Nutritional And Hydrogen Cyanide Compositions And Consumers Preference In Cassava Varieties Grown In East Hararghe Zone Of Oromia, Ethiopia

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Abstract: This study was conducted to determine nutritional quality and hydrogen cyanide content of cassava varieties grown in East Hararghe Zone, Oromia, Ethiopia and to study consumer preference for the cassava based food products. The nutritional and hydrogen cyanide content of cassava were analyzed using standard procedures. Proximate composition and minerals content were analysed using SAS software whereas sensory evaluation was analyzed using R software. The moisture, ash, crude fiber, crude protein, crude protein, cyanide, carbohydrate, Ph, zinc, iron, and calcium contents of cassava varieties on wet basis ranged from 58.50 – 65.32 %, 2.21 – 3.06 %, 2.01 –2.51 %, 1.58 – 1.79 %, 0.87 – 1.21 %, 0.47 – 0.85 mg/100g, 26.44 – 32.53 %, 0.07 – 0.09 %, 0.20 % – 0.29 % and 0.62 – 0.99 % respectively. Consumer preference for cassava based food products showed that cookies and porridge prepared from 50 % and 20 % of cassava recipes respectively had better acceptance. While for the cassava based injera 30 % sorghum and 70 % of cassava recipe were preferred for Kello and Local varieties.

Key words: cassava varieties, consumer, cyanide and nutritional composition

INTRODUCTION

Cassava (Manihot esculenta Cratz) belongs to root crop and used as source of food as well as feed in Africa. Cassava is produced in Ethiopia and especially in Southern part and promoted to other parts of the country. Cassava is one of the most important food crops that constitute a considerable portion of the daily diet of the people and also serves as a major source of carbohydrate in Southern Ethiopia [1]. It is a good source of carbohydrate and other nutrients which are important for human beings. Cassava has an advantage over other crops particularly in many of the developing world because of its outstanding ecological adaptation, low labor requirement, ease of cultivation, high yields, drought tolerant crops and successfully grown on marginal soils, where many other crops do not grow well [2]. According to FAO report; the nutritional content of cassava depends on the specific plant part (root or leaves), geographic location, varieties, age of the plant and environmental conditions [3]. Even though cassava has many advantages; its roots are perishable and can deteriorate within two to three days after harvest [4]. For these reasons cassava is usually sold as a processed product while other roots and tubers are most frequently sold as fresh produce [5]. It has also cyanogenic glucosides which should be reduced to a level which is acceptable and safe for consumption. The plant is famous for the presence of free and bound cyanogenic glucosides; linamarin and lotaustralin which are converted to Hydrogen Cyanide (HCN) in the presence of linamarase, a naturally occurring enzyme in cassava [6]. Consumption of cassava and its products that contain large amounts of cyanogens may cause cyanide poisoning with symptoms of vomiting, nausea, dizziness, stomach pains, weakness, headache and diarrhoea and occasionally death [7& 8].

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Cassava is eaten in various forms; these determine the methods of processing, which aim to provide products that are storable and easy to transport, improve the taste of final products, reduce potential cassava toxicity, and provide products such as flour for subsequent conversion to a variety of end products (9 & 10). The processing of cassava into various forms of products affects nutritional value of final products [11 & 12]. The levels of total cyanoglucosides and linamarin are also affected during processing [10]. In areas where there are minimum cultivated land, infertile land, recurrent drought food security problems; cassava is a staple food. West and East Hararghe zones of Oromia are characterized by high population, limited farm land and erratic rainfall and have food security problem. Hence cassava production and its adaptations were introduced by non-governmental organization and Fedis Agricultural Research Center in Fedis, Kombolcha and Babile districts of Oromia regional State. However, post-harvest management practices, and ways of HCN removal/reduction as well as development of different food products are not well known by farmers. Therefore, the objectives of this experiment were to determine nutritional composition and cyanide content of Qulle, Kello and Local cassava varieties and evaluate consumers' preference of cassava based traditional food products.

