].

Fig.1 cassava root Fig.2 cassava plant

2.2 Crude protein

Cassava contains about 1-2% protein which makes it a predominantly starchy food. The protein content is low at 1% to 3% on a dry matter basis and between 0.4 and 1.5 g/100 g fresh weight [20, 23]. About 50% of the crude protein in the roots consists of whole protein and the other 50% is free amino acids (predominantly glutamic and aspartic acids) and non-protein components such as nitrite, nitrate and cyanogenic compounds. In contrast, maize and sorghum have about 10 g protein/100 g fresh weights [23]. As human food, it has been criticized for its low and poor protein content, but the plant produces more carbohydrate per unit area than other staple food crop under comparable agro-climatic conditions. Protein is key to good health and it is involved in immune function, oxygen transport and maintaining strong muscle tissue. Crude protein is a measure of how much protein is in food, based on laboratory tests studying the food's chemical composition.

2.3 Minerals

Cassava roots have valuable minerals like calcium, iron, potassium, magnesium, copper, zinc, and manganese contents comparable to those of many legumes, with the exception of soybeans.

The calcium content of cassava is high compared to that of other staple root crops and ranges between 15 and 35 mg/100 g edible portion [24].

The mineral contents are lower in cassava roots than in sorghum and maize [24]. These minerals are necessary for proper development, growth and function of human body's tissues. For example, calcium is necessary for strong bones and teeth; iron helps in the formation of two proteins hemoglobin and myoglobin which carry oxygen to your body; and manganese helps in the formation of bones, connective tissue and sex hormones. Potassium is necessary for synthesis of proteins and helps in the breakdown of carbohydrates

2.4 Carbohydrate

Cassava is an energy dense food and therefore ranked high for its calorific value as compared to rice, wheat, maize, sorghum [19]. The root is a physiological energy reserve with high carbohydrate content, which ranges from 32% to 35% on a fresh weight basis, and 80% to 90% on a dry matter basis. Raw cassava root has more carbohydrate than potatoes and less carbohydrate than wheat, rice, yellow corn, and sorghum on a 100 g basis [5, 24].

2.5 Lipid/fat

The lipid content in cassava roots ranges from 0.1% to 0.3% on a fresh weight basis with ranges at 0.1% to 0.4% and 0.65% on a dry weight basis [20, 25, 26]. This content is relatively low compared to maize and sorghum, but higher than potato and comparable to rice. Dietary fiber cannot be digested and absorbed in the human small intestine. Instead, it can be fermented in the large intestine by colon microorganisms to produce short chain fatty acid, which in turn can be absorbed and contributes to human health such as antitumor and anti-inflammation properties. In recent years, diabetes, obesity, and other health issues of human beings increased significantly due to low dietary fiber intake.

2.6 Ash

Ash or mineral content is the portion of the food or any organic material that remains after it is burned at high temperature. The ash constituents include potassium, sodium, calcium and magnesium, which are present in larger amounts as well as smaller quantities of aluminum, iron, copper, manganese or zinc, arsenic, iodine, fluorine and other elements present in traces. Its content represents the total mineral content in foods and is the first step in preparing a food sample for determination of specific elemental analysis. Analytical techniques for providing information about the total mineral content are based on the fact that the minerals (the analyte) can be distinguished from all the other components (the matrix) within a food in some measurable way [27]. The most widely used methods are based on the fact that minerals are not destroyed by heating, and that they have a low volatility compared to other food components. Ash contents of fresh foods rarely exceed 5%, although some processed foods can have ash contents as high as 12% [28].

2.7 Moisture content

Moisture affects the processing, shelf life, usability and quality of many products such as pharmaceutical substances, plastics and foods. Moisture content is one of the most commonly measured properties of food materials. The moisture content is important in food science to determine the quality of food. The texture, taste, appearance and stability of foods depend on the amount of water they contain. Cassava roots and leaves which constitute 50% and 6% of the mature plant, respectively, are the nutritionally valuable parts of the plant [29]. The edible starchy flesh comprises some 80% to 90% total weight of the root with water forming the major components. The water content of cassava ranges from 60.3% to 87.1%, moisture content for cassava flour varies from 9.2% to 12.3% and 11% to 16.5% [20, 25, 30,31]. Water is an important parameter in the storage of cassava flour; very high levels greater than 12% allow for microbial growth and thus low levels are favorable and give relatively longer shelf life [32]. Water is removed from plant tissue to stop enzymatic reactions and to stabilize the sample. Enzymes present in plant tissue become inactive when the plant tissue is dried.

2.8 Cyanide

Cassava (*Manihot Esculenta Crantz*) is cyanide containing food crop used by many indigenous peoples. The exact amount of cyanide in cassava varies and dependent of many factors like plant genetics, plant part, degree of processing, environmental conditions, soil, water, location and season in which the plant grows. Processing situations can alter the cyanide content of this plant, that it is released to the air in the form of gas [33].

Linamarin and Lotustralinis the toxic chemical that contains CN ion attached. Toxic elements which can damage human kidney, liver and brain parts related to pituitary glands are accumulated on peel or surface of the plant [34].

There is a general consensus that crop yields do increase with application of fertilizer, there is debate however on the relationship between addition of fertilizer and cyanide content of cassava.

A food safety problem with cassava is that cassava roots contain considerable quantities of cyanide which occurs in the form of cyanogenic glycosides, primarily linamarin and a small amount of lotaustralin [35]. These cyanogenic glycosides break down to release toxic hydrogen cyanide gas during digestion. The consumption of cassava can therefore be harmful to human health. Despite the presence of these naturally occurring toxins, millions of people all over the world have been safely consuming cassava for hundreds of years. The on-going challenge is to ensure that the presence of these cyanogenic glycosides are minimized through proper understanding and possibly control of factors that affect cyanogenic glycoside content of cassava. Roots and leaves contain the highest amount of linamarin [36].

