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Detoxification and Consumption of Cassava Based Foods in South West Ethiopia

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Abstract: Cassava (*Manihot esculenta*) was introduced in Ethiopia around 1960's. But the consumption was not practiced until 1984. Currently the plant is being distributed throughout the country as a tool to tackle food insecurity. However, the distribution is not supported by proved food preparation techniques for optimal processing to increase nutrient density and eliminate the toxin. Hence, development of suitable detoxification methods and optimal food processing without affecting consumers acceptance is essential. The aim of this paper is to evaluate the existing processing technologies in order to identify effective methods for reducing the cyanide content and improve nutritional quality of cassava based foods. Primary and secondary data were collected from four cassava producing and consuming districts of south west Ethiopia using Focus Group Discussion (FGD), key informants interview and review of written documents. Processing methods such as washing, boiling, drying and fermenting with flour of cereals were evaluated to increase nutritional content and reduce cyanide level. Laboratory and kitchen trial of cassava mix with cereals at two levels were conducted to evaluate the toxin content and nutritional value of products. In this study solar drying and fermentation were found to be the best methods in totally removing the cyanide content of cassava. The results show that both cassava mix are suitable (at 95%CI) for Anebabero, Injera, Dabbo (Bread) and porridge preparation. Cereal blends improve nutritional quality of cassava based foods.

Key words: Cassava, detoxification and sensory evaluation

INTRODUCTION

Cassava was believed to be carried to Africa by Portuguese traders from the Americas and spread rapidly. Nowadays it is a staple food in many parts for western and central Africa and is found throughout the humid tropics (CGIAR, 2001; Abuye *et al*., 2008; Enidiok *et al*., 2008). Today it is grown in over 90 countries (CIAT, 2001). The crop has become widespread and assumed its current importance as a food during the 20th Century. It is valued over other root crops for its outstanding ecological adaptation, low labor requirements, ease of cultivation, pest resistance and high productivity. It is therefore usually considered as an important famine reserve crop in countries with unreliable rainfall (Oboh and Elusiyan, 2007; Abuye *et al*., 2008). The carbohydrate rich but low in protein storage roots represent an important energy source and are a staple foodstuff for more than 500 million people throughout tropical Africa, Latin America and parts of Asia (Yeoh *et al*., 1998; Chijindu and Boateng, 2008). Farmers grow cassava for food, cash and livestock feeds (CGIAR, 2001). 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 (Haque and Bradbury, 2004; Wilson, 2003). The amount of cyanide in the tuber is variety dependent. All plant parts contain cyanogenic glucosides with the leaves having the highest concentrations. In the roots, the peel has a higher concentration than the interior. Processes like boiling, grinding, drying, or fermenting are used to neutralize the cyanide (CIAT, 2001; CGIAR, 2001).

In Ethiopia, this crop has been cultivated in the southern and southwestern regions for decades as an alternative food insecurity crop (Taye, 2000; Desse and Taye, 2001). Processing methods, storage experience and modes of consumption are not yet customized unlike most of cassava producing and consuming African countries. Cassava is one of the underutilized root crops in the country. The crop has been used in south western areas of Ethiopia mainly to tackle seasonal food shortage. Currently, some cassava varieties are being promoted in food insecure northern areas of Ethiopia. However, the distribution of the cultivars is not supported with proven food preparation techniques to increase nutrient density and cyanogenic free cassava based foods without affecting consumers taste. The main purpose of this paper is therefore to investigate effective method of reducing the cyanide level and improve the nutritional quality of cassava based Ethiopian cultural foods through experimental trail.

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MATERIALS AND METHODS

Description of study areas: The study was conducted in Konso, Kindokoisha, Sahula and Amaro districts of South Nations Nationalities People Region (SNNPR), Ethiopia. Part of the study places are escarpments of the Main Ethiopian Rift Valley with an altitude range of 600-2100 meter above sea level. Mainly they are semi dry lands and among the frequently affected areas by shortage of rainfall. The annual average rainfall is 400-1400 mL with the lowest average in Konso. According to information gathered from key informants and secondary source almost half of the study population faces seasonal food shortage. The study districts are among the most cassava growing areas in Ethiopia.

Data collection: Semi-structured open-ended questions were developed and used for key informants interview, Focus Group Discussion (FGD) and secondary data to gather information on history of cassava introduction, meal preparation, consumption and cyanide removal techniques. Secondary data were collected from district agricultural and health offices. In each district representative communities were selected based on intensity of cassava production and consumption. 7-9 people were used for focus group discussion. In each district two FGD were conducted. Key informants used in this study are knowledgeable community elders, government officials from office of agriculture and health. Investigators were responsible for FGD and key informants interview. Mini radio tape recorder was used in addition to note taking to gather each bit of information from the discussion.