MATERIALS AND METHODS

Description of the Study Area

The study was conducted at Fedis Research Substation of Fedis Agricultural Research Center (FARC), Oromia Agricultural Research Institute and the laboratory analyses were done at Food Science Department of Haramaya University, Ethiopia. Fedis district is located in East Hararghe zone of Oromia Region, Ethiopia (figure 1). Mainly it is dry land and one of affected area because of shortage of rainfall.

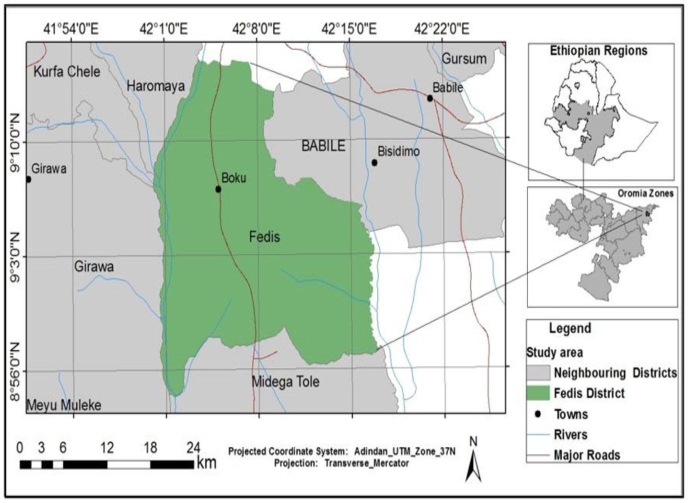

Figure 1. *Map of the study area*

The annual rainfalls for consecutive five years (2010 to 2014 G.C) were ranged from 791mm to 1102.9 mm. The annual minimum and maximum average temperature for consecutive five years (2010 to 2014 G.C) were 9.82^{o}C and 27.87^{o}C respectively [13]. Because of drought problem there is shortage of food several times in study site.

Sample Collection and Preparation

Three cassava varieties namely; Qulle (104/72), Kello (44/72) and Local Check were obtained from Crop Research Team of FARC. The samples were harvested at age of 2.2 years from research sub-site at Fedis District of East Hararghe, Oromia Region, Ethiopia. They were sorted, washed with potable water to remove soil and then peeled manually with knife. Peeled roots were sliced into similar size and soaked with water in jar for 43.5 hours. The fermented samples were sun dried and finally ground in a commercial roller mill that passes through a 250-μm sieve. The flour samples obtained were then packaged into polypropylene bags and kept at room temperature until analyses. After that cassava proximate composition, minerals and HCN contents were determined. Sorghum and maize flours were obtained from local flour provider while wheat flour was purchased from factory of Dire Dawa Flour Share Company (Dire Dawa, Ethiopia) as shown on figure 2.

Local Cassava Based Food Preparation

Ingredients substituted for local food preparation were evaluated by wheat, maize and sorghum flours with reconstituted cassava flours and used in the traditional preparation of cookies, porridge and injera respectively. Three substitution levels of cassava flour (20 %, 50% and 70%) and control (0 %) with wheat, maize and sorghum flours were used for respected food item.

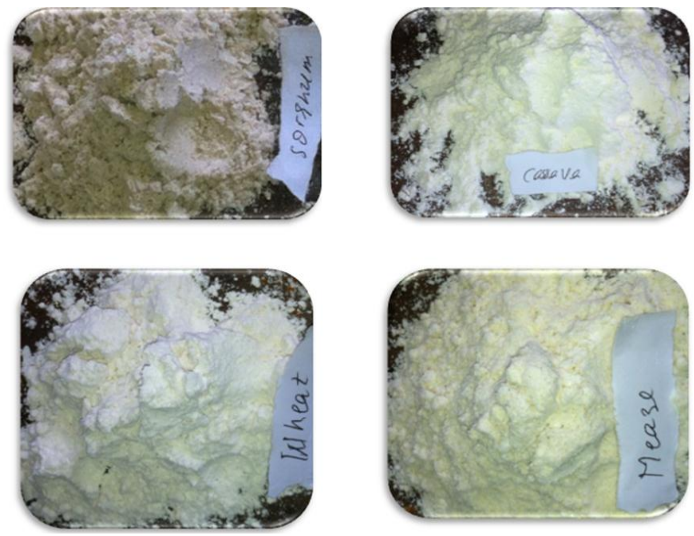

Figure 2. *Photo of sorghum, wheat, maize and cassava flours used in this experiment*