2.9 Heavy metals

Heavy metals are non-biodegradable and can be accumulated in living tissues, causing various diseases and disorders. Metals such as cadmium, lead and copper are cumulative poisons, which cause environmental hazards and are reported to be exceptionally toxic [37]. Some heavy metals like zinc and Iron play a role in human metabolic activities when consumed at permissible level, but harmful to human health at excessive concentration. They are toxic substances either in elemental form or combined form. Accumulation of heavy metals in crop plants need great concern because of its potential for food contamination through the soil root interface [38]. People may be exposed to small amounts of heavy metals through food, water, air, and commercial products. Each metal is different in where it is found and how it behaves in our bodies. High accumulation of heavy metals in agricultural soils, resulting in elevated heavy metal. Uptake of heavy metals by food crops is of great concern because of potential health risk to the consumer of the food [39].

3. MATERIALS AND METHOD

3.1 Sample Collection Site

Five Woredas of Jimma zone, Mana (1786 m), Sakachekorsa (2107 m), Dedo (2096 m),Sokoru (1620 m), Gomma (1805 m) and JARC (1753 m) were selected purposively. Two varieties were collected from GommaWoreda (white and red), but only the white variety was collected from the other four Woredas. Map of Jimma zone and the areas of sampling sites were displayed in Figure 3 below.

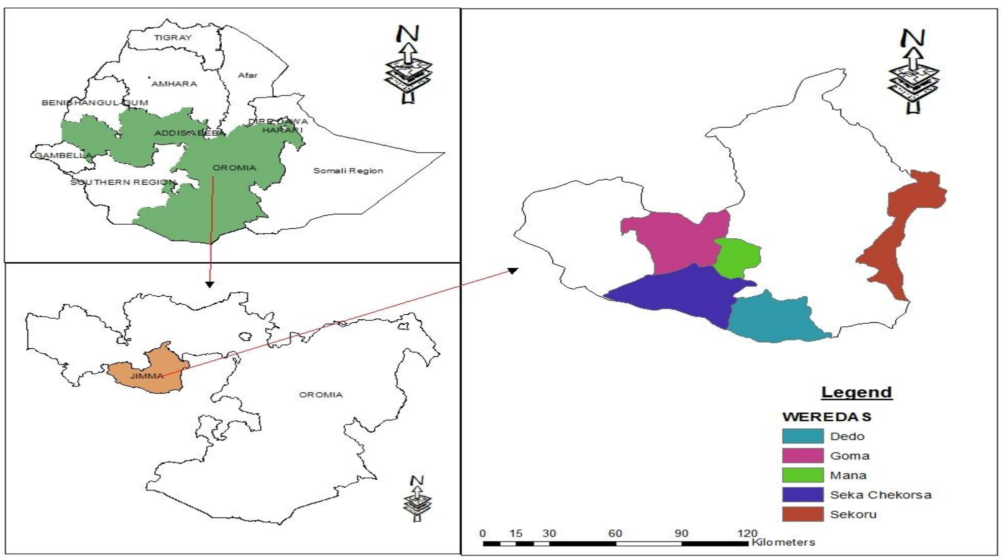


Fig. 3 Map of the sampling area

3.2 Sampling and Sample Pretreatment

Locally grown representative cassava root samples were collected randomly from five selected Woredas of Jimma Zone to determine their nutritional value, to investigate the level of some heavy metals and anti-nutrients. The analysis was conducted by categorizing into two sub-categories; which were collected from the farmer's farm land of different Woredas and the second category was collected from Jimma Agricultural Research Center. All the analyses were conducted in triplicate on cassava root. After collection, the samples were washed with tap water to remove soil and the outer parts of the root were mechanically removed using knife and transported to the laboratory soaked overnight in plastic pot [40] and then, dried at room temperature. The dried samples ground using mortar and pestle. The samples were made ready for analysis in triplicate.

Fig 4.Red cassava Fig 5.White cassava

3.4 Sample Digestion Procedure by wet Method

One (1 g) of powdered sample was weighed into the digestion tube and 2 mL of HNO_3 (69%), 2 mL of $HClO_4$ (70%) and3 mL of H_2O_2 was added using a pipette to each sample. Both the spiked and unspiked sample was digested for 3 hrs on digestion block, colorless aliquot was obtained and the digest was filtered to 50 mL volumetric flask and filled to the mark with distilled water [41]. The blank sample was digested in the same way like the sample.

3.5 Instruments and apparatus

Different equipments such as analytical balance, digestion tube, Atomic Absorption spectroscopy(Agilent 240 Series AA), Near Infrared spectroscopy, furnace (Karl Kolb), drying oven (Memmert),fume hood

3.6 Reagents

Analytical and reagent grade chemicals were used such as H_2SO_4, $HClO_4$ (70%), H_2O_2 (30%), HNO_3 (69%), NaOH, H_3BO_3, methyl orange

3.7 Determination of the crude protein using Kjeldahl method

The method consists of heating a substance with sulphuric acid which decomposes the organic substance by oxidation to liberate the reduced nitrogen as ammonium sulphate [42].