Sample collection, transportation and storage: The samples are collected from 2 years age cassava plant roots (5 kg from each variety) directly from farming plots of voluntary farmers and Hawassa agriculture research center. The soil is removed and packed in polyethylene bags until brought to laboratory. The varieties are identified by agricultural expert.

Sample preparation: The samples were peeled and chopped for the analysis of cyanide and moisture content within 24 h. A duplicate portion is sun dried and ground for preparation of cassava based Ethiopian traditional recipes. To reduce the cost of the research Amaro kelle red was selected for recipe preparation. The selection was conducted based on low cyanide level observed, witnessed production yield and high geographical distribution of the variety.

Nutrient and cyanide analysis: Moisture content was estimated by oven drying method at 105°C (Osborne and Voogt, 1978). Protein and fat contents were determined by the Kjeldahl (Tecator manual, 2003) and Soxhlet methods (Tecator Manual, 1998). Crude fiber and ash were determined by the standard method of AOAC (1990). Analysis of minerals were carried out by using Flame Atomic Absorption spectrophotometer (Varian, SpectrAA20 plus) as described by Osborne and Voogt (1978); AOAC (1990). The values for carbohydrate was given as "total carbohydrate by difference", that is the sum of the figures formed from moisture, protein, ash and fat subtracted from 100. Cyanide level in cassava and prepared food products was analyzed both qualitatively using picrate paper (Egan *et al*., 1998) and quantitatively using acid hydrolysis of cyanogenic glucosides as described by Bradbury *et al*. (1991).

Organoleptic test: Four types of Ethiopian traditional recipe were prepared with two level of cassava blending with cereals. 50% and 70% cassava was blended with teff or maize for preparing Injera, wheat or maize for preparing Dabbo and Anebabero, barley or maize for preparing Porridge. The sensory characteristics used in the assessment include: appearance, taste, texture-hand and mouth feel, pliability (for Injera and Anebabero), aroma and overall acceptance. To quantify the level of sensory attributes nine point hedonic scale is used with "1" corresponding to "extremely disliked" and "9" corresponding to "extremely liked" using expert panelist from Food Science and Nutrition Research Directorate of Ethiopian Health and Nutrition Research Institute. The data was entered and analyzed using SPSS 13 for windows.

RESULTS

Cassava introduction, varieties and cyanogenic levels: Cassava was introduced in the study areas by missionaries and/or merchants from neighboring countries around 1960's, said the discussants. The information agrees with literature reviews (Abuye *et al*., 2008). According to FGD, until 1984, period of severe famine in the country, people did not consume it. Farmers are realizing the importance of cassava recently. Key informants emphasized the use of cassava as a food security crop. In Southern Ethiopia it grows in Konso, Amaro, Gedeo, Sidama, Wolayita and Gamo-Gofa districts while in south-western part of Ethiopia it grows in some pocket areas of Illu Abba Bora, Jimma, West Wollega zone and Benshangu-Gumuz region. Very recently, Cassava has been promoted to many part of the country where it hasn't been known before (Abuye *et al*., 2008). Different varieties of cassava exist in south western Ethiopia (Fig. 1). People identify varieties based on sweetness/bitterness, color of stem and leaf, size of leaves and tree height. The sweet varieties are called "Seetie" meaning female and the bitter ones are called "Wonde" meaning male signifying the strength of bitterness.

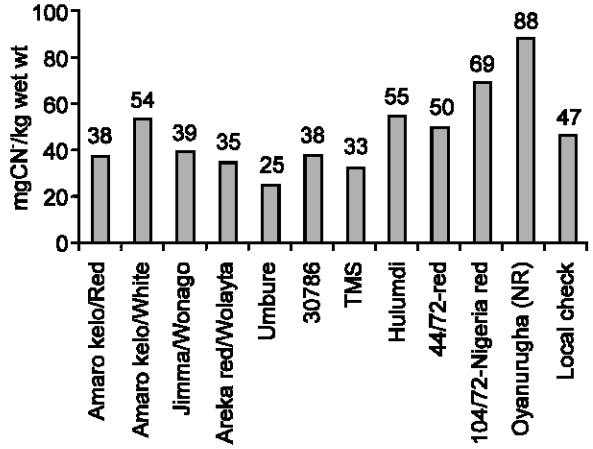

Fig. 1: Selected cassava varieties found in south western areas and their cyanogenic level (Names of the varieties were obtained from Hawassa agriculture research center, Ethiopia)