Methodologies of Proximate Composition Analysis

The proximate composition [moisture, carbohydrate, crude protein (N x 6.25), crude fat, ash and crude fiber] contents of cassava flours as well as pH and minerals (Zn, Ca and Fe) composition were determined according to methods described by Association of Official Analytical Chemists' [14].

Analysis of Cyanide in Cassava

The cyanide determination was performed using BALTHA, 2006 methods [15]. The extracts of cassava tissues separately (parenchyma and cortex) and the cassava root combined (parenchyma + cortex) and leaves were analysed by this method. The previously weighed tissues were disintegrated in 50 ml of distilled water with a mixer Taurus Robot 250 INOX for 60 seconds. The extract has the endogenous linamarase enzyme to hydrolyze linamarin to acetone cyanidrin as described by Bradbury, [16]. The test tubes containing samples and color reagents were incubated for 15 minutes in water bath at 37^{o}C. Before reading was taken 15 μL of sulfuric acid (H_2SO4) was added to stop the reaction and increase the stability of reading. The extract was filtered with filter paper size 185 mm diameters (Whatman ® Sheleicher & Schuell). The obtained for samples readings was used to replaces the X value on equation obtained from the standard curve. The samples were prepared in triplicate and a white reading without cassava extract was used in order to eliminate possible interference during adjustment of the equipment. The result was expressed in cyanide mg/100g fresh matter.

Sensory Evaluation

Three types of Ethiopian traditional foods with different recipe were prepared with three level of cassava blending with cereals. The local foods prepared were evaluated by wheat, maize and sorghum flours with reconstituted cassava flours and used in the production of cookies, porridge and 'injera' respectively. Three substitution levels of cassava flour (20 %, 50% and 70%) and control (0 %) with other cereals were used for food production. Sensory evaluations of cassava food products were carried out by 5 trained panelists and they were asked to rank for prepared cassava foods by evaluating color, odor, taste, and texture of the product. The best score for each attribute given from 1 for best and 4 for the last one.

Statistical Analysis

Proximate composition, minerals and cyanide contents of cassava were analyzed by using SAS software and data of sensory evaluation were presented as means and 99% confidence intervals of the individual treatments. Analysis of variance for sensory evaluation data was carried out using R software version 3.4.3(2017-11-30).

RESULTS AND DISCUSSION

The proximate and minerals composition of the cassava varieties at fresh harvest and after processing were shown in Table 1 and 2 respectively. All analyzed nutritional and cyanide contents of cassava at wet basis were significant expect ash and crude protein. While, only moisture, crude fat, zinc and cesium were significant at dry basis. The moisture content of the fresh cassava roots varied from 58.52 % (Kello variety) to 65.32 % (Qulle variety). The moisture content of Qulle variety was significantly higher when compared with Kello and local ($p < 0.05$). Similarly, higher moisture content for the fresh cassava varieties reported by other researchers. The moisture content of cassava varieties examined in this study were below those (65 - 74% wb) reported by Wheatley and Chuzel [17] on four cultivars harvested at various ages and seasons, and those of 60.3% to 87.1% reported by Padonou [18]. On dry basis, moisture content of cassava flours ranged from 7.53% to 9.91% which were low when compared to Emmanuel finding which was with values of 9.2% to 12.3% (19). Varieties with low moisture content would be suitable for prolonged root storage [20]. Moisture 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. All the samples had good moisture levels and hence have the potential for better shelf life. The crude protein content of the three varieties examined ranged from 1.58 % (Local Check) to 1.79 % (Qulle) for wet base and 1.63 % (Qulle) to 1.80 % (Local) dry base. There was not a significant difference among the studied varieties regarding the protein content. This finding is similar to Buitrago report [21] which was 1% to 3% on a dry matter basis. According to the study conducted by Bradbury and Holloway the crude protein content of cassava on fresh base ranged from 0.4 to 1.5 % [22]. The ash content of the cassava flour samples ranged from 2.21% (Local)

