

# Selecting and Introducing Preferable Methods of Cyanide Removal from Cassava Root in Selected Iodine Deficiency Disordered (IDD) Areas of Wolaita Zone

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## Abstract

Cassava is a major source of food in developing countries, but consumption of cassava products that contain large amounts of cyanogens can cause cyanide poisoning. Identification of highly effective methods or procedures that reduce the cyanogens contained in cassava roots which require no sophisticated equipment, and can readily be adopted by users is of tremendous importance. So the aim of the study was to select and introduce the best methods of cyanide removal from cassava by the detoxification methods: fermentation, sun drying, boiling, milling and ANU (wetting) methods. And to assess the iodine status of the community, urine samples were selected from the health centers for urinary iodine excretion test. The result obtained indicates that the most compatible methods for reduction of the cyanide from the cassava was found to be the ANU (wetting) methods and fermentation methods, which reduces 94.55% and 90.35% mean reduction of cyanide respectively. The median urinary iodine concentration (38.27 $\mu$ g/L) was also found in study site confirms that the area is moderately affected by iodine deficiency. So there is need to use improved methods of processing that greatly reduce the total cyanide content of flour like fermentation and wetting methods, to lower cyanide concentration to be blow WHO tolerance limits. The occurrence of IDD is very probably due to high cyanide intake over several years from mainly high cassava consumer.

**Keywords:** Cassava, cyanide, urinary iodine, detoxification, wetting, fermentation.

## 1. Introduction

Cassava is the third most important food source in the tropics after rice and maize. 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). Some varieties produce cyanide-containing compounds (cyanogens), which gives a bitter taste and are called 'bitter cassava'. 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, Milling et. al., 2011, Ngudi, 2005).

Konzo is an upper motor-neuron disease of sudden onset that causes irreversible paralysis of the legs and occurs particularly in children and women of child bearing age. More than 2,000 cases of konzo have been reported in Northern Mozambique, two recent outbreaks have involved hundreds of cases in Tanzania and there are reported to be up to 100,000 cases in the Democratic Republic of Congo due to the prolonged civil war. There are also reports of konzo from Cameroon and Central African Republic. These medical conditions caused by cyanide overload can be prevented by a considerable reduction in the per capital cyanide intake (Nwabueze and Odunsi, 2007).

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 alternative cyanide removal methods from cassava food that is one cause for goiter prevalence and to introduce the best methods for the society.

### 1.1. Significance of the study

This study was enabling in identifying the effect and contribution of cassava consumption in goiter prevalence. It also helped in identifying the best method of cyanide removal and assessing the indigenous knowledge among the community.

## 1.2. Objectives

### 1.2.1. General objectives

- To select and introduce the best methods of cyanide removal from cassava root found in goiter areas of Wolaita Zone.

### 1.2.2. Specific objectives

- To determine the cyanide content of different cassava samples.
- To compare different alternative methods of cyanide removal and select the best method for the society.
- To assess the contribution of cassava consumption to goiter prevalence
- To determine median urinary iodine excretion in samples of population

## 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 Koyssha, 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 KindoKoyssha; 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.

### 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;  $\mu\text{g}$  Based Wavelength Selection; 4 Digit LED Display for Wavelength; 3  $\frac{1}{2}$  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 ( $-18^{\circ}\text{C}$ ) 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.

### 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. Bradburry H. J. and Egan S. V. (Bradburry, *et. al.*, 1999). Also for flour sample analysis, developed by Bradburry 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).

### 2.4.3 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 (Bradbury, *et. al.*, 1999). Besides, relative standard deviations calculated are also all below 10%, which is usually acceptable error range.

### 2.5 Methods of cyanide removal from cassava

- a) **Boiling in water:** The enzymatic breakdown of linamarin during boiling was small because of heat denaturation of linamarase at 100°C. It was found that after 25min boiling of fresh cassava chips in water, 45% of linamarin was retained (Cardoso, *et. al.*, 2005).
- b) **Drying-**Since cassava root contains about 61% water, coupled with the solubility of its cyanogenic glucoside component, the dehydration (dewatering) process results in a substantial reduction in the content of this toxin in the pressed pulp. The retention of cyanide on sun drying(25–33%) is of the same order as that for boiling, which shows that both these methods are only suitable for the processing of sweet cassava (Cardoso, *et. al.*, 2005).
- c) **Making Flour:** Cassava flour is made commonly by sun drying of the peeled root followed by pounding and sieving, or heap fermentation. However due to only limited disruption of plant cells with limited contact between linamarin and linamarase, the amount of residual total cyanide in the flour amounts to 25–33% of that originally present for sun drying, and 12.5–16.5% for heap fermentation ( Bradbury, 2006).
- d) **Fermentation:** Unlike alcoholic fermentation, the biochemistry and microbiology is only superficially understood, but it is believed that some cyanidophilic/cyanide tolerant microorganisms affect breakdown of the cyanogenic glucoside.

