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Determination of Cyanide Concentration Levels in Different Cassava Varieties in Selected Iodine Deficiency Disordered (IDD) Areas of Wolaita Zone, Southern Ethiopia

Fekadu Muleta[*1] Abedelfeta Mohammed[2]
Collage of Natural and Computational Science, Department of chemistry, Wolaita Sodo University, PO. Box 138, Ethiopia

The research is financed by Wolaita Sodo University, PO. Box 138, Sodo, Ethiopia

Abstract
Cassava (Manihot esculenta Crantz) is a cyanogenic plant which is toxic when consumed without sufficient processing. Cassava is characterized by presence of linamarin a cyanogenic glycoside and when acted upon by an enzyme linamarase is hydrolysed into cyanohydrin which is further hydrolyzed to give hydrogen cyanide (HCN) which is toxic. This study aimed at determination of the levels of cyanide in the sweet cassava variety grown in different geographical regions of Wolaita zone namely Offa, Kindo koysha and Kindo didaye woredas. The picrate paper method and UV-Visible Spectrophotometric Determination Procedure were used. The study also reports on variation of cyanide concentration within varieties and its concentration in different parts of cassava root. The concentration of cyanide varied significantly ($p<0.05$), with the geographical location. The concentration of cyanide in cassava from Kindo koysha was highest (66±3.5 mg/kg), while cassava from Kindo didaye had the lowest cyanide concentration (29.35± 3.7 mg/kg), While the cyanide concentration in cassava from Offa was 47.725± 4.21 mg/kg. Three parts of cassava root (Pith,Cortex and Parechyma) contained significantly different concentrations of cyanide; 49.24±3.12, 81.23±2.84, 68.45±2.2mg/kg respectively. The concentrations of cyanide in cassava from all the study sites were higher than the recommended level by WHO (10mg of HCN/kg body weight). The median urinary iodine concentration (38.27µg/L) was also found in study site confirms that the area is moderately affected by iodine deficiency. This study provides critical information on the potential toxicity of cyanide in cassava from the three woredas of Wolaita zone.
Keywords: cassava; cyanide; picrate method; Kello; Qulle

1. Introduction

Cassava (Manihot esculenta Crantz) is an extensively cultivated tuber crop and a staple food for millions of people in the tropical regions of Africa, Latin America and Asia (Atehnkeng, *et. al.,* 2006, Nhassico, *et. al.,* 2008). Cassava is popular because it is easy to grow, yields well in good conditions and even in poor soils subject to dry conditions it still produces edible roots and leaves (Nwabueze and Odunsi, 2007). There are a number of varieties of cassava „sweet cassava‟ and „bitter cassava‟. The term "bitter" cassava, as opposed to "sweet" cassava, refers to the taste of the root parenchyma. Bitterness is associated with higher levels of cyanogenic glucosides (Cock, 1985). Certain ecological stress factors, such as pest attacks, prolonged drought and low phosphorus and potassium levels in the soil may cause roots to acquire bitterness, and this coincides with an increase in the levels of cyanogenic glucosides (Ayanru and Sharma, 1984el-). Bitter cassava varieties are more drought resistant and thus more readily available and cheaper (Akintonwa and Tunwashe, 1992).

Abuye, Berhane, and Ersumo (2008) assessed iodine deficiency disorder and related diet in five regions of Ethiopia (Amhara, Oromiya, Tigray, SNNP and Benishangul-Gumuz). In the two regions SNNP and Benishangul-Gumuz, which are cultivators and consumers of cassava, cassava consumption was significantly associated with total goiter rates in both children and their mothers. In these two regions in last thirty years cassava consumption has been increasing with concomitant increase in goiter rate and other associated health problems with even observation of acute cyanide intoxication of children.

In order to prevent cyanide poisoning, medium and high cyanide cassava roots require some form of processing before they are eaten. Consumption of cassava or cassava products that contain large amounts of cyanogens may cause cyanide poisoning with symptoms of vomiting, nausea, dizziness, stomach pains, weakness, headache, diarrhoea and occasionally death (Duffus and Worth, 2006). Large cyanide intake is considered to be the cause of konzo in Eastern, Central and Southern Africa (Bradburry et. al., 2011, Mlling et. al., 2011, Ngudi, 2005).

The crop was introduced to Ethiopia in the 19th century. The ones identified as the bitter cultivars by locals had been introduced first, and then followed by the sweet cultivars, having high and low cyanide contents, respectively. It is known by a variety of local names like ‘’Mita Boye‟,’’Yenchet Boye‟, ‘’Furno Tree‟ and ‘’Mogo‟ in the southern parts of Ethiopia, where it is dominantly grown and utilized. It is primarily grown and used as food crop for about a century in southern and south-western parts of Ethiopia (Dejene, 2006). The population of the south western part of Ethiopia has the dietary habit of consuming tubers and roots, unlike other

parts of the country where cereals and legumes are the main staple foods. Although not given a priority, cassava is being produced and becoming a staple food for people in the study areas. Cassava is consumed mainly in boiled form and for making bread. It is a staple in diets of Konso people (Konso district, SNNPRS), especially for "Cheqa" (non-distilled local beverage which can be made in alcoholic or non-alcoholic form) preparation. Other areas like in Amaro Woreda, Benishangul Gumuz and Gamo Gofa, cassava cultivation is progressively increasing. (Kebede and Wondimu, 2012).