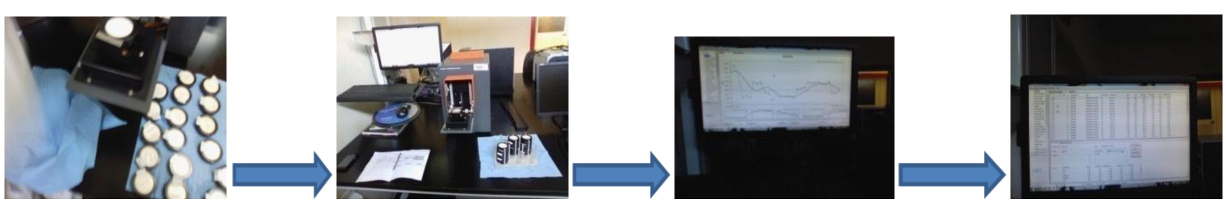
0.5 g of sample was weighed and transferred to digestion tube. 2 mL of H_2SO_4, and selenium was added as a catalyst to the sample and digested for 3 hrs. Acid digest samples were transferred to macro Kjeldahl flask and 20 mL boric acid solution was measured to Erlenmeyer flask and two drops of indicator solution was added and placed under the condenser. 75 mL of NaOH (40%) was poured to the distillation flask containing digests, distillation flask to the holder was fitted and the distillation was started and 80 mL of distillate was collected and the receiver flask was removed. The distillate was titrated against 0.1 N H_2SO_4 and the volume of 0.1 N H_2SO_4 consumed was recorded and %N was determined. Crude protein was calculated from percentage of nitrogen (CP = 6.25*%N), crude protein

3.8 Determination of the moisture

Moisture content is one of the most commonly measured properties of food materials. It was determined by the following procedures [43]. The wet sample was weighed (g) and recorded. Wet sample was dried in dry oven to a constant weight, at 105 ºC and each sample was cooled and the weight (g) was taken, B. The percentage of moisture was calculated

3.9 Determination of crude fat and crude protein by Near Infrared spectroscopy

Dried ground sample loaded to the sample holder was scanned by near infrared spectroscopy. Spectral data of sample was obtained by Near Infrared spectrometer and percent of crude fat and fiber were determine [44]



Loaded sample Scanning spectra Data

3.10 Determination of Ash

2 g of grounded sample was weighed into a porcelain crucible, W_a and the sample was transferred into the muffle furnace set at 550^0C and ashed for 4 hrs. The crucible and its content was weighed after ashing, $W_{b.}$ The percentage ash was calculated [45]

$$\% \text{ ash} = W_b / W_a * 100$$

3.11 Determination of carbohydrate

The total carbohydrate content determined by difference method using the following formula

% carbohydrate = 100 - (ash% + moisture% + crude fat% + crude protein% + Crude fiber %)

3.12 Determination of Cyanide by titration

20 g of grounded cassava root was transferred into a distillation flask and left to stand for 3 hrs. It was then distilled until 150 mL of the distillate was obtained. 20 mL of 0.02 M sodium hydroxide was added to the distillate and the volume completed to 250 mL in a volumetric flask using distilled water. Three aliquots, two of 100 mL each and one of 50 ml were obtained. 8 mL of 6 M ammonium solution and 2 mL of 5% potassium iodide were added to the 100 mL aliquots. This was titrated using 0.02 M silver nitrate and turbid color was developed which indicates the end point. The equation below was used to get HCN in mg. [46]

1 mL of 0.02 M silver nitrate = 1.08 mg HCN according to AOAC (1990).

3.13 Validation of method

Validation of an analytical procedure is the process by which it is established, by laboratory studies, that the performance characteristics of the procedure meet the requirements for the intended analytical applications. The power of detection of any atomic spectrometric method of analysis is conveniently expressed as the lower limit of detection (LOD) of the element of interest. The detection limits were obtained by the mean reagent blank signal (χ_{blank}) plus three times the standard deviations of the mean reagent blank signal (S_{blank}). Analyses of ten blank samples for all metals of interest were performed and the standard deviation of the seven blank reagents was calculated

$LOD = X_{blank} + 3 * S_{blank}$

The lowest concentration level at which the measurement is quantitatively meaningful is called the limit of quantification. In this study, LOQ was obtained from analysis of ten reagent blanks which were digested in the same digestion procedure as the actual samples. It was calculated by multiplying standard deviation of the blank (S_{blank}) by ten plus the mean of the reagent blank (X_{blank}).$LOQ = X_{blank} + 10 * S_{blank}$

3.14 Statistical analysis

The mean, SD, LOD and LOQ was determined (calculated). The mineral, cyanide and heavy metal concentration of each sample was analyzed by using AAS. The result obtained from the instrument was calculated statistically by using SAS software.

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4.RESULTS AND DISCUSSION

Table 1. Useful information for instrumental and method LOD, LOQ, wavelength, slit width

Element	Wavelength, λ nm	Slit width, nm	Instrument, LOD mg/L	Method LOD, mg/L	LOQ, mg/L
Ca	422.7	0.5	0.001	2.275	4.746
Mg	285.2	0.5	0.003	0.755	1.521
Cd	228.0	0.5	0.002	0.017	0.046
Cu	324.8	0.5	0.003	0.004	0.011
Cr	357.9	0.2	0.006	0.007	0.019
Fe	248.3	0.2	0.006	0.910	2.521
Mn	279.5	0.2	0.002	0.085	0.122

Woreda/ variety	Recovery, %				
	Cr	Cu	Fe	Mn	Ca
SK	84.42	95.83	87.20	82.33	108.17
DD	96.42	96.83	86.60	82.00	100.29
HS	96.58	84.33	107.80	106.67	87.26
GMW	101.92	108.17	94.20	87.50	119.35
QL	103.08	101.67	106.10	109.83	104.32
SQ	115.92	109.17	80.80	94.17	83.79
MN	105.58	102.50	101.20	104.83	84.15
GMR	98.58	106.50	115.05	104.33	96.25
CH	120.58	99.00	83.30	97.33	107.07
KL	114.42	82.67	106.30	85.00	84.15

Table 2. Proximate composition of cassava from Mana, Sakachekorsa, Gomma, Sokoru andDedo Woreda