Either naturally or with selected microbial inoculums fermentation has also been extensively used to enhance the nutrient potentials of cassava and its by-products both for human and livestock consumption (Aro, 2008). Fermentation possibly causes more cell rupture which easily brings about contact between substrate cyanoglycosides and the enzymes, thus leading to the breakdown of cyanoglycosides to liberate free HCN.

In heap fermentation, the roots are peeled, sun-dried for 3 to 4 days, piled in a heap and covered for several days, scraped clean of mold, crushed, sun dried for 2 to 3 days, and then pounded and sieved into flour. The processing experiment described reduced total cyanogens by 95 % and took about 5 days (Cardoso, *et. al.*, 2005).

Objectionable odor arises from the butanoic acid produced (along with acetic and propanoic acids) during fermentation can be reduced by alkaline treatment, hydrogen peroxide treatment and carotene treatment (Ohuchuku, 1985).

#### e) **wetting method:- how to remove the poison from cassava flour by wetting method**

1. Some quantity of flour that we want to cook was taken.
2. The flour was put in a pan or basin, smooth out the surface of the flour and then mark the height of the flour with the point of a knife.
3. Clean water was added little by little, string, until the flour is wet and the level is the same as that of the dry flour (already marked inside). The flour was completely wet, but not like porridge and also not with balls of dry flour.
4. The flour was spread on a sieve, mat, or any clean flat surface using a spoon or your hand, so that the thickness of the flour is no higher than a fingernail. Then left in the hot sun for two hours or in the shade for five hours.
5. Water were Put in the pan, boiled, and the water were treated with flour until the right consistency. Less water were used than usual because the water left in the treated flour also counts.
6. Now surely good food that will not cause poisoning or paralysis was prepared.

*Source: from Australian national university (ANU)*

### 2.6. 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.

### 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 and different alternative methods of removal techniques were applied.

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 local health authorities. 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 Analysis of total cyanide concentration and detoxification methods in cassava

The total analysis is done for all samples and the results for fresh cassava weight are presented in tables 1. 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 -1:-** Fresh Cassava samples Average Cyanide Concentration from the Three Sample area'

Sample	Offa	Kindo koysha	Kindo didaye
S <sub>1</sub>	53.2	73.2	31.3
S <sub>2</sub>	43.3	63.3	21.5
S <sub>3</sub>	51.2	73.7	35.1
S <sub>4</sub>	43.2	53.8	29.5
Mean	47.725	66	29.35
Sta.dev	5.231	9.43	5.730

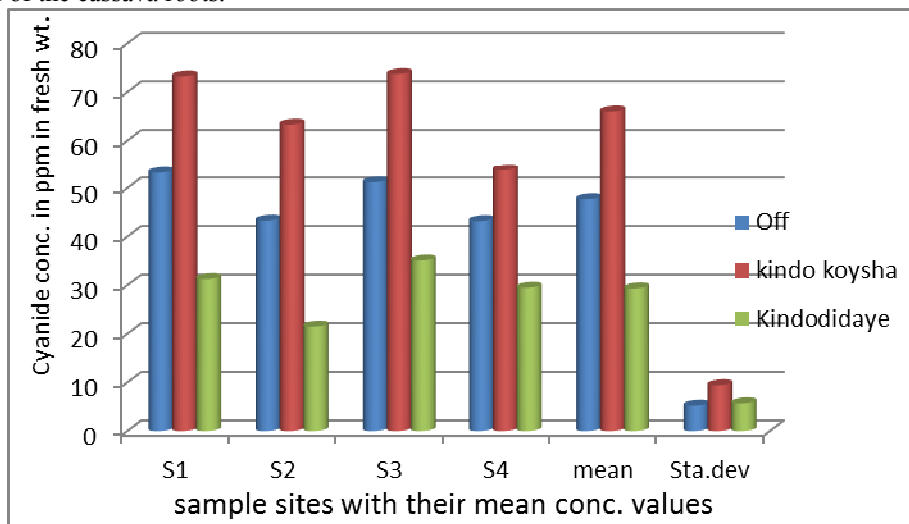
\*S<sub>1</sub>= site one

\*S<sub>2</sub>= site two

\* S<sub>3</sub>= site three

\*S<sub>4</sub>= site four

From table 1. 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 the samples from Bele in 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. From the data we have seen there should be some means of mechanisms to reduce the cyanide level of the cassava roots.