Cassava production, consumption and its health implication: Data from the study districts show that productivity of cassava is in the range of 7-8 tons per hectare. From the FGD it was learned that cassava is consumed mainly in boiled form to tackle seasonal food shortage otherwise it is used for preparation of local traditional beverages. High cassava consumption in all the districts is observed in May-June each year. People in Konso complain burning effect and increased alcoholic strength of the local beverage made of cassava. To reduce the effects of the local drink, people used to boil or made warm before drinking. In all the study districts, problems such as nausea, vomiting, distress in abdomen, blotting, weakness, headache and dizziness are common symptoms occurring mainly on children and seldom on adults when consumed frequently. The summary from focus group discussion show that death of cattle is common in January just after dry season when rain begins and the first new bud of cassava appears. According to key informants from Amaro district communities traditionally treat the problem associated with cassava consumption using cow milk. Milk or milk mixed with sheep or goat blood was reported to treat cyanide fatality from cassava consumption in similar areas (Abuye *et al*., 1998).

Detoxification of cassava based foods: In our assessment, the effect of peeling, taking out the center, washing, sun drying, grinding and fermenting on cyanide content were tested (Table 1) on Amaro red variety. Peeling, removing the center and washing two-times reduced the cyanide content by about 38%. Peeling and boiling reduces over 60% of the cyanide provided that the water used for boiling is disposed. Combined use of peeling, washing and boiling reduced the cyanide to less than 15% of the original content. Peeling, chopping, sun drying on aluminum pan and grinding removed almost 90% of the cyanide content in the original sample. Fermentation of cassava flour for 24-hr according to traditional customs for making 'Injera" and "Dabbo" is found to be the best method in totally removing the cyanide content of cassava below detection limit as proved by both qualitative and quantitative test.

Blending of cassava with cereals in traditional foods preparation: All meals in South include cassava during summer (Abuye *et al*., 2008). Boiled cassava is common in all the study sites. Prepared traditional foods in the areas include "Injera (yeast-risen flat bread slightly spongy texture made out of cereals), "Dabbo (Ethiopian traditional bread)", "Anebabero" (Injera with double thickness), Porridge, "Qitta"(Unleavened bread), "Kurkuffa", "Fossosie" and "Cheqa". Since cassava root contains high amount of starch the first four prepared foods were tried in kitchen by mixing cassava with cereals. The foods were prepared following local traditional technology keeping the preference and taste of consumers.

Nutritional quality and organoleptic attributes of cassava based foods: Consisting of 30-40% dry matter, cassava root contains mostly carbohydrates, calcium and phosphorus. It is poor in protein and fat (Table 2). Cassava leaves in contrast contain high levels of protein in addition to being rich in vitamins (CIAT, 2001). The nutrients in deficit can be enriched during food

Table 1: Processing and detoxification of cassava (Amaro red), (mean of 3 measurements)

Processing used	mgCN/100 g	% Removed
Raw Cassava, peeled	3.78	-
Peeled, center taken out and washed 2-times	2.34	38.09
Peeled and Boiled, boiling water disposed	1.48	60.84
Peeled, center taken out washed 2-times and boiled	0.53	85.97
Peeled, chopped and sun dried	0.50	86.77
Peeled, chopped, sun dried and ground	0.41	89.15
Semi chopped and boiled cassava	1.39	36.80
Bread: Maize + Cassava flour (50% mix)	< DL*	≈ 100.00
Bread: Enset + Cassava flour (50% mix)	< DL*	≈ 100.00

DL* = Detection Limit

Table 2: Proximate composition of cassava (Amaro red) based traditional Ethiopian recipes (mean of 3 measurements)

Recipe name	Blend propotion	Moisture (%)	Fat (%)	Protein (%)	Ash (%)	CHO (%)	Crude fiber (%)	Energy (kcal/100 g)
Anebabero	50/70% Cassava with Maize	56.7/62.0	0.9/07	3.5/2.7	2.4/2.8	36.6/31.9	0.9/0.9	168.5/144.7
	50/70% Cassava with Wheat	61.0/62.8	0.3/0.5	3.3/2.7	2.7/3.0	32.8/31.1	1.0/1.0	147.1/139.7
Dabbo	50/70% Cassava with Maize	43.4/45.9	1.5/0.7	4.1/3.0	2.5/3.1	48.5/47.4	1.0/1.0	223.9/207.9
	50/70% Cassava with Wheat	45.5/46.8	0.3/0.8	4.4/3.2	3.0/3.6	46.8/45.6	1.2/1.2	207.5/202.4
Injera	50/70% Cassava with Maize	60.6/62.0	0.4/0.3	2.4/1.9	2.5/2.8	34.2/33.0	1.1/2.2	150.0/142.3
	50% Cassava with Teff	61.0/58.9	0.3/0.3	2.4/2.1	2.9/2.6	33.3/36.1	0.8/0.9	145.5/155.5
Porridge	50/70% Cassava with Barley	73.8/67.6	0.2/0.1	1.4/1.4	3.8/2.7	20.8/28.2	0.5/0.6	90.6/119.3
	50/70% Cassava with Maize	65.1/68.9	0.2/0.1	1.8/1.2	3.5/3.3	29.5/26.5	0.6/0.6	127.0/111.7
	Cassava Flour, 100%	8.3	1.3	1.6	3.2	85.5	2.1	360.1