Woerda	Parameters					
	Ash (%)	Crude fiber (%)	Crude Protein (%)	Crude Fat (%)	Moisture (DM) (%)	Carbohydrate (%)
MN	1.17 ± 0.29	1.69 ± 0.06	1.42 ± 0.08	1.68 ± 0.05	1.73 ±0.1	92.32 ±0.33
SQ	4.33 ± 0.76	1.58 ± 0.01	1.32 ± 0.03	1.72 ± 0.03	2.13 ±0.18	89.04 ±0.92
SK	2.17 ± 0.29	2.96 ± 0.09	1.37 ± 0.06	1.38 ± 0.10	1.67 ±0.01	90.47 ±0.15
GMW	2.00 ± 0.82	2.69 ± 0.03	1.43 ± 0.04	2.64 ± 0.05	1.91 ±0.08	89.33 ±1.08
GM R	1.83 ± 0.58	2.63 ± 0.02	1.55 ± 0.03	3.06 ± 0.07	1.80 ±0.01	89.13 ± 0.62
DD	1.33 ± 0.29	1.72 ± 0.03	1.90 ±0.05	1.76 ± 0.02	1.91 ±0.06	91.48 ± 0.32
LSD	1.12	0.08	0.10	0.19	0.24	1.27

Where; LSD- Least Significance Difference; GMW- Gomma white, GMR-Gomma red, SK-Sokoru, DD- Dedo, SQ- Sakachekorsa, MN- Mana. Values are mean ± SD of three individually analyzed triplicates (n=3), (p<0.05).

4.1 Proximate composition of raw cassava flour

The nutritional composition and anti-nutritional factors of cassava raw flour were investigated. Crude Fiber: Fiber is composed of plant based food matter that can't be broken down by the digestive system. Food contain both soluble (dissolves in water) and insoluble (doesn't dissolve in water) fiber. The fiber content of Sokoru and Sakachekorsa Woredas shown highest and lowest value (2.96% and 1.58%) as both samples were white respectively. GMR was higher in the percentage of crude fiber than the GMW collected from the same Woreda. The ash value of the Woreda's cassava was varied from the range of 4.33% to 1.17% Table 2.

Crude Protein: Protein is essential for appropriate growth of body, maintenance and repairs. Comparatively high amount of protein is required growth. In this study there was a significant increase in the potential level in cassava root collected from different Woredas. From Table 2, the protein content of the samples collected from each Woreda was analyzed on the cassava root. The availability of protein in the cassava root ranged from 1.90% to 1.32% and were significantly different. The mean value of protein of Dedo Woreda is higher (1.90%) when compared to other Woreda's mean value of protein. This implies that it consists of higher nitrogenous substances than the others, while the protein content of Sakachekorsa sample is smaller than all of the others, this indicates its nitrogenous substances content is lower. The mean values indicated that the protein content (%) of Mana and Sokoru Woreda has no difference statistically.

Ash: Ash content is an indication of the mineral composition of any sample, which implies that as the ash content of a sample raises up in proportional way the mineral content increases. The ash mean value of the Woreda sample was in the range of 4.33% to 1.33%. In this study, Sakachekorsa Woreda had the highest, at least twice of the others ash content as compared to other samples collected from Sokoru, Mana, dedo and Gomma. Consuming cassava collected from Sakachekorsa for food purpose gives lowest proximate values than consuming cassava flour collected from other Woreda's included in this study except ash. The ash constituents include calcium, iron and magnesium, which are present in larger amounts as well as smaller quantities of copper, manganese, chromium or cadmium and other elements present in traces.

Moisture: Moisture is an essential parameter in life maintenance and its analysis is widely used in food processing. It can also affect the processibility, shelf life, usability and quality of food and other products. In this study, the moisture level was found in the range of 2.13 % to 1.67 %. Raw cassava flour obtained from Sakachekorsa Woreda contains highest moisture content than other samples taken from other all Woredas. Sokoru samples of cassava flour showed that its moisture level is the least of all other Woredas included in this study. Moisture content of flour is very important regarding its shelf life, lower the flour moisture, the better its storage stability. Moisture content of the food material is important to consider the food is suitable before the consumption, because moisture content affects the physical, chemical aspects of food which relates with the freshness and stability for the storage of the food for a long period of time and the moisture content determine the actual quality of the food before consumption and to the subsequent processing in the food sector by the food producers. Moisture rich foods are easily susceptible to the microbial attack and got rotted and damaged. Thus the shelf life of the food material is determined by the moisture content in the food. Low moisture containing foods usually slow down growth of microorganisms hence the need for analysis and control of food moisture. As reported [47,48] values of moisture indicated that the moisture content of cassava root in Jimma is lower comparatively to the other countries moisture level and this indicates that the cassava varieties found in Jimma are less perishable and can stay for long period of time and it is also less susceptible to microorganism reproduction.

Crude fat: In this study, there was high variation in crude fat content between the collected from different Woredas Table 2. The range of variation in this parameters were from 3.06 % to 1.38%. The cassava root sample collected from Gomma Woreda is highest of all others, while the sample from Sokoru Woreda contained lowest percentage of crude fat than all the other Woredas. This difference could be contributed due to the environmental condition or geographical location.

Carbohydrate: Carbohydrates are the main source of energy for our body. The mean values indicated in Table 2 shows that there were significance difference among the Woreda cassava root in their carbohydrate content in the same column. Sample collected from Mana Woreda were highest (92.32%) in their carbohydrate contents as compared to other Woredas, while Sakachekorsa cassava root was the least (89.04%) in carbohydrate content. Gomma of white variety cassava root was higher (89.33%) in its carbohydrate content than that of the red variety from the same Woreda (89.13%). The carbohydrate content ranged from 92.32% to 89.04% as indicated in the Table 2 above. The output of this investigation implies that the carbohydrate content of cassava from Jimma were higher than other cassava in their carbohydrate content. Thus consuming cassava that were grown in Jimma are more valuable than others indicated in different studies, as it stores more carbohydrate as well gives more energy [48].