**Fig.2.** 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 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 those population had visible goiter (as shown in tale-2 below).

**Table 2.** Concentration of HCN before and after treatments

The percentage of reduction is calculated by dividing amount of cyanide removed in the sample by the method divided by the amount of total cyanide in fresh cassava root and then multiplying by 100.

Sample	Initial conc. of HCN	Residual [cyanide] after M1*	% reduction	Residual [cyanide] after M2*	% reduction	Residual [cyanide] after M3*	% reduction	Residual [cyanide] after M4*	% reduction	Residual [cyanide] after M5*	% reduction
S1 from ofaa	53.2	12.3	76.87	6.8	87.22	3.1	94.17	21.2	60.16	15.2	7
S3 from K.kosha	73.7	17.9	75.74	7.5	89.82	2.1	97.14	16.5	77.61	18.2	
S3 from K.didaye	35.1	15.3	56.44	2.1	94.01	2.7	92.33	9.2	73.78	15.3	5
mean	54	15.17	69.68	5.47	90.35	2.63	94.55	15.63	70.51	16.23	6
St.Dev	19.312	2.802	11.482	2.936	3.425	0.503	2.427	6.046	9.173	1.703	
Rank			4		2		1		3		5

\*M1= detoxification method by sun drying  
 M2=detoxification method by fermentation methods  
 M3= detoxification method by wetting methods

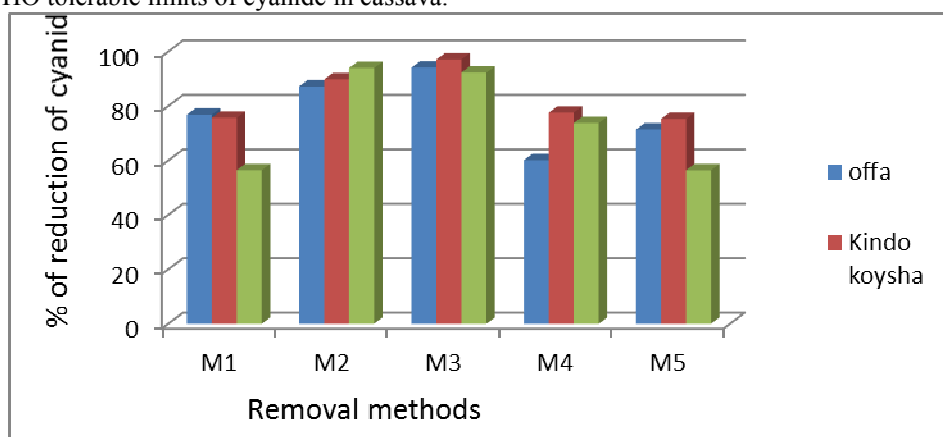
M4= detoxification method by boiling  
 M5=detoxification method by milling



As we can see from table two the most compatible methods for reduction of the cyanide from the cassava is found to be the wetting methods and fermentation methods. The fermentation process is need the soaking of the cassava tuber and grating cassava .The fermentation methods required 5 to 6 days to get a better reduction capacity.

It reduces the cyanogenic glucosides to relatively insignificant levels. The wetting methods were found to be very much effecting for cassava flour products .where as if we are interested to use the tuber without milling the fermentation methods found to be very effective. But if we see the final results of the four methods they all reduces cyanide level above 50% of the initial concentration. The choice of the methods depend on the purpose were going to use the cassava tuber/flour.

Boiling also reduce the most of the free cyanide from the fresh cassava chips. The process destroy the enzyme linamarase at about 72°C thus leaving a considerable portion of the glucoside in fact. WHO set the safe level of cyanide in cassava is 10ppm and methods two (2) and method three (3) is found to be reliable method to meet the WHO tolerable limits of cyanide in cassava.