The Wolaita zone is one of among the highly consumer and producer of cassava as food source in SNNP region. Unfortunately, the area which are almost known for their production of cassava, there is high prevalence of goiter and other iodine deficiency disorder (IDD). Despite the recognition of the problem in the areas, an iodine deficiency controlling program was never officially implemented and no survey has been conducted on the status of iodine deficiency in cassava consumers of Wolaita zone. Studies confirmed that the cyanide in cassava has a contribution for the IDD (Harbor and Ogunda, 2009, Chandra, *et. al*., 2008). Hence the present study was conducted in order to assess the toxic cyanide concentration level in different cassava varieties which are used as food source and to aware its toxicity for the society.

1.1. Significance of the study

The information obtained in this study on, concentration of cyanide in cassava will be crucial for awareness campaigns to its users. Further, such information will be important for extension services geared towards training of farmers and consumers by agricultural officers and other regulatory bodies, to aware its toxicity for the society.

1.2. Objectives

1.2.1. General objectives

- To determine the concentration of cyanide in cassava varieties grown in different areas of Wolaita Zone.

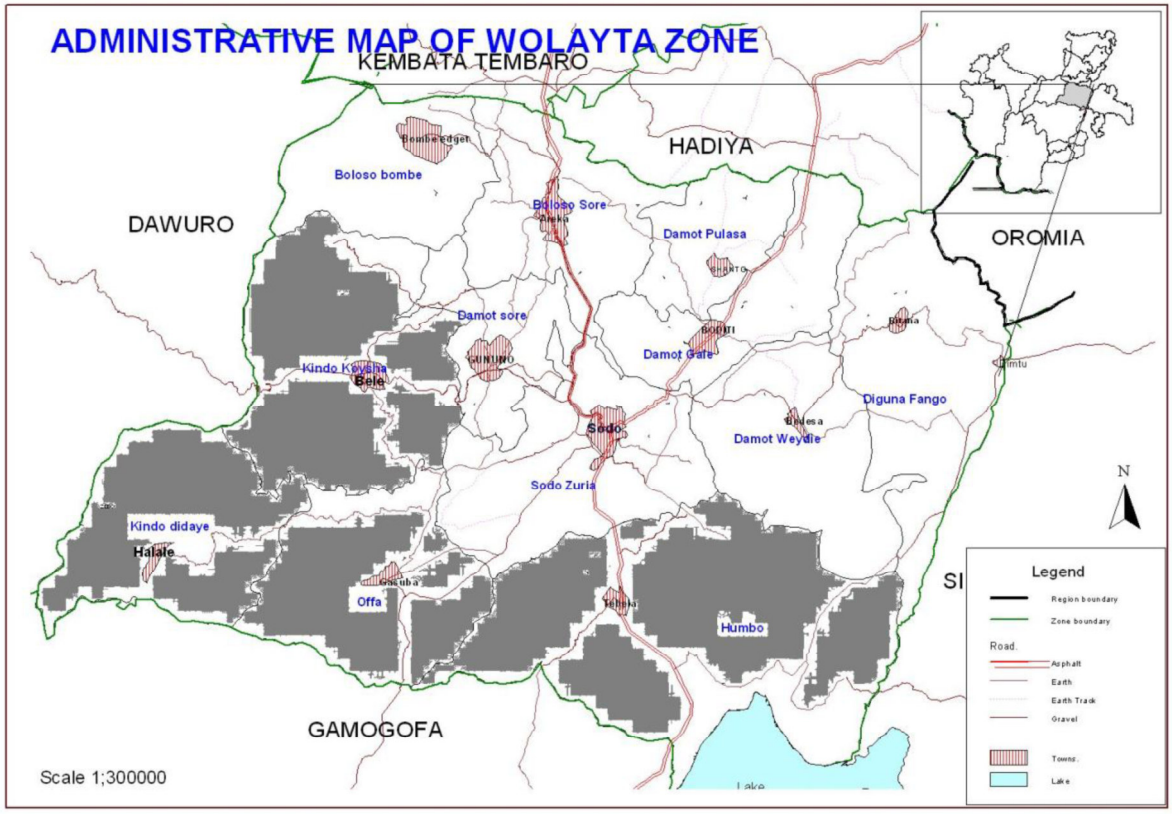
1.2.2. Specific objectives

- To determine the concentration of cyanide in different cassava varieties.
- To compare the concentration of cyanide in peel, cortex and parenchyma of the cassava root.
- To assess the contribution of poisoned cassava consumption to goiter prevalence.
- To determine median urinary iodine excretion in samples of population.
- To aware the toxic level of different cassava varieties for the community.
- To select the best variety for the community to cultivate.

2. Methodology of the study

2.1. Study Area

This research was under taken in SNNRP region Wolaita zone selected woredas. Considering the amount of cultivation of cassava and the high rate of IDD three Woredas, Kindo Koysha, Kindo Didaye and Ofa are selected as areas of focus from the twelve woredas of Wolaita Zone. The sites selected for cassava root collection, based on high production and high rate of IDD are Anaze, Sorto and Bele in Kindo Koysha; Zaro, Bereda and Poteta in Kindo Didaye; Busha, Galda and Sere Esho in Ofa. Each of the Woreda and Kebele from other areas were selected from 12 Wereda purposely based on the amount of cultivation of cassava and the severity of the problem (the cyanide and iodine) by consulting the zone agricultural and rural development department and zone health departments in Wolaita zone.



F.g. 1. Administrative Map of Wolaita Zone, with shaded study area. (Source: Wolaita Zone Finance Economy and Development Bureau). Shaded region: study site.