Table3. Proximate composition of Cassava flour of different Varieties of JARC

Variety	Moisture % (FW)	Moisture %(DM)	Ash (%)	Crude Protein %	Crude Fat (%)	Crude Fiber (%)	Carbohydrate (%)
CH	32.93 ± 3.20	0.91 ± 0.31	2.00 ± 0.50	1.52 ± 0.08	2.13 ± 0.03	2.23 ± 0.01	91.58 ±0.61
HS	39.01 ± 1.98	1.55 ± 0.01	1.33 ± 0.29	1.50 ± 0.04	1.72 ± 0.08	2.69 ± 0.03	91.28 ±0.33
QL	42.21± 2.56	1.67 ± 0.10	1.17 ± 0.29	1.16 ± 0.05	2.17 ± 0.03	2.45 ± 0.07	91.09 ±0.17
KL	33.25 ± 1.38	1.85 ± 0.40	1.17 ± 0.09	1.38 ± 0.12	2.35 ± 0.07	2.24 ± 0.08	90.87 ±0.35
LSD		0.76	0.74	0.17	0.13	0.14	0.70

Where; LSD- Least Significance Difference; CH- Chichu, KL- kello, QL- Qulle, HS-Hawassa 1; Values are mean ± SD of three individually analyzed triplicates, (p<0.05).

Evaluation of Proximate composition of food has its own contribution both for the consumers and producers. From Table 3, the moisture (DM) content of the varieties of the cassava root was ranged from 1.85% - 0.91%. Kello variety in moisture level was the highest of all other varieties, but Chichu had the lowest moisture. Both Qulle and Hawassa 1 varieties moisture content level didn't show any significance difference.

High fiber containing diet has an essential value in reducing obesity, diabetes and heart diseases [49]. The crude fiber level of the varieties analyzed were ranged from 2.69% - 2.23% Table 3. Hawassa 1 variety contained highest fiber than other varieties and it is so useful to consume and produce this variety to be cured from the above listed diseases. Chichu and Kello contains the same percentage of crude fiber. The protein content in Hawassa 1, Kello and Chich was significantly not different (p<0.05), but it was smaller in Qulle variety. Fats are vital to the structure and biological function of body cells and are used as an option for energy source [50]. Crude fat varied in content significantly from 2.35% in Kello variety to 1.72% Hawassa 1 variety. It was significantly greater in Kello (2.35%) than any other varieties included in this study. The ash or mineral content of cassava varied (p< 0.05) significantly among the four varieties and it was greater in Chichu (2.00%) and lower in both Kello and Qulle (1.17%) varieties incorporated in this investigation Table 2. The carbohydrate content varies from 91.58% -90.87% as shown in Table 3. Carbohydrates are the body's main source of energy. They are easily digested and broken down into glucose, which the body uses to perform its numerous functions. Cassava root, since it contains high carbohydrate, and carbohydrate is easy to break down to glucose than protein and fat and used by our body for tissue it is so helpful to consume it after proper processing.

Results obtained from different variety data were significantly different (p<0.05) as analyzed by SAS software. This variation of the result recorded could be due the environmental condition, topography and cassava planting time.

Table 4. Concentration (ppm) of heavy metals analyzed samples from Woreda and JARC

Woreda	Parameters (ppm)						
	Ca	Mg	Cr	Cd	Cu	Fe	Mn
GMR	157.78 ± 3.32	204.82 ± 5.82	6.61 ± 1.24	ND	3.27 ± 0.51	97.55 ± 1.48	18.53 ± 1.41
SK	327.13 ± 1.93	195.29 ± 8.70	18.39 ± 1.62	ND	6.70 ± 0.56	81.16 ± 2.73	11.83 ± 1.13
DD	436.03 ± 3.74	136.99 ± 5.23	17.37 ± 2.43	ND	5.38 ± 5.38	91.90 ± 1.04	21.28 ± 1.48
SQ	153.51 ± 6.69	97.20 ± 4.41	8.64 ± 0.34	ND	4.70 ± 0.88	75.23 ± 4.89	15.50 ± 2.86
GMW	316.68 ± 4.96	92.62 ± 1.65	18.04 ± 1.27	ND	6.17 ± 0.81	84.61 ± 3.21	16.55 ± 1.23
MN	373.88 ± 3.74	61.27 ± 1.46	5.02 ± 0.44	ND	1.70 ± 0.56	54.23 ± 1.45	5.22 ± 0.80
LSD	6.55	7.93	2.75		1.28	4.89	2.54

Variety	Parameters (ppm)						
	Ca	Mg	Cr	Cd	Cu	Fe	Mn
CH	161.94 ± 3.90	130.20 ± 3.90	9.67 ± 0.61	ND	4.10 ± 1.00	86.60 ± 3.47	13.92 ± 2.33
KL	157.18 ± 3.86	65.85 ± 4.13	7.89 ± 0.70	ND	3.93 ± 1.06	69.78 ± 4.00	10.60 ± 1.32
QL	372.04 ± 7.32	207.94 ± 3.58	23.97 ± 2.19	ND	6.22 ± 0.46	127.03 ± 3.71	21.17 ± 1.37
HS	425.39 ± 6.08	102.34 ± 4.41	23.70 ± 1.72	ND	7.23 ± 1.38	75.26 ± 3.35	15.20 ± 2.77
LSD	12.65	7.99	2.74		2.31	8.28	3.83

Where; LSD- Least Significance Difference; GMW- Gomma white, SK- Sokoru, DD- Dedo, SQ- Sakachekorsa, MN- Mana, CH- Chichu, KL- kello, QL- Qulle, HS-Hawassa 1. Values are mean ± SD of three individually analyzed triplicates, (n=3) (*p*<0.05).