**Fig.3.** Percentage wise comparison of the removal methods on reduction of cyanide in the cassava in the three woredas (as shown in table 2)

As it is seen in fig -3 methods two and three had high percentage of reduction in the three study woredas, 90.35% and 94.55% mean reduction respectively. So the methods fermentation and wetting were considered to be the best and effective methods for the study areas.

#### 4.2. 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 3 below.

**Table-3:** 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:** 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- 5:** Classification according to IDD status using urinary iodine concentration (UIC) (n = 30), from **Kindo Didaye**

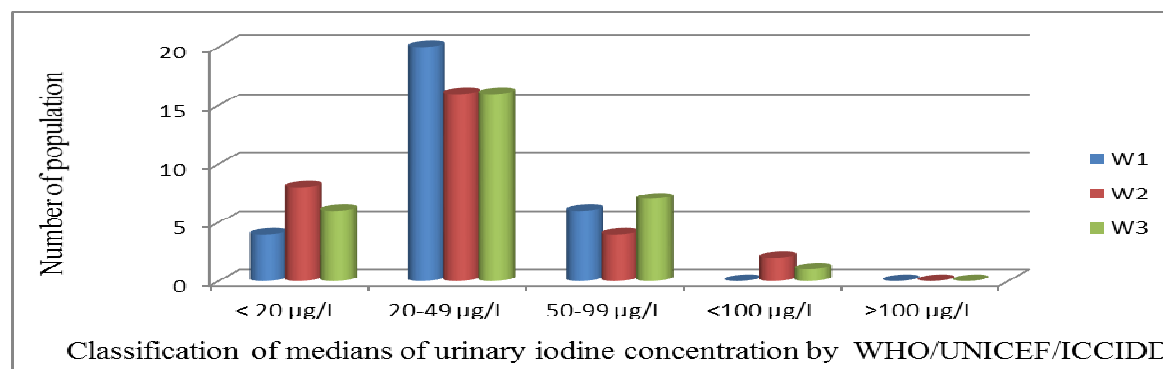
Iodine status (UIC)	Mean UI Concentration ± SD	Frequency	Proportion (%)
Sever deficiency (< 20 µg/L)	16.50 ± 1.96	6	20.00
Moderate deficiency (20-49 µg/L)	35.69 ± 1.96	16	53.33
Mild deficiency (50-99 µg/L)	60.50 ± 1.12	7	23.33
Optimal (100-194 µg/L)	109.6	1	3.33
More than adequate (200-299 µg/L)	-	-	-
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 observed 16.50 ± 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 -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
<b>Total</b>	<b>90</b>	<b>100</b>

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 Koysa Woreda sites (Fig.4), samples from Bele contains the highest level  $84.55 \pm 0.84$  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 levels of total cyanide in cassava flour prepared by sun drying, boiling and milling indicates that all the values exceed the safe limit of 10 ppm set by WHO/FAO (1993) for cassava flour. The mean percentage reduction of cyanide by these processes were 69.68%, 70.51% and 67.71% respectively, which are lower compared to other methods used by countries (Cardoso et. al., 2005). But the mean percentage reduction of cyanide by the two methods fermentation and wetting processes were 90.35% and 94.55% respectively, which indicates the values are lower than safe limit of 10 ppm set by WHO/FAO (1993).

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 20 µg/L: insufficient, severe iodine deficiency; 20 – 49 µg/L: insufficient, 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 (52.61 µg/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 100 µg/L. In Wolaita Zone, where cassava flour is made by sun drying commonly there is high retention of cyanide in flour after processing. So there is need to use improved methods of processing that greatly reduce the total cyanide content of flour like fermentation and wetting methods, to lower cyanide concentration to be blow WHO tolerance limits. The occurrence of IDD is very probably due to high cyanide intake over several years from mainly high cassava consumer.

### 5.2. Recommendations

Although processed foods are generally safe, lack of standardization in the methods used, the environment and the hygiene of the people that prepare them, will determine the quality of the product [30]. So there is need to educate the citizens on the need of consuming treated and safe foods. 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). A reduction in the HCN potential of cassava can occur during every unit operation in the processing of the roots, resulting in near detoxification of the product. But all the methods don't reduce cyanide levels to the standard limit. In detail, the results of this study show that fermentation and wetting process resulted in end products with low cyanogen levels. Moreover, based on the results presented here, it is strongly advisable that the community can easily apply the two methods in order to ensure safe cassava end-products.

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