Table 1. *The proximate chemical and minerals composition of the cassava varieties at fresh harvest (wet basis)*

Cassava variety	Cassava proximate chemical and minerals content										
	Moisture content (%)	**Ash (%)**	**Crude fiber (%)**	**Crude protein (%)**	**Crude fat (%)**	**Cyanide (mg/100g)**	**Carbohydrate (%)**	**pH**	**Zn (mg/100g)**	**Fe (mg/100g)**	**Ca (mg/100 g)**
Kello	58.50^{b}	3.06^{a}	2.33^{ab}	1.78^{a}	1.20^{a}	0.58^{b}	32.53^{ab}	5.72^{b}	0.07^{b}	0.20^{b}	0.99^{a}
Local Check	58.55^{b}	2.21^{a}	2.01^{b}	1.58^{a}	0.87^{b}	0.85^{a}	34.79^{a}	5.95^{b}	0.09^{a}	0.29^{a}	0.80^{b}
Qulle	65.32^{a}	2.66^{a}	2.51^{a}	1.79^{a}	1.21^{a}	0.47^{a}	26.44^{b}	6.36^{a}	0.07^{b}	0.23^{b}	0.62^{c}
CV	4.80	15.81	6.62	10.44	11.02	4.54	7.49	1.90	4.15	6.20	4.29
LSD (0.05)	6.61	0.95	0.34	0.41	0.27	0.07	7.49	0.01		0.03	0.08
P value	*		*		*	*	*	*	*	*	*

In each column means followed by different letters (a, b, c, etc.) are significantly different at $p < 0.05$

Table 2. *The proximate chemical and minerals composition of the cassava varieties after processing*

Cassava variety	Cassava proximate chemical and minerals content										
	Moisture content (%)	**Ash (%)**	**Crude fiber (%)**	**Crude protein (%)**	**Crude fat (%)**	**Cyanide (mg/100g)**	**Carbohydr ate (%)**	**pH**	**Zn (mg/100g)**	**Fe (mg/100g)**	**Ca (mg/100g)**
Kello	8.54^{b}	1.58^{a}	2.10^{a}	1.69^{a}	1.32^{b}	1.13^{a}	83.55^{a}	5.53^{a}	0.09^{a}	0.26^{a}	0.60^{c}
Local Check	7.53^{c}	2.09^{a}	1.76^{a}	1.80^{a}	1.22^{c}	1.15^{a}	80.19^{a}	5.52^{a}	0.07^{a}	0.35^{a}	0.70^{b}
Qulle	9.91^{a}	2.52^{a}	1.75^{a}	1.63^{a}	1.47^{a}	1.02^{a}	84.08^{a}	5.47^{a}	0.09^{b}	0.24^{a}	0.97^{a}
CV	1.61	23.3	6.62	5.39	2.33	12.33	6.45	1.42	8.6	18.5	4.13
LSD(0.05)	0.32	1.09	0.46	0.21	0.07	0.31	12.1	1.09	0.02	0.12	1.09
P value	*				*				*		*

In each column means followed by different letters (a, b, c, etc.) are significantly different at $p < 0.05$

to 3.06% (Kello) and 1.58 % (Kello) to 2.52 % (Qulle) with Local Check having the lowest and Kulle the highest for wet and dry basis respectively (Table 1 and 2). There was no significant differences ($p>0.05$) existed in the ash content of the cassava varieties. The crude fat content of the cassava flour samples ranged from 0.87 % to 1.21 % and 1.22 % to