2.2 Chemicals and Apparatuses`

i) Chemicals and Apparatuses for cyanide determinations

Digital UV-Vis spectrophotometer -371 (a single beam, Range 190 To 1000 nm; µg Based Wavelength Selection; 4 Digit LED Display for Wavelength; 3 ½ Digit LED Display for Data; 4 Position Sample Holder) is used for absorbance measurement. Analytical balance is also used to weigh the sample. Deep freeze refrigerator (-18^{0}C) is used to store picrate papers and the 50 ppm standard linamarin, because, yellow picrate paper darkens when left at room temperature for over a month (Bradbury, *et. al*., 1999). Digital Analytical balance Model ESJ200-4 for mass measurement was employed. Drying oven is used to dry test tubes. Glass cuvette, Stainless steel knife and Teflon chopping board is used for cutting the tubers. Plastic balance, bottles and glass test tubes were also used. Homogenizer is used to form fine powders of cassava flour followed by sieving. Distilled water is used to rinse apparatuses and glassware and throughout the experiment.

ii) Chemicals and Apparatuses for UI determination

Iodine concentration in urine samples was determined using Sandell-Kolthoff Reaction in which urine was digested first with ammonium persulphate (Bradbury, *et. al*., 1999).The concentration of iodine was determined from its catalytic reduction of ceric ammonium sulphate in the presence of arsenious acid. A spectrophotometer (Uv-Vis) was used to examine the reduction of ceric ammonium sulphate (yellow).

2.3. Sampling Method

A. Sampling method for cassava samples

Based on the information obtained from Agricultural bureaus cassava samples were collected from the selected sites in each Woredas, three farm plots are chosen to collect cassava root samples. Fresh cassava roots are collected from the farm fields by digging with auger with laborers or the owners of the farms. Healthy matured cassava plant about 1 kg from each site is chosen and collected from the farm plot. The cassava plant age ranges from one to three years. The collected cassava root is placed in plastic bag, transported to the laboratory immediately for further processing.

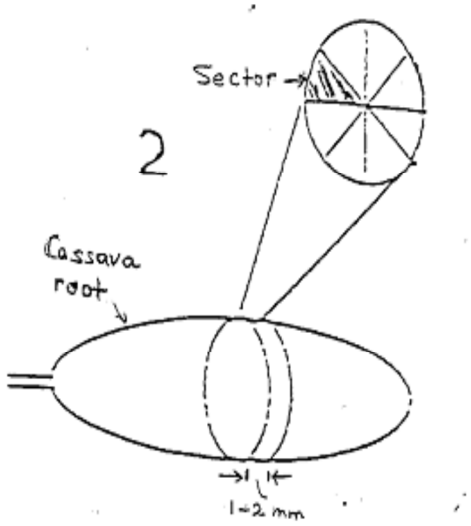
B. Sampling method for UI determination

The urine samples were collected from the three woredas which is selected purposefully due to high cultivation of cassava and also suspected visible goiter. The urine samples were collected from health centers and hospitals of the three woredas randomly. From the total patients come to the health center and hospitals, 90 of them were

selected for the study and the urine samples were collected and sent to the Ethiopian Nutrition and Health Research Institute laboratory.

C. Sample Preparation of Cassava Root

The fresh cassava root is processed according to protocol A of Cyanide analysis methods (Bradbury *et. al*., 1999). The tubers are separated into outer peels, inner peels and raw pulp with stainless knife. A 1-2 mm thick cross section of the clean cassava root is cut across the middle of the root (Figure 2). The peel is removed and a sector is cut and its weight adjusted to 100 mg by cutting off small pieces along the straight edge of the sector and weighing on the small balance supplied with the kit or analytical balance in the laboratory. (Bradbury, *et. al*., 1999).



F.g.2. Sketch for Cutting of Cassava Root for Analysis. (Source: Bradbury, et. al., 1999)

2.4. Method of Cyanide Determination

For total cyanide determination in cassava root protocol A is followed using kit A according to method developed in Australia National University by Bradburry, M. J. Bradbury H. J. and Egan S. V. (Bradbury*, et. al.,* 1999). Also for flour sample analysis, developed by Bradbury H. J. and his coworkers is used. The procedures are described below. All measurements absorbance are made at 510 nm wavelength. (Cardoso, et*. al*., 1998).

2.4.1 Picrate Paper Preparation

A round paper disc containing buffer at pH 6 is placed in a flat-bottomed plastic bottle and a 100 mg sector of cassava root loaded on top of it. A 0.5 ml of clean distilled is added using the plastic pipette to which yellow picrate paper attached to a plastic strip is added immediately and the bottle closed with screw capped lid. Standard pink linamarin paper corresponding to 50 ppm total cyanide is also used in parallel to check the method. For standard solution, a round paper disc containing buffer and enzyme is placed in another the bottle. A pink standard linamarin paper is added and then 0.5 ml distilled water from a pipette is followed. The bottle is also immediately closed with the screw capped lid. Blank sample is prepared similarly except in that no cassava root is present. The bottles are allowed to stand for 16-24 hour at room temperature.

The color of the picrate papers is read off matched against the shades of colour of the colour chart supplied with the kit for approximate level of cyanide. Similarly the picrate paper from the blank and standard are checked to be close to zero and 50 ppm, respectively. However in the lab further analysis is carried out with UV-Visible spectrophotometry as follows.

