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NUTRITIONAL AND ANTI - NUTRIENT CONTENT OF CASSAVA (MANIHOT ESCULENTA CRANTZ) GROWN IN HARARGHE, EASTERN ETHIOPIA: AS AFFECTED BY VARIETIES AND PROCESSING METHODS

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Abstract

Cassava's (Manihot esculenta Crantz) consumption in Ethiopia is limited because of inadequate production and lack of knowledge to its processing techniques. This study was initiated to investigate the effect of varieties (Kello and Qulle) and processing methods (sun drying, boiling, and soaking) on nutritional quality of cassava. The experiment was laid out as a randomized complete design and replicated three times per treatment. The results revealed that, processing methods and varieties had significantly affected the nutritional qualities. Minerals, total ash and crude protein contents were higher in Kello however less in fat, fibre, moisture and ascorbic acid contents compared to Qulle variety. The proximate compositions, minerals and anti -nutrients of the boiled and soaked cassava were slightly lower than the sun dried. The highest total ash yield was obtained for Kello (2.56%) but the lowest (1.00%) was recorded for Qulle. The highest calcium (15.50mg/100g), phosphorus (39.97mg/100g) and iron (0.74mg/100g) were recorded for sun dried Kello. In addition, the highest hydrogen cyanide was obtained for Qulle (0.96mg/100g) for sun dried and the lowest (0.2mg/100g) was recorded for soaked Kello. The outcome of the study revealed that as both of variety has good nutritional qualities and concurrently less amount of hydrogen cyanide and phytic acid. Furthermore, soaking significantly reduces the anti-nutrients than sun drying and boiling though it had effect on some nutritional qualities.

1. INTRODUCTION

Cassava is a perennial woody shrub that produces storage roots that can be harvested 6 months to 3 years after planting. It is propagated by mature woody stem cuttings, while seeds are used mainly in breeding programs. Under optimal environmental conditions, it compares favourably in the production of energy with most other major staple crops due to its high yield potential [1]. The varieties of cassava are traditionally characterized as high or low cyanide content which is bitter and sweet respectively. The potential of the cassava is large, because it offers the cheapest source of food calories and the highest yield per unit area. It also has multiple roles as a famine reserve, food and cash crop, industrial raw material and livestock feed [2].

The advantage of cassava has over other crops particularly, in many of the developing world is its outstanding ecological adaptation, ease of cultivation and high yields. It is also one of the most drought tolerant crops and can be successfully grown on marginal soils, giving reasonable yields where many other crops do not grow well [3]. It is the fourth most efficient crop plant, the most widely distributed and cultivated in different parts of the tropics among the tropical root crops [4]. Because of the perceived agricultural advantages of growing cassava and increasing population pressures, its usage is being extended to regions in Africa and elsewhere in which it was not formerly used.

Cassava is mostly sources of a starchy food. According to [5] age of the plant, variety, climatic conditions and cultural practices like processing methods are among the factors that affect chemical composition of the cassava root. The cassava root has an average composition of 60%- 65% moisture, 30% - 35% carbohydrate, 0.2% -0.6% extractives, 1%-2% crude protein, 0.3%-1.3% ash, 0.8%-1.3% fibre and vitamin C is found in an appreciable amount [6]. Cassava also provides minerals including relatively high amount of calcium and iron which are found in higher qualities in some product such as grain than in the raw root [7].

Major disadvantages of the cassava crop are the low tuber protein content, rapid tuber perishability following harvest, and high content of the cyanogenic glucosides: linamarin and lotaustralin which is the main toxic substance in cassava roots. In addition other anti-nutritional factor such as phytates is found in small proportion as compared to cyanide and reduces the bioavailability of essential nutrients. Therefore, all cassava and cassava based products should pass through different effective processing methods to suppress an adverse health effect that arises from cyanide toxicity as a result of cassava consumption and also to improve the nutritional profile and reduce the anti-nutritional factors that hinder normal absorption of nutrients.