1.47 % for wet and dry basis respectively (Table 1 and 2). There were significant differences ($p<0.05$) at wet and dry basis. Qulle variety had the highest crude fat at both bases. The crude fiber content of the cassava flour samples ranged from 2.01 % to 2.51 % with local check having the lowest and Qulle the highest at wet basis (Table 1). There was significant differences ($p<0.05$) between local check and Qulle varieties while no significant difference between local check and Kulle varieties. Carbohydrate values ranged from 26.44 % (Qulle) to 34.79% (local) at fresh harvest and 80.19 % (local) and 84.08% (Qulle) at dry basis. There were significant ($p < 0.05$) variations in the carbohydrate content between Qulle and Local cassava varieties on wet basis but not significant different for dry basis. This result is in line with the finding reported by Montagnac et al. [23] which ranged from 32 % to 35 % and 80% to 90% wet and dry basis respectively. The minerals compositions of the cassava varieties at wet basis as presented in table 1 indicates that Zn, Fe and Ca were analysed with highest mean values of 0.09 (Local), 0.29 (Local) and 0.99 (Kello) mg/100g and the lowest value of 0.07 (Qulle and kello), 0.23 (Qulle) and 0.62 (Qulle) mg/100g at wet basis respectively. The composition of Ca in this finding indicated significantly different in all varieties ($p< 0.05$) at wet basis. Zn and Fe compositions were not significantly different for Qulle and Kello varieties. Local variety was superior by Zn and Fe contents than others. The result of all minerals analysed in this study agree with Ammanuel et al. reports conducted in six cassava varieties at wet basis [19]. The minerals composition of the cassava varieties as presented in table 2 indicates that Zn, Fe and Ca were quantified with highest mean values of 0.09 (Qulle), 0.35 (Local) and 0.97 (Qulle) mg/100g and the lowest value of 0.07 (local), 0.24 (Qulle) and 0.60 (kello) mg/100g at dry mass respectively. The composition of Zn and Ca in the studied varieties indicated significantly different ($p < 0.05$). The cyanide content of studied cassava varieties ranged from 1.02 to 1.15 mg /100g and 0.47 to 0.85 mg /100g (Table 1 &2) for dry and wet basis respectively. Qulle variety had the lowest cyanide content while local check had the highest. There was significant differences in cyanide content ($p<0.05$) among the cassava variety for dry basis. Assume a person who has 60 kg body weight had 400g of cassava food at a time. The maximum cyanide content was found 1.15 mg/100g in local check. Therefore, he/she could eat 4.6 mg/400g of cassava which below than WHO/FAO recommendations (<10 mg cyanide equivalents/kg body weight DM) [24].

Sensory Evaluation

Processed cassava food products

Prepared traditional foods in the study area include injera (yeast raised flat bread slightly spongy texture), porridge and cookies made from cereals as shown on figure 3. Sorghum and maize are most dominant crops produced in the area and as well widely consumed. However, because of environmental conditions there is limitation for food access and thus cassava proposed to compensate the other cereals because of its agro-ecology advantages.

Figure 3. *Cassava flour constituted traditional food in the study area*

The treatments for consumers preference conducted among cassava varieties were not significant. However, all substituted cassava flour for all of prepared traditional foods were highly significant. Cookies made from half cassava with wheat flour (50:50%) has most acceptance than others substitutes and highly significant at ($P<0.01$). The least preference was obtained from 70 % of cassava flour for Local and Kello varieties. This result showed that 50 % cassava flour substitute with wheat flour can provide best cookies and even better than 100 % wheat flour from Kello variety.

	Cookies preference (mean)				Injera preference (mean)				Porridge preference (mean)			
Cassava variety	Cookies (70 % cassava)	Cookies (50 % cassava)	Cookies (20 % cassava)	Cookies (0 % cassava)	Injera (70 % cassava)	Injera (50 % cassava)	Injera (20 % cassava)	Injera (0 % cassava)	Porridge(70% cassava)	Porridge(50% cassava)	Porridge(20% cassava)	Porridge (0 % cassava)
Kello	2.75	1.50	2.00	3.75	2.00	2.20	2.60	3.00	2.80	2.40	1.60	3.20
Local	4.00	1.00	3.00	2.00	1.60	2.00	3.60	2.80	2.00	3.75	2.00	3.75
Qulle	3.40	1.00	2.60	3.00	2.20	1.40	2.80	3.60	2.00	3.00	1.60	3.40