2.4.2 UV-Visible Spectrophotometric Determination Procedure

The plastic backing sheet is carefully removed from the picrate paper. The picrate paper is place in a test tube and 5.0 ml of water measured with a pipette is added. Then the test tube is left at room temperature for about 30 min with occasional gentle stirring. The blank and standard picrate soultions are also prepared similarly. The absorbance of the solutions is measured with UV-Vis spectrophotometer pouring the solution to quartz cuvette. The absorbance is measure at wavelength of 510 nm for picrate solution from cassava against the blank and also checking the standard solution. The total cyanide is obtained by multiplying absorbance with 396. Finally the result from the reading is compared with the previous one obtained by matching with color chart.

2.5. Methods in UI determination

The three most popular methods for urinary iodine measurement are ammonium persulfate digestion with spectrophotometric detection of the Sandell-Kolthoff (SK) reaction; modified microplate method for the determination of urinary iodine concentration; and ICP-MS.

The first method is based on the spectrophotometric determination of the SK reaction. With the introduction of ammonium persulphate as the oxidizing agent to replace hazardous chloric acid, during the digestion step, most laboratories to use the safer persulfate digestion method. The colorimetric measurement of the SK reaction with microplate applications, either with mild chloric acid or ammonium persulphate, has demonstrated good performance characteristics, or has resulted in the production of comparatively less toxic waste from arsenic trioxide (0.4 mL per test versus 5.0 mL per test).

The second alternative, the microplate method, can be slightly modified to suit laboratory infrastructure by using a heating block instead of the cassette. Advantages of this modification include an even distribution of heat in the heating block; a more representative urine sample (250 µL) used for digestion; a high volume of samples analyzed; and the opportunity to repeat the SK reaction, if necessary, on the same day. Additionally, the modified microplate method showed good agreement with the Technician autoanalyser method. A comparison between the microplate method, the conventional chloric acid digestion method, and the ICP-MS method yields good correlation coefficients.

2.6. Method Validation

During each analysis, a blank solutions and standard solutions are prepared as a method checking method. The 50ppm standards provided with the kit used are analyzed in similar manner and yields a concentration range between 40 – 60 ppm, which is recommended region (Bradnbury, *et. al*., 1999). Besides, relative standard deviations calculated are also all below 10%, which is usually acceptable error range.

3. Data collection, organization and analysis

3.1. Data collection methods

3.1. a. Data collection method of cassava samples

Traditionally processed from volunteer individual households & fresh cassava samples were collected from the farm fields in the selected Kebele and tested for amount of cyanide presence.

Structured questionnaires and interviews were used to assess the effect of cyanide in cassava to the effect of goiter prevalence and secondary data to gather information on history of cassava introduction, meal preparation, consumption and cyanide removal techniques. Secondary data were also collected from district agricultural and health offices. In each district representative communities were selected based on intensity of cassava production and consumption.

3.1. b. Data collection method of UI determination

Thirty urine samples were randomly selected from the health centers for urinary iodine excretion test from each woredas. These peoples were provided with screw cap plastic bottles and a casual (morning) (5ml) urine sample was collected under the supervision of the health workers. Samples were put in an ice-packed cool box and transported to the Ethiopian Nutrition and Health Research Institute Laboratory for measurement. Iodine concentration in urine samples was determined using Sandell-Kolthoff Reaction in which urine was digested first with ammonium persulphate [28, 27]. The concentration of iodine was determined from its catalytic reduction of ceric ammonium sulphate in the presence of arsenious acid. A spectrophotometer (Uv-Vis) was used to examine the reduction of ceric ammonium sulphate (yellow). The disappearance of the yellow color is proportional to the amount of iodine present in the sample. A standard iodine solution was used in order to extrapolate the concentrations of iodine.

After determination, the concentration of iodine was recorded in micrograms of iodine per liter of urine and classified according to IDD status.

3.2. Data organization and analysis

The data from the experiment in laboratory and the collected questionnaires were analyzed and with appropriate statistical methods like SPSS. ANOVA were also used to assess relation between cyanide level, consumption and overload. It also checked the effect of cyanide over load to iodine deficiency disorder.

3.3 Ethical approval:

The study was approved by the Review Committee of Wolaita Sodo University, and written consent was obtained from college of natural science. Permission for collecting urine and cassava sample was obtained from the communities through the health directorate and parent committee prior to the survey. People who declined participation were substituted by other selected randomly from the sample frame.

4. Result and Discussion

4.1 Determination of cyanide concentration in cassava using the methods

Cyanide levels for cassava root samples were determined using the picrate paper method. The mean total cyanide in fresh cassava root samples collected from the sites are presented in mg HCN equivalents/kg of fresh cassava

weight in the tables. For the flour samples, the unit per dry weight is expressed.