Heavy metals and mineral composition of foods is an immense interest because of its considerable essential or toxic nature. Uptake of heavy metals in staple food could be from soil, atmosphere or water. Unlike organic wastes, heavy metals are non-biodegradable and can stay for long period of time in living tissues, causing various diseases and disorders. Metals like cadmium and copper are cumulative poisons, which cause environmental hazards and are reported to be exceptionally toxic [50]. The evaluation of minerals in cassava is an important exercise from nutritional to the toxicological point of view. This is because some metals have long term effects on human health when accumulated in target organs. The higher Ca, Mg, Cr, Cu, Fe and Mn contents in the cassava varieties was comparable with the study of [50]. Metal deficiency syndrome like rickets and calcification of bones is caused by calcium deficiency. Magnesium deficiency in man is responsible for severe diarrhea, migranes, hypertension, cardiomyopathy, arteriosclerosis and stroke. According to Reddy and Love, copper is needed for growth, production of bones, teeth, hair, blood, nerves, skin, vitamins and hormones. In this study the mineral, essential and toxic metal concentration were determined by atomic absorption spectroscopy in mg/L.

Calcium: From the results obtained for Ca in this study, the cassava varieties of Chichu and Kello sample are not significantly different ($p<0.05$). But the results of Ca concentration in Qulle, Hawassa 1 and Kello were significantly different ($p<0.05$) as obtained from the Table 4, HS has high concentration of Ca than any other varieties included in this study. Availability of Ca in the selected varieties is in the order of 425.39 > 372.04 > 161.94 > 157.18 ppm for HS, QL, CH and KL respectively. The concentration of calcium in cassava root collected from different Woredas were in the order of 436.03 > 373.88 > 327.13 > 316.68 > 157.78 > 153.51 ppm for DD, MN, SK, GMW, GMR and SQ respectively. From the given values of Woreda sample, there was significance difference.

Magnesium: The levels of Magnesium for samples obtained from Woreda and the varieties of present study were 204.82-61.27 and 207.94-130.20 ppm respectively. The levels of Mg concentration in varieties in present study were significantly different ($p<0.05$) as indicated in Table 4 above. Similarly, the results obtained from the Woreda data were also significantly different ($p<0.05$) as analyzed by SAS software. This variation of the result recorded could be due the environmental condition, topography and cassava planting time.

Chromium: Chromium is used in the leather tanning industry, the manufacturing of catalyst, pigment and paints, fungicides, the ceramics and glass industries. As shown in Table 4, the level of Cr concentration in Woreda sample varied from 5.02-18.39 ppm were observed in MN and SK Woreda respectively. The levels of Cr concentration in present study were ranged from 7.89-23.97 ppm in the varieties of KL and QL respectively. The concentration of Cr was found at higher level in the released varieties (23.97 ppm) than the Woreda samples (18.39 ppm), this could be because of many daily activities that are done in the center (JARC). As observed in Table 4 above, the mean values in the same column followed by the same superscript letters in each varieties were not significantly different ($p<0.05$) as seen individually. The Cr concentration content of cassava samples greatly varied among the different Woreda's in the study area.

Cadmium: Cadmium occurs naturally in Zn, Pb, Cu and other ores which act as source to ground and surface waters. In this study Cd was not detected, because, it was below the detection limit of the instrumental

Copper: High concentration of Cu causes metal fumes fever, hair and skin decolorations, dermatitis, respiratory tract diseases, and some other fatal diseases in human beings (Khan *et al*., 2008). The level of cupper concentration in Woreda’s were ranged from 1.70-6.70 ppm in MN and SK Woreda respectively. While the copper concentration in the released varieties varied from 3.93-7.23ppm KL and HS variety's respectively. The Cu concentration is relatively high (7.23 ppm) in the sample collected from JARC than the Woreda samples (6.70 ppm), this could be due to the routine activities made daily in the center. As indicated in the Table 4 above, the mean values with the same column followed by the same letters are not significantly different ($p<0.05$). The copper concentration from Woreda’s result was higher than the concentration of copper from the varieties in this study. As reported by [51], the concentration of copper in the cassava root was 3.84 mg/kg, but in this study the maximum concentration of copper in cassava root from Woreda (6.70 ppm) and the released varieties (7.23 ppm) was higher than the reported value. This may be due to environmental and topography of the area. Cu is essential element and is required for hemoglobin synthesis and in the catalysis of metabolic growth. The highest concentration of Cu determined in all the cassava root samples was 7.23 mg/Kg which is far below the 40 mg/Kg limit that has been set by WHO (WHO 1982) as limit of Cu in foods[52].Statistically, there was significant differences in the concentration of Cu in cassava root which are grown in selected Woreda of Jimma Zone

Iron: Fe is essential in the body and its benefit is carrying oxygen to human blood cells. About two-thirds of the body iron is found in hemoglobin. The benefit of iron corresponds to proper growth of human body and maintaining robust health, also to produce red blood cells. But in very high amount, it causes vomiting, abdominal pain and liver enlargement. The distributions of Fe concentration in cassava flour obtained from Woreda's sample were ranged from 54.23-97.55 ppm in MN and GMR respectively. While the concentrations of Fe in the varieties study were ranged from 69.78-127.03 ppm in the varieties of KL and QL respectively. According to [50], the availability of iron in cassava is (29.908 mg/kg), lower than the results found in this study. As showed in Table 4 above, the mean values of the iron concentration between the sampling site from Woreda's and varieties study were significantly different ($p<0.05$).Fe is also essential metal for the body but excess intake may lead to colorectal cancer [53]. The concentration of Fe determined in cassava root were above the 15 mg/Kg limit set by WHO as limit of Fe in Foods (WHO 1982). All the cassava root samples analyzed for iron were found to exceed acceptable limit at very high concentrations for samples from each location. The benefit of iron correspond to proper growth of human body and maintaining robust health also to produce red blood cells but in very high amount causes vomiting, abdominal pain and liver enlargement.