In Ethiopia, cassava has been cultivated in the southern and southwestern regions for decades as an alternative food security crop [8]. In the Southern Ethiopia, particularly in Amaro-Kello area, cassava is almost used as a staple food. In Wolayta and Sidama Zone, cassava roots are widely consumed after washing and boiling or in the form of bread or "*injera*"(Ethiopia staple food) after mixing its flour with that of some cereal crops such as maize , wheat, sorghum and, *tef* [9].

Processing of cassava roots into dry form reduces the moisture content; convert it into more durable and stable product with less volume, which makes it more transportable. Processing is also necessary to improve palatability, eliminate or reduce the level of cassava cyanide contents [10]. On the other hand, in Ethiopia, processing methods, storage experience and modes of consumption are not yet tailored unlike most of cassava producing and consuming African countries. Currently, some cassava varieties are being promoted in some parts eastern Hararghe, Ethiopia by Haramaya University. However, this distribution of the cassava cultivars is not supported by proper training to process cassava into value added products or for domestic consumption. Therefore, it is a need for development of improved cassava food processing methods especially for populations living in rural and poor areas. In addition, the nutritional quality of cassava can be affected by different factors in which varieties and processing methods are the one. Hence, the study fills this gap by investigating on the effect of varieties and processing methods on nutritional and anti-nutritional content of cassava.

2. MATERIALS AND METHODS

2.1 Experimental Site

The laboratory analysis was conducted at the central laboratory and Department of Food Science and Postharvest Technology, Haramaya University, Ethiopia.

2.2 Experimental Materials

The study materials consisted of two sweet cassava varieties; namely, Qulle and Kello and three processing methods (sun drying, soak – sun drying and boil-sun drying). Samples of the cassava roots were transported from the source to the laboratory within 2 hours of harvest. The cassava roots were 12 months old at the time of harvest.

2.3 Experimental Design

The effect of variety and processing methods on nutritional and anti-nutrient content of cassava was studied using Completely Randomized Design in a factorial arrangement. The treatment was replicated three times. The nutritional and anti-nutrient content of cassava of both varieties were studied on freshly harvested (sun drying), soak – sun drying, and boil - sun drying. The output sun dried data was used as a control treatment.

2.4 Sample preparation

For the purpose of the study, fully matured, 12 months after planting fresh cassava samples were collected from gara mulata, Gurawa Woreda of east Hararghe zone. The roots were sorted and washed with tap water to remove adhered soil. Then the tubers were washed, the outer layers peeled off manually with knife, sliced into chips 2-3 cm in length and were subjected to three different processing methods prior to sun drying. These included (1) soaking in water for 48 hours with exchanging water with every 12 hrs. The ratio of cassava chips (kilogram) to volume of water (litres) used was 1:3 w/v modification of method by [11]. (2) Boiling in water for 3 minutes at 100°C with continuous stirring of the mixture. (3) The last batch was immediately sun-drying after chipping without any treatment. After processing with above process, the chips were sun-dried (3 days, 27 ± 2^{o}C) on cleaned stainless steel trays placed on bed about 2 m above the ground. The dried chips were finely milled into flour using sample miller and sieved to pass through 250 μm aperture. The cleaned cassava flour sample was packed in polyethylene plastic bags, and stored in a refrigerator temperature (4^{o}C) until analysis.

2.5 Nutritional and Anti – nutritional Analysis of Cassava

Moisture content was determined by drying the samples at 105 ^{o}C for 3 hours. Crude protein content was determined by *micro*-Kjeldahl method (digester F30100184, SN 111051, VELP Scientifica; distiller F30200191, SN 111526, Europe) of nitrogen analysis (% protein = %N x 6.25) by taking about 1.0g cassava flour [12] using urea as a control in the analysis. Ash content was determined after carbonization of about 2.0g cassava flour and ashing (525^{o}C) in a muffle furnace (Model: MF 120, SN: 04- 1524, Ankara-Turkey) until ashing was complete [12]. Crude fiber content was determined by taking cassava flour sample (about 3.0g) as a portion of carbohydrate that resisted sulfuric acid (1.25%) and NaOH (1.25%) digestion followed by sieving (75 μm), washing, drying and ignition to subtract ash from fiber [12]. Crude fat was analysed by using Soxhlet extraction method. Carbohydrate content of cassava was determined by subtracting the above proximate composition values from 100 using formula of

$$C(\%) = 100 - (\%M + \%A + \%F + \%FB + \%P)$$

Where: C(%), % M, % P, % F, % Fb and % A) are percentage of carbohydrate, moisture content, protein, fat, fiber and ash content respectively. Energy was calculated as described by Osborne and Voogt (1978) using the Atwater factors: 1g of carbohydrates (C) provides (4 kcal), 1g of protein (P) provides (4 kcal) and 1g fat (F) provides (9 kcal).