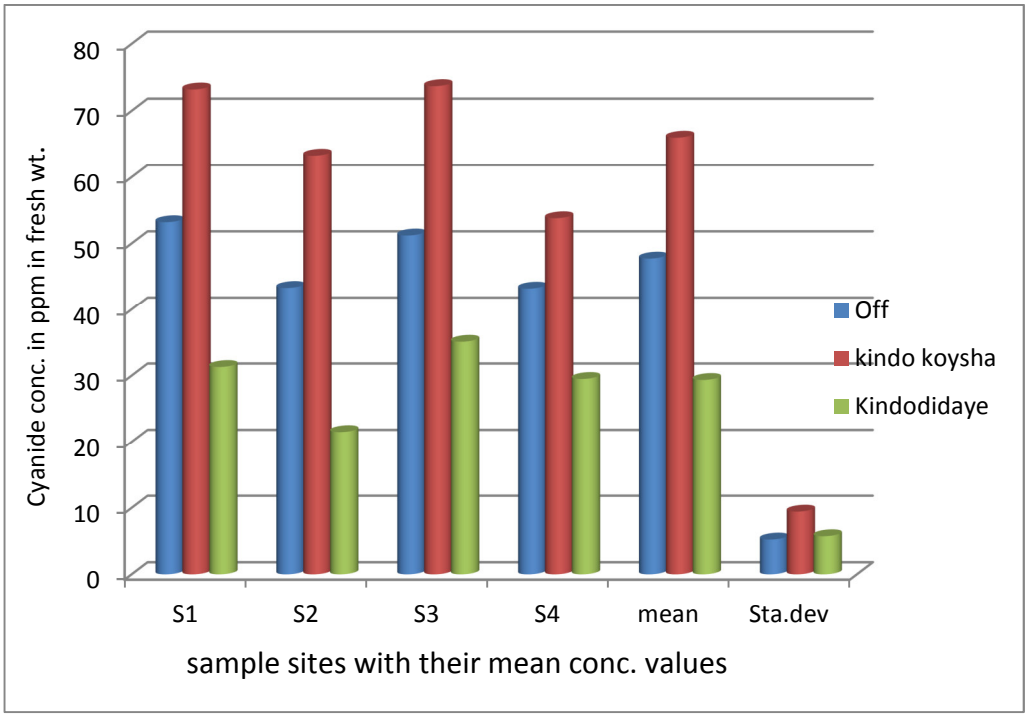
1 in mg HCN equivalents/kg = 1 parts per million = 1 ppm = 1µg HCN / g fresh cassava weight

Table 4.1: Concentration of cyanide (mg/Kg HCN equivalent) in cassava samples collected from the Three Sample area`

woredas	**S**	**Mean (mg/Kg HCN equivalent)**	**Minimum**	**Maximum**	**Sta.dev**
Offa	4	47.725	43.2	53.2	5.231
Kindo koysha	4	66	53.8	73.2	9.43
Kindo didaye	4	29.35	21.5	35.1	5.730

* S is the sample sites in each woredas, cyanide levels measured in mg HCN equivalents/ kg fresh cassava weight

From the table we can observe almost all fresh cassava samples were contain high concentration of cyanide which is above the recommended value for edible limits of 10ppm. Among the samples sites the samples from kindo koysha shows relatively high values of cyanide with average cyanide concentration of 66ppm compared to the least value of cyanide from Kindo didaye, this might due to the weather and topography and some other factors.



F.g.3. Distribution diagram of total cyanide in cassava root collected from (a) Offa, (b) Kindo Koysha, and (c) Kindo Didaye Woredas

In kindo koysha Woreda, the highest level of cyanide is observed in which the mean value was, 66 mg HCN equivalents/kg of fresh cassava weigh (table 4.1). The least is in kindo didaye, 29.35 mg HCN equivalents/kg of fresh cassava weight. Almost all fresh cassava samples were containing high concentration of cyanide which is above the recommended value for edible limits of 10ppm. As it was done also during urinary iodine excretion analysis, the mean UIE value of peoples in kindo koysha Woreda was 38.27µg/L, which indicates the site is under moderate iodine deficiency. It is observed also that most of those populations had visible goiter. Looking at all the areas, the difference in concentration (HCN equivalent) can be attributed to the fact that, the chemical composition of cassava varies according to variety, location, age, method of analysis, and environmental conditions (Githunguri *et al*., 1998; Githunguri, 2002). Cassava cyanogenic potential changes with change in agro-ecological zone (Githunguri *et al.*, 1998, 2002). This is in line with previous studies in which concentration of cyanide levels has been shown to depend on environmental conditions in which the cassava plant grows (Charles *et al*., 2005).

4.2 Concentration of cyanide in different parts of cassava root (cortex, pith and parenchyma)

Concentration of cyanide in different parts of cassava (cortex, pith and parenchyma) of the same type (sweet variety) all collected from the three woredas was determined using the picrate paper method. There was significant variation ($P < 0.05$) in the concentration of cyanide in the three parts of the cassava root (Table 4.2).

Table 4.2: Comparison of concentration of cyanide (mg/Kg HCN equivalent) in parts of cassava root

Parts	S	Mean±SE	Minimum	Maximum
Pith	4	49.24±3.12	34.42	86.89
Cortex	4	81.23±2.84	60.45	95.65
Parenchyma	4	68.45±2.23	41.49	81.48

From table 4.2 it is observed that the cortex had the highest concentration of cyanide (81.23±2.84 mg/kg) followed by the parenchyma (68.45 ±2.23 mg/kg), while pith had the lowest concentration (49.24±3.12 mg/kg). There is a gradual reduction of cyanide content from the peel (81.23±2.84 mg/kg) through the pith (49.24±3.12 mg/kg). This may be related to the fact that mostly people were removing the cortex part while using the cassava as food source.

4.3 Total cyanide concentration levels in the two Varieties of cassava

There are two common verities of cassava that were used by the community in the study sites. These are the kello and the Qulle varities.

Table.4.3 Level of Total HCN in the two fresh cassava root verities.