Injera prepared from 30 % sorghum and 70 % cassava recipe were preferred for Kelo and Local varieties but from half cassava with sorghum flour (50:50%) had more acceptance than others blending ratio for Qulle variety. The least preference was obtained from 0 % of cassava flour for Kello and Qulle varieties, but 20 % of cassava was for local variety. This result showed that at least 70 % cassava flour substitute with sorghum flour can provide best injera. Porridge made from 20 % cassava with 80 % maize flour has most acceptance than others substitutes and highly significant at (P<0.01). This result showed that 20 % cassava flour substitute with maize flour can provide better porridge.

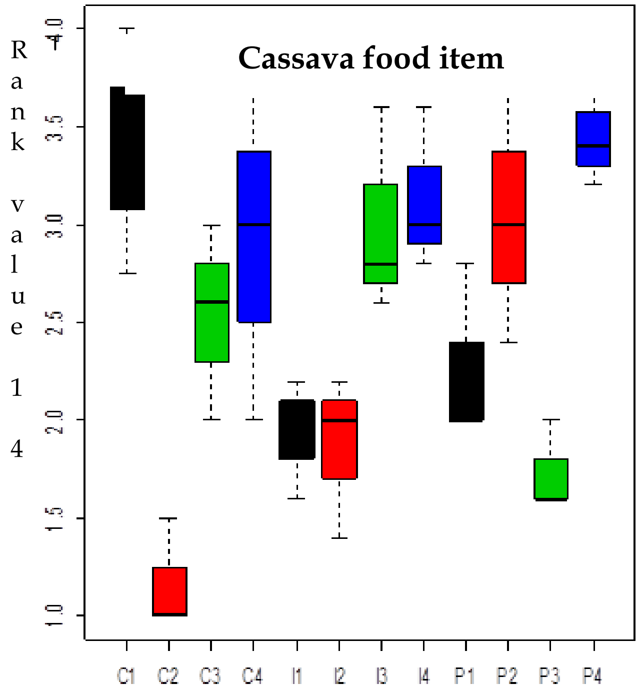

Figure 4. *The rank of cassava blend processed different local foods*

Where, C1= stands for cookies (70% cassava and 30% wheat four), C2= stands for cookies (50% cassava and 50 % wheat four), C3= stands for cookies (20% cassava and 80 % wheat four), C4= stands for cookies (100 % wheat four), I1= stands for injera (70% cassava and 30 % sorghum four), I2= stands for injera (50% cassava and 50 % sorghum four), I3= stands for Injera (20% cassava and 80 % sorghum four), I4= stands for Injera (100 % sorghum four), P1= stands for Porridge (70% cassava and 30 % maize four), P2= stands for porridge (50% cassava and 50 % maize four), P3= stands for porridge (20% cassava and 80 % maize four) and P4= stands for porridge (100 % maize four)

CONCLUSION AND RECOMMENDATION

All of cassava varieties have good and acceptable proximate, minerals and cyanide composition. The combination of fermenting and sun drying method of cyanide chemical elimination from cassava root were guaranteeing the safe consumption of cassava food. In this study, cassava varieties had low cyanide levels which were all below the WHO/FAO recommendations (<10 mg cyanide equivalents/kg DM) and thus could all be safely recommended for consumption without toxicity to humans. Qulle variety more recommended for its highest composition of carbohydrate and low content cyanide compared to other but it need immediate processing (reduce moisture) to prolong its shelf life. Cookies prepared from half cassava and wheat flour (50:50%) were preferred by panelists. Cassava based Injera with recipe of Cassava: Sorghum 50:50 % mix had good acceptance when compared with wheat and maize substitutes. Different cassava processing techniques that reduce/eliminate the cyanide toxicity in the cassava food products, not include in this study, need to be studied and the nutrient content of the cassava based foods should be studied.

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