Manganese: The levels of Manganese element for samples obtained from Woreda and different varieties collected from JARC in this study were 5.22-21.28 ppm in MN and DD Woreda's and 10.60-21.17 ppm in KL and QL variety's respectively. Results showed that the levels of this metal in cassava root were found to be relatively high when compared with values obtained from the Woreda's results. The levels of Mn concentration in different variety's study were significantly different ($p<0.05$) as indicated in Table 3 aboveexcept QL varieties which was significantly different from the other results. Similarly the results obtained from the Woreda data were also significantly different ($p<0.05$) as analyzed by SAS software. This variation of the result recorded were could be due to the environmental condition, topology and amount of fertilizer applied during cassava planting time. The SAS result shows that, the mean values in the same rows followed by the same superscript letters are not significantly different ($p<0.05$) as seen individually. The prolonged consumption of unsafe concentrations of heavy metals through foodstuffs may lead to the chronic accumulation of heavy metals in the kidney and liver of humans causing disruption of numerous biochemical processes, leading to cardiovascular, nervous, kidney and bone diseases (WHO, 1992). The analysis of cassava root has revealed that the presence of poisonous metals such as chromium and manganese. Excessive intake of metals like iron can could result in complications ranging from gastro-intestine irritation, vomiting to tissue damages and skin pigmentation while the excessive intake of manganese can cause diseases of brain and nervous system, muscular rigidity and slow, imprecise movement[54].Metals and other elements can be naturally present in food or can enter food as a result of human activities such as industrial and agricultural processes. The metals of particular concern in relation to harmful effects on health are manganese, chromium and cadmium. The toxicity of these metals is in part due to the fact that they accumulate in biological tissues, a process known as bioaccumulation. This process of bioaccumulation of metals occurs in all living organisms as a result of exposure to metals in food and the environment. So the presence of these heavy metals in cassava root could be due to the absorbance of the metals through their root from the soil, water and agricultural activities that are done daily and human being can uptake these metals while consuming the plant.

Table 5. Concentration of cyanide in cassava flour in edible portion and the internal (non-edible) portion of different Woredas

Woreda	Cyanide in edible portion, mg/L	Cyanide in non-edible portion, mg/L
MN	2.16 ± 0.04	0.55±0.04
SQ	3.83 ± 0.03	0.45 ± 0.03
GMR	1.15 ± 0.04	0.39 ±0.04
GMW	1.33 ± 0.1	0.53 ± 0.05
SK	3.13 ±0.03	0.42 ± 0.03
DD	0.91± 0.08	0.63 ± 0.07
LSD	0.16	0.08

Table 6 Concentration of cyanide in raw cassava flour in edible portion and the internal (non-edible) portion of different the released varieties, JARC

Variety	Cyanide in edible portion, mg/L	Cyanide in non-edible portion, mg/L
KL	5.02 ± 0.10	0.59 ± 0.07
CH	0.83 ± 0.04	0.34 ± 0.04
QL	1.87 ± 0.14	0.63 ± 0.03
HS	0.83 ± 0.05	0.43 ± 0.05
LSD	0.13	0.09

The concentration of cyanide in edible portion of the cassava root was ranged from 3.13-0.91 mg/L, as indicated in Table 5.The result of cyanide found in cassava root which was analyzed showed that, the level of its toxicity in Woreda samples was higher in Sakachekorsa (3.13 mg/L) and lower in Dedo Woreda (0.91 mg/L). The concentration of this anti-nutrient could be reduced while processing such as grinding, soaking and drying. In this study, there was significant difference in the level of cyanide between each sample collected from different Woredasas the mean values were indicatedin Table 4.Results revealed that the higher in Sakachekorsa, Sokoru, Mana, Gomma white, Gomma red, and Dedo (3.83 > 3.13 > 2.16 > 1.33 > 1.15 >0.91mg/L) respectively. The level of cyanide in the non-edible portion of cassava root treated in this study differs significantly. When compared, the edible and non-edible portion, the concentration of cyanide is higher in the edible part than non-edible. For example, in edible portion the cyanide concentration in Sakachekorsa Woreda was 3.83mg/L, but from the same Woreda the concentration of cyanide in non-edible was 0.55mg/L. This implies that the cyanide concentration increases from the internal part to the outer part [55].

From Table 6 above, the cyanide concentration was by far highest in the Kello variety (5.02mg/L) and lowest in both Hawassa 1 and Chichu (0.83 mg/L) varieties. This cyanide variation could be because the presence of difference between the varieties. Even though the cyanide concentration in the indicated variety was highest, it is not above the permissible limit set by WHO. Compared to[56],(15.4-7.92 ppm),results reported from Nigeria, the level of cyanide determined in this study was by far lower. The statistical values indicated that there was a significance difference ($p<0.05$) in the level of cyanide concentration among the varieties investigated in this study. Different countries have different safe levels of cyanide, for example the acceptable limit in Indonesia is 40 ppm, but WHO has set safe level of cyanide to 10 ppm [40]. From this study the level of cyanide in the released varieties and samples collected from different Woredas as compared to WHO (< 10 mg/kg) is at safe level if consumed.

4.2 Conclusions

Cassava root has a major potential as a substitute for other types of flour or it can be used by mixing it with other flours. Its unique adaptivity to different ecological conditions gave it the most important famine crop reserve. Cassava flour has considerable values in terms of its proximate composition and mineral elements which are related to human health and food. From the selected cassava samples used in this study it is possible to conclude the following:

a) The protein, fiber, fat and carbohydrate percentage is higher in Woreda samples than the samples collected from Jimma agricultural research center. The consumption of these woreda samples could provide relatively more benefits than the Jimma agricultural research center samples.
b) The mean concentration of metals like iron and chromium which could cause health problem at excessive level to the consumers was higher than the reported values. These heavy metals sometimes are accumulated in the cassava through the soil.
c) Cassava root contains some essential minerals for our body like Ca, Mg and Fe. The presence of Fe in low concentration plays a vital role in body.
d) The low concentration of cyanide in all these samples which are below the WHO permissible limit could make these samples to be consumed safely for its benefit for our body by processing it properly.
e) Although it is below the permissible limit set by WHO, cassava roots collected from Jimma Agricultural Research Center contains more cyanide than the Woreda samples.