(In mg HCN equivalents/kg of fresh cassava weight, n = 2, mean ± SD)

No.	Sample sites	HCN Mean Concentration ± SD in the two varities	
		kello	Qulle
1.	Offa	47.725	53.2
2.	Kindo koysha	66	73.7
3.	Kindo didaye	29.35	35.1

The level of total cyanide for Kello variety ranges from 29.35 in Kindo didaye to 66mg HCN equivalents/kg of fresh cassava weight in Kindo koysha (Table 4.3). For Qulle variety, the level of mean total cyanide in cassava root ranges from the lowest 35.1to the highest 73.7mg HCN equivalents/kg of fresh cassava weight in Kindo didaye and Kindo koysha, respectively. So most of the kello varieties contain highest cyanide concentration.

4.4 Total Cyanide in Cassava Flour

Analysis of dried grated cassava collected from market and those prepared from fresh cassava root in the laboratory by sun-drying and pounding is also done for some sites and presented as follows (Table 4.4). The percentage of reduction is calculated by dividing amount of cyanide in the flour divided by the amount of cyanide in fresh cassava root and then multiplying by 100.

Table 4.4. Level of Total mean HCN concentration in Cassava Flour (In mg HCN equivalents/kg of dry weight, n = 2, mean ± SD)

No.	Sample Site/Variety	Woreda	HCN Mean Concentration ± SD	RSD (%)	% Reduction of HCN
1	Bele/ Kello	Kindo Koysha	66 ± 2.24	9.43	75.74
2	Poteta /Qulle	Kindo Didaye	29.35 ± 1.6	5.730	56.44
3	SereEsho/ Kello	Ofa	47.72 ± 2.80	5.23	46.60

The level of total mean cyanide concentration in cassava flour of the three samples sites varies from 29.35 ± 1.6 mg HCN equivalents/kg of dry weight in Poteta Qulle to 49.10 ± 2.24 in Bele Kello mg HCN equivalents/kg of dry weight. The percentage of reduction after sun-drying and pounding into flour is below 50% for all cases with slightly higher reduction for Kulle variety. The levels of cyanide in the flour are above WHO safe limit level 10 ppm in flour and thus requiring further processing to reduce toxic cyanide (FAO/WHO,1993).

4.4. Urinary iodine concentration test among cassava consumers

Evaluation of concentration of Urinary Iodine Excretion:

The mean total iodine in urine samples were collected from the sites is presented in µg/L of urine in the table 4.4 below.

Table 4.4:- Classification according to IDD status using urinary iodine concentration (UIC) (n = 30), from **kindo koysha**

Iodine status (UIC)	Mean UI Concentration ± SD	Frequency	Proportion (%)
Sever deficiency (< 20 µg/L)	17.64 ± 1.12	4	13.33
Moderate deficiency (20-49 µg/L)	32.68 ± 1.40	20	66.67
Mild deficiency (50-99 µg/L)	64.50 ± 1.45	6	20.00
Optimal (100-194 µg/L)	-	-	-
More than adequate (200-299 µg/L)	-	-	-
Excessive (>= 300 µg/L)	-	-	-

The Median urinary iodine concentration of the population in Kindo Koyisha site was 38.27µg/L, with minimum and maximum values of 17.64µg/L and 64.50µg/L respectively.

One fifth (20%) of had mild iodine deficiency, while 13.33% had completely under sever iodine deficiency. Those population had also visible goiter while 66.67% most of them had moderate iodine deficiency. No one have above optimal urinary iodine concentration in this study site.

Table 4.5:- Classification according to IDD status using urinary iodine concentration (UIC) (n = 30), from **Offa**

Iodine status (UIC)	Mean UI Concentration ± SD	Frequency	Proportion (%)
Sever deficiency (< 20 µg/L)	18.54 ± 1.96	8	26.67
Moderate deficiency (20-49 µg/L)	30.69 ± 1.96	16	53.33
Mild deficiency (50-99 µg/L)	68.50 ± 1.12	4	13.33
Optimal (100-194 µg/L)	140.78 ± 1.42	2	6.67
More than adequate (200-299 µg/L)	-	-	-
Excessive (>= 300 µg/L)	-	-	-

In Offa Woreda, the highest urinary iodine excretion was observed in two collected samples from Sere Esho, 140.78 ±1.42 µg/L urine samples. The least urinary iodine excretion was observed from samples collected from Busha, 18.54 ±1.96 µg/L of urine sample. The average Median urinary iodine concentration of the population in Offa site was 64.63µg/L, with minimum and maximum values of 18.54µg/L and 140.78 ± 1.42 respectively. Almost one half (53%) of had moderate iodine deficiency, while 26.67% had completely under sever iodine deficiency, which is greater than observed in kindo koysha.

Table- 4.6:- Classification according to IDD status using urinary iodine concentration (UIC) (n = 30), from **Kindo Didaye**