Table 3: Mineral content of Cassava (Amaro red) based traditional Ethiopian recipes

Recipe name	Blend proportion	Calcium	Zinc	Iron	Phosphorous
Anebabero	50/70% Cassava with Maize	98.5/110.9	1.7/1.9	2.3/4.9	27.0/22.4
	50/70% Cassava with Wheat	125.2/198.6	1.9/1.8	4.1/4.9	24.2/26.3
Dabbo	50/70% Cassava with Maize	91.1/105.2	2.3/1.3	3.3/2.6	11.3/20.8
	50/70% Cassava with Wheat	126.6/123.8	1.8/1.4	4.2/3.0	16.7/10.3
Injera	50/70% Cassava with Maize	161.6/275.4	1.5/1.4	7.7/6.3	20.9/20.1
	50/70% Cassava with Teff	164.8/217.5	2.1/1.5	18.8/12.1	24.5/22.1
Porridge	50/70% Cassava with Barley	102.0/120.0	1.5/1.3	3.2/3.0	22.2/6.2
	50/70% Cassava with Maize	80.5/99.3	1.2/1.2	2.0/2.2	19.5/6.6
	Cassava flour, 100%	237.8	1.0	1.4	88.0

Table 4: Sensory characteristics of prepared Anebabero (A) and Injera (I)

Recipe and Blend proportion	Appearance	Taste	Texture hand feel	Texture mouth feel	Odor	Pliability	Over all acceptance
A, 50% cassava with wheat	7.78^{a}	8.34	8.62	8.48	7.78^{a}	8.75^{a}	8.20^{a}
A, 70% cassava with wheat	6.72^{a}	7.25	8.09	7.46	7.67^{a}	7.99^{b}	7.67^{a}
A, 50% cassava with maize	9.00^{b}	8.34	8.34	8.34	8.48^{b}	8.62^{a}	8.48^{b}
A, 70% cassava with maize	9.00^{b}	8.62	9.00	8.94	8.73^{b}	9.00^{a}	9.00^{b}
I, 50% cassava with Maize	7.22	7.55	7.71	7.22^{a}	7.55	8.04	7.22
I, 70% cassava with Maize	8.05	7.90	8.50	8.65^{b}	7.60	8.35	8.20
I, 50% cassava with Teff	6.73	6.89	7.87	7.87^{a}	7.87	8.36	7.55
I, 70% cassava with Teff	6.25	6.70	7.45	7.15^{a}	6.85	7.75	7.15

Values within the same column with different superscript are significantly different ($p<0.05$)

Table 5: Sensory characteristics of prepared Dabo (D) and Porridge (P)

	Appearance	Taste	Texture hand feel	Texture mouth feel	Odor	Over all acceptance
D, 50% cassava with wheat	6.85	6.55	7.00	6.71	7.15	7.00
D, 70% cassava with wheat	7.81	7.04	7.43	6.90	7.17	7.43
D, 50% cassava with maize	7.60	7.46	7.15	7.60	7.45	7.45
D, 70% cassava with maize	8.15	7.94	7.69	6.91	7.04	7.69
P, 50% cassava with Barley	6.40^{a}	5.80^{a}	6.60	6.40	6.00	5.80^{a}
P, 70% cassava with Barley	6.25^{a}	5.95^{a}	6.40	6.85	6.40	6.40^{a}
P, 50% cassava with Maize	9.00^{b}	7.20^{b}	7.60	7.80	7.40	7.80^{b}
P, 70% cassava with Maize	8.53^{b}	7.38^{b}	7.87	8.04	7.38	8.04^{b}

Values within the same column with different superscript are significantly different ($p<0.05$)

preparation by blending with other food items such as beans, meat, cereals and vegetables. The nutrient content of the food products were presented in Table 2-3.