4.3 Recommendations

Cassava roots are widely used for food security and it represents a basic diet of about 500 million people in the World. But in Ethiopia, till now there was no enough information regarding its proximate composition, mineral content and heavy metal level. Since Jimma agricultural research center has been performing research on the productivity of these varieties than the nutrient composition, it is advisable to concentrate on the quality beside the productivity of these varieties. Since this study was performed on the cassava root and the result was obtained without incorporating the soil result, it is better to analyze this plant by including the soil result to see its effect at the same time. In addition, as the government has given a great concern to this crop it is better to work further investigation on cassava to sustain food scarcity.

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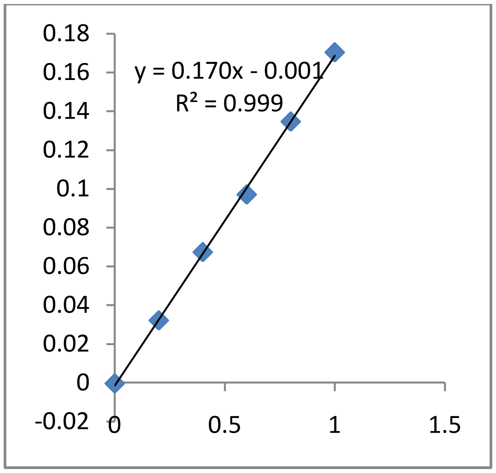
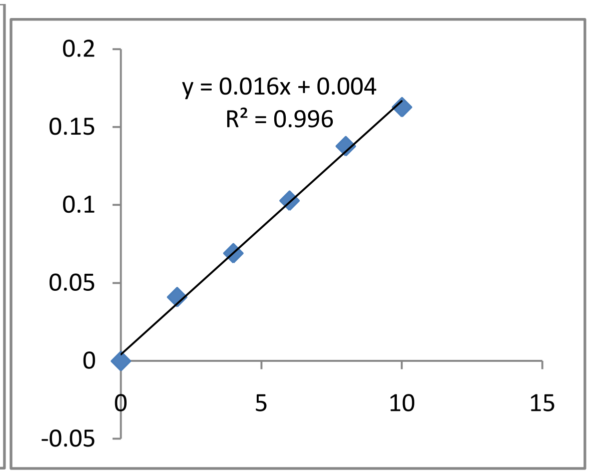
APPENDIX

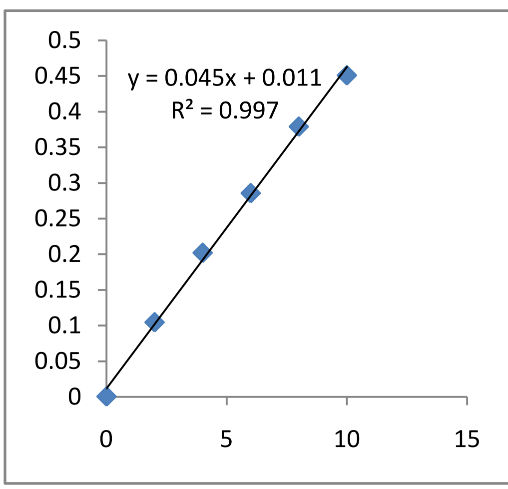
Analytical performance study



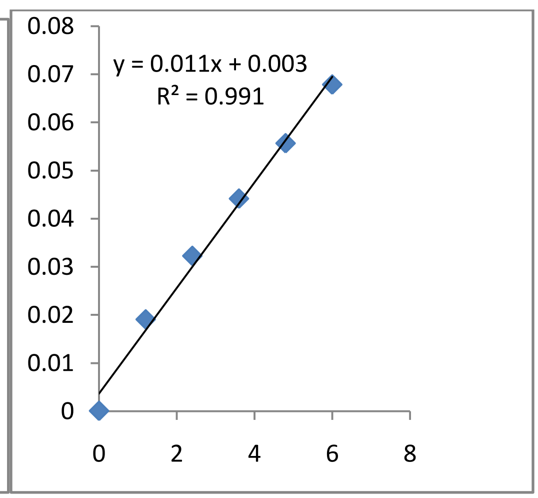
Mg cal. curve



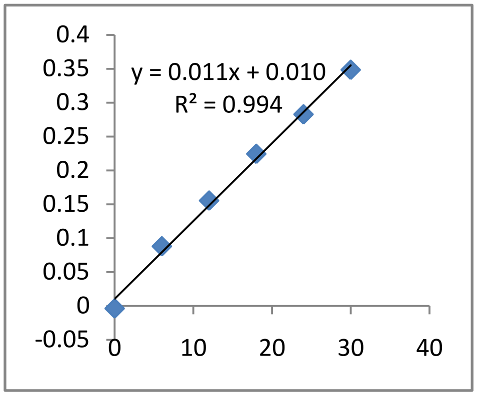
Mn cal. curve

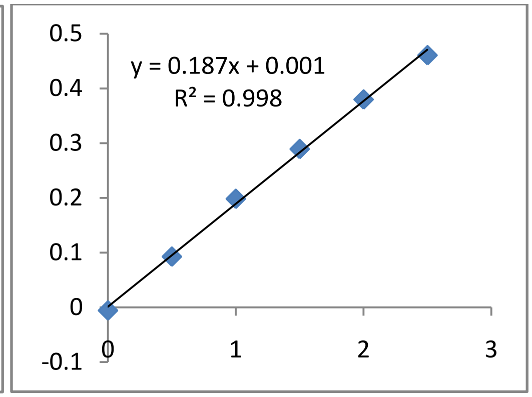


Cu cal. curve



Ca cal. curve





Fe cal. curve

Cd cal. curve