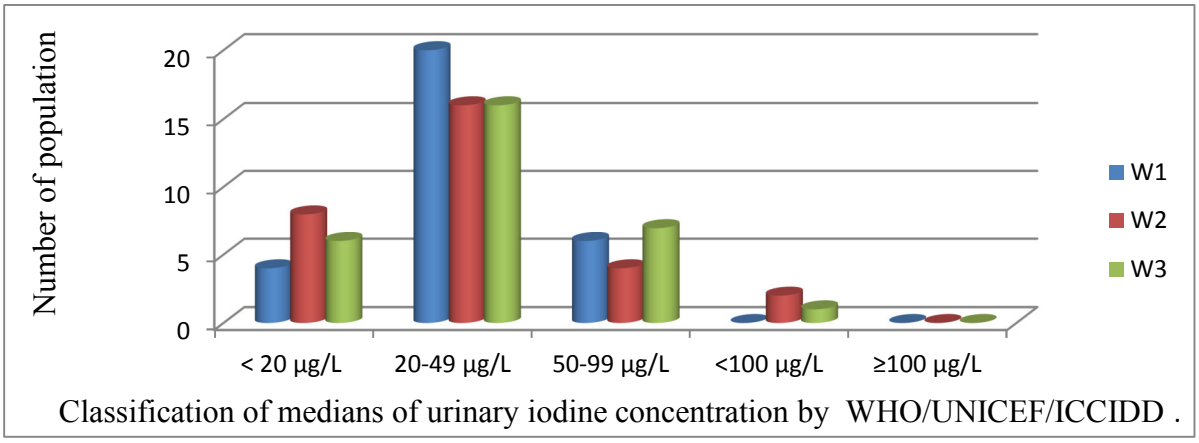
Iodine status (UIC)	Mean UI Concentration ± SD	Frequency	Proportion (%)
Sever deficiency (< 20 µg/L)	16.50 ± 1.96	6	20.00
Moderate deficiency (20-49 µg/L)	35.69 ± 1.96	16	53.33
Mild deficiency (50-99 µg/L)	60.50 ± 1.12	7	23.33
Optimal (100-194 µg/L)	109.6	1	3.33
More than adequate (200-299 µg/L)	-	-	-
Excessive (>= 300 µg/L)	-	-	-

In Kindo Didaye Woreda, the highest urinary iodine excretion was also observed in one collected sample 109.6µg/L urine sample. But the least urinary iodine excretion was observed16.50 ± 1.96µg/L of urine sample. The average Median urinary iodine concentration of the population was 55.57µg/L, with minimum and maximum values of 16.50µg/L and 109.6µg/L respectively. Almost one half (53%) of had moderate iodine deficiency, while 20% had completely under sever iodine deficiency.

Table -4.6. Summary of distribution of Urinary Iodine excretion (n = 90)

Urinary iodine level	Number	%
< 20 µg/L	18	20
20-49 µg/L	52	57.78
50-99 µg/L	17	18.89
<100 µg/L	87	96.67
≥100 µg/L	3	3.33
Total	90	100

As it is indicated from table 6, almost most of the populations are under IDD (96.67%) having less than 100µg/L, which is WHO limit of iodine deficiency disorder.



***F.g.4**. Comparison of urinary iodine concentration among the three woredas.(W1 = Kindo koysha,W2 = Offa & W3 = Kindo Didaye).*

Among cassava sample collected from Kindo Koysha Woreda sites (Fig.4), samples from Bele contains the highest level 84.55 ± 0.84 mg HCN equivalents/kg of fresh cassava weight. This can be indication for the cause of having lowest urinary iodine excretion among the populations.

5. Conclusions and Recommendations

5.1 Conclusions

The level of cyanide concentration in the fresh cassava samples indicates that the values exceed those safe limit of 10 ppm set by WHO/FAO (1993) for cassava flour. Concerning the toxicity level classification (Kobawila et. al., 2005), cassava samples of Kello variety in the study sites can be grouped in moderately toxic regions. But Qulle variety collected from Sorto, Anaze, Zaro, Bareda and Poteta have cyanide levels between 50 ppm and 100 ppm, so grouped in highly toxic regions. However all the cassava root contains above 10ppm total cyanide that is toxic. Among the Woredas, **Kindo koysha** has the highest distribution of cyanide in the two varieties of cassava samples. Urinary iodine concentration in community members is also a good index of iodine intake, by the community. Medians of urinary iodine concentration have been classified by WHO/UNICEF/ICCIDD as follows: (1) less than 20µg/L: insufficient, severe iodine deficiency; 20 – 49 µg/L: insuffient, moderate iodine deficiency; 50– 99 µg/L: insufficient, mild iodine deficiency; 100 – 199 µg/L: adequate, optional; 200 -299 µg/L: more than adequate; greater than 300 µg/L, risk of adverse consequences. The median urinary iodine concentration (52.61µg/L) found in the study area confirm that the areas were mild iodine deficiency.

This value is greater than national median urinary iodine excretion concentration of 24.5 µg/L determined in school age children in Ethiopia in 2005, which is an indication of the recent progress but it is still lower than the usually accepted median value of 100µg/L. The occurrence of IDD is very probably due to high cyanide intake over several years from mainly high cassava consumer.

5.2. Recommendations

In view of the importance of cassava as a major source of food to the local people in developing countries, fear of HCN toxicity still exists by these people. Hence, searching for and application of different post harvest practices that can significantly reduce HCN had great role in promoting the wider production and consumption of cassava (Nebiyu and Getachew, 2011). The following recommendations were made from this study:

i. Consumers should be sensitized on effective methods of cassava processing and encouraged to use them before consumption of cassava.
ii. Studies on cyanide content in cassava based products like flours, cassava crisps should be undertaken.
iii. Public awareness campaigns should be carried out to sensitize the public about high levels of HCN equivalent/kg of cassava compared to the recommended standard WHO reference value.