Anebabero made from maize has shown more rates in appearance, odor and overall acceptance than that of wheat ($p<0.05$). The sensory attributes of Injera made from maize and cassava are moderately accepted (Table 4). Dabo from maize and wheat are liked moderately by the panelist (Table 5). The appearance and over all acceptability of porridge made from maize is more rated than that of Barley ($p<0.05$). The porridge made from both 50% and 70% cassava blended with barley is slightly liked by the panellist. Over all, the textural and appearance of cassava based foods are improved by increasing percent of maize. The finding clearly indicated the importance of cereal blend of cassava not only in terms of organoleptic attributes but also in increasing the nutritional quality of traditional recipes.

DISCUSSION

The observed productivity of cassava in the study areas is very low when compared with other cassava growing countries (CIAT, 2001). The low productivity might be due to poor soil condition and cultivation of cassava not as a priority crop. In some of the areas, as noted by investigators, cassava is planted on poor soil after proofing the unsuitability of the soil for other crops.

According to the FGD, although cassava is becoming staples in the diet of the study group they did not consider its importance due to the health implication. As a response to problems occurred by consuming boiled cassava and few studies conducted concerning health impact of cassava consumption, the people have information on its cyanogenic effects. They consume cassava only as a means to tackle seasonal food shortage. Among the study group physically feasible neurological problems such as "konzo" was not visible (Ernesto *et al*., 2002; Cardoso *et al*., 2004; Nhassico *et al*., 2008) and no fatal intoxication has been reported. However, in all the study areas people complain different health problems by frequently consuming boiled cassava and brewed alcoholic and non-alcoholic beverages. The burning effect of cassava made local alcoholic beverage might be attributed due to residual dissolved linamarin. The problem is serious when the diet is not complemented with protein rich foods especially sulfur containing amino acids (Cardoso *et al*., 2004). Moreover, the toxin inhibits iodine uptake by the thyroid gland thereby aggravating iodine deficiency. The symptoms observed agrees with studies reported from cassava consuming populations elsewhere in the world (Nhassico *et al*., 2008; Akintonwa *et al*., 1994; Abuye *et al*., 2008). The death of cattle as a result of consuming cassava leaves just after dry season may be due to the higher enzymatic activity in the young fresh leaves (Metre, 2006).

Cassava is one of the very few tropical crops where cyanide content has not restricted its use as an important food for human consumption. This is because a large variety of processing techniques have been developed in different parts of the world. The degree of reduction of cyanide in the final product varies greatly with the type of processing techniques used (Nhassico *et al*., 2008; Cardoso *et al*., 2005; Bradbury, 2004). As the plant has long history of cultivation and consumption in other parts of the world, different processing methods had developed to neutralize the toxin. But in Ethiopia the crop has becoming popular very recently. The south western part of Ethiopia has dietary habit of tubers and roots unlike cereals and legumes dependent northern and central parts of the country. Although not given a priority, cassava is being produced and becoming a staple food of people in diets of the study areas. Few processing methods such as washing, boiling, drying and fermenting with cereals are used to remove or reduce cyanide in cassava. The removal efficiency of the processing methods described here agrees with the results reported in different papers (Cardoso *et al*., 2005; Bradbury, 2004). Solar drying and fermentation were found to be the best methods in removing cyanide content and detoxifying cassava based foods. Moreover blending of cereals, legumes and animal products in preparation of cassava based foods play great role in detoxification as well as increasing nutrient density and nutritional quality of cassava based foods.

Conclusion: The investigation obtained in this piece of report shall be considered and implemented in the study areas as well as in areas where plantation of cassava is currently being promoted throughout the country. In addition other processing methods; mechanical, electrical and chemical to remove the toxin should be researched and tested for cyanide removal. Since cassava is being promoted to northern dry-land and food insecure areas of the country, cassava blend of staple diets of these areas should be attempted in order to reduce the cyanide content, increase nutrient density and improve nutritional quality without affecting consumer acceptance. Legumes such as Grass pea and Chick pea might be used to increase the protein content of cassava based diets.

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Definitions:

Cheqa: Non distilled beverage made in alcoholic or non-alcoholic form from cereals mainly maize and sorghum

Fososie: is a traditional dish of north omo ethnic groups made by boiling maize flour, kale and haricot bean together

Kurkufa: is a traditional dish among north Omo ethnic groups. It is a spiced food made of mainly maize powder cooked with haricot bean/meat and kale.

Teff: Eragrostis tef

Injera: is a yeast-risen flatbread with a unique, slightly spongy texture. Traditionally made out of teff flour, it is a national dish in Ethiopia and Eritrea.

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