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6. References

1. ATSDR. (2004).Toxicology profile for cyanide. Atlanta, GA, U.S Department of Health and Human Services, Public Health Services, *Agency for Toxic Substance and disease Registry*, pp. 30865-30868.
2. Atehnkeng, J.;, V.O. Adetimirin, V.O. and Ng, S.Y.C.(2006). Exploring the African cassava (Manihot esculenta Crantz) germplasm for somatic embryogenic competence. *African Journal of Biotechnology*, 5 (14), 1324-1329.
3. Abuye, C; Kelbessa, U; and Wolde-Gebriel, S.(1998). Health effects of cassava consumption in south Ethiopia. *East African Medical Journal*, 75(3):166-170.
2. Abuye, C., Berhanu, Y., and Ersumo, T. T. (2008). The role of changing diet and attitude on goiter revalebce in five regional states in Ethiopia. *East African Journal of Public Health*, 5(3), 163-168.
3. Amey, M.A. (1987). Some traditional methods of Cassava conservation and processing in Uganda Paper presented at the Third East and Southern Africa. *Crops Workshop*, 7-11
4. Akinrele, I.A., A S. Cook, and R.A. Holgate. (1962).The manufacture of gari from Cassava in Nigeria. *In Proceedings, First International Congress on Food Technology, London*. 633-644.
5. Bradbury, H. J.; Cliff, J.; Ian C. Denton, I. C. (2011). Uptake of Wetting Method in Africa to Reduce Cyanide Poisoning and Konzo from Cassava. *Food and Chemical Toxicology*, (49) 539–542.
6. Bradbury, H. J. and Haque, R.M. (1999). Simple Method for Determination of Thiocyanate in Urine. *Clinical Chemistry*, 45 (9), 1459 –1464.
7. Bradbury, H. J. (2006). Simple wetting method to reduce cyanogenic content of cassava flour. *Journal of Food Composition and Analysis*, (19) 388–393.
8. Bull, S.E.; Ndunguru, J.; Gruissem, W.; Beeching, J.R.; and Vanderschuren, H. (2011). Cassava: constraints to production and the transfer of biotechnology to African laboratories. (A Review). *Plant Cell Reports,* 30:779–787.
9. Burns, A.; Gleadow, R. Cliff, J.; Zacarias; A. and Cavagnaro, T. (2010). Cassava: The Drought, War and Famine Crop in a Changing World. *Sustainability,*2, 3572-3607.
10. Bradbury, H. J. and Haque, R.M. (1999). Simple Method for Determination of Thiocyanate in Urine. *Clinical Chemistry*, 45 (9), 1459 –1464.
11. Cardoso, A. P.; Ernesto, M.; Cliff, J.; Egan, S.V.; and Bradbury, H. J. Cyanogenic (1998) Potential of Cassava Flour: Field Trial in Mozambique of a Simple kit. *International Journal of Food Sciences and Nutrition*, 49, 93-99.
12. Cardoso, A.P., Ernesto, M., Nicala, D. (2004). Combination of cassava flour cyanide and urinary thiocyanidemeasurements of school children in Mozambique. *International Journal of Food Science and Nutrition*, 55,183-190.
13. Chandra, A.K., Mukhopadhyay, S.S., Lahari, D. and Tripathy, S. (2004). Goitrogenic content of Indian cyanogenic Plant foods and their invitro anti-thyroidal activity. *Indian Journal of Medical Research*, 119, 180-185.
14. Cherinet, A., Kelbessa, U. and Wolde-Gebriel, S. (1998). Health effects of cassava consumption in south Ethiopia. *East African Medical Journal*, 75, 166-170.
15. Cherinet, A., Omwega, A.M. and Imungi, J.K. (1999). Familial tendency and dietary association of goiter in Gamo-Gofa, Ethiopia. *East African Medical Journal*, 76, 447-451.
16. Conn, E. (1969). Cyanogenic glucosides. *Journal of Agricultural and Food Chemistry*, 17(3): 519-526.
17. Dufour, D. L. (2007). "Bitter" Cassava: Toxicity and Detoxification. *Proceedings of First International Meeting on Cassava Breeding, Biotechnology and Ecology, Univeristy of Brasília, Brasília, Brazil*, 171-184.
18. Ewnetu, W. and Jemal, A. (1990). Normal thyroid function values in Ethiopians. *Ethiopian Medical Journal,* 28,139-143.
19. Ermans, A.M., Mbulamoko, N.M., Delange, F. and Ahluwalia, (1980). Role of cassava in the etiology of endemic goiter and cretinism. *International Development Research Center, Ottawa*, 1-182.
20. Etejer, G.O., and RB.Bhat. (1985). Traditional preparation and uses of cassava in Nigeria. *Economic Botany* ,39: 157-164.
21. Hahn, S.K, and J. Keyser. (1985). Cassava: a basic food of Africa. *Outlook on Agriculture*, 4: 95-100.
22. Ikpi, A.E., T. Gebremeskel, N.D. Hahn, H. Ezumah, and J.A. Ekpere. (1986). Cassava -a crop for household food security. *United Nations Children's Fund, New York, US*A.113 pp.
23. Jones, W.O., and A.I. Akinrele. (1986). Improvement of cassava processing and marketing - recommendations and report to National Accelerated Food Production Program. *IITA, Ibadan, Nigeria,* 53 pp.
24. Lancaster, P.A., and J.E. Brooks. (1983). Cassava leaves as human food. *Economic Botany,* 37(3): 331 -348.
25. Van Etten, C.H. (1969). *Goitrogens*. In: Liener, I.E., Ed., Toxic Constituents of Plant Food stuffs. *Academic Press Publications, New York*, 103-142.