$$\text{Energy (kcal/100g)} = [9 \times \text{fat}(\%) + 4 \times \text{carbohydrate}(\%) + 4 \times \text{protein}(\%)]$$

Hydrogen cyanide content was determined using the alkaline picrate paper spectrophotometric method as described by [13]. Phytic acid was determined through phytate phosphorus (Ph-p) analysis by the method described by [14]. The concentrations of Ca in cassava sample were determined by flame atomic absorption spectrophotometer (Buck Scientific Model 210 VGP, East Norwalk, USA) using an air -acetylene flame. Iron in cassava samples was determined following the method of [15] and the level was determined

using atomic absorption spectrophotometer. Phosphorus content was determined after digestion of cassava flour (about 10 mg) and measuring the absorbance of phosphomolybdate blue color at 822 nm with UV–Vis spectrophotometer [16]. Phosphorus content was estimated from a series of standard (0.2-1.2 µg P/mL) calibration curve prepared from K_2HPO_4. Ascorbic acid content was determined using the indophenols titration method as described by [17]. The pH was determined according to [18]. The cassava juice was extracted and filtered through cheese cloth. The pH of juice was determined by a glass electrode attached to pH meter (Metrohn 510 pH meter).

2.6 Data Analysis

Analysis for the nutritional and anti-nutritional data was carried out using two ways analysis of variance (ANOVA) using SAS statistical package (version 9.1, SAS Institute Inc., Cary, NC, USA). Means separation was done using the Fischer's least significant differences (LSD) at $p < 0.05$.

3. RESULTS AND DISCUSSIONS

Results of the proximate composition of cassava tubers were shown in **table 1**. Total ash, crude protein, crude fat, fibre and carbohydrate contents of the cassava tubers had significantly ($P < 0.05$) affected with the main effect of variety and processing methods, and their interactions. However, while moisture contents affected by main effects of variety; the energy value was not influenced with main effect of variety and processing methods (**Table 1**). In this study, total ash and crude protein contents were higher in Kello variety however less in fat, fibre and moisture contents compared to Qulle variety. The significant differences in proximate composition among the cassava varieties in this study could be attributed to varietal differences as reported by [19]. The proximate compositions of the boiled and soaked cassava tubers were slightly lower than the sun dried samples, probably due to leaching [20] reported that heat processing might release some nutrients in food samples**.**

The ash contents obtained from this study (1.00% and 2.56% for soaked and sun dried respectively) were comparable to the value reported by [21], of 2.9 to 3.0%. However, the result of ash obtained in this study is greater than ash content for Nigerian cassava flour (0.33 to 0.77 %) reported by [22]. The amount of protein obtained in this study was 1.64 % to 2.63 % in Kello variety and it is corroborating with the reported result of [23] which is 1% to 3%. Furthermore, as the report of [24], most of the cassava cultivars have protein contents in the range of 1.5 to 4.7%. Boiling and soaking reduces the amount of protein in both varieties. This effect could probably due to the denaturizing of protein caused by the effect of heat on the cassava samples during blanching and soaking time.

Table 1. Effects of varieties and processing methods on proximate composition and energy values of cassava (dry matter basis)

Variety	Processing method	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Fiber (%)	CHO (%)	Energy (kcal/100g)
Qulle	Boiled-Sun Dried	9.52±0.17^{a}	1.11±0.19^{d}	2.12±0.14^{c}	1.08±0.00^{a}	2.99±0.00^{a}	83.17±0.29^{bc}	350.87±1.37^{a}
	Soaked-Sun Dried	9.63±0.16^{a}	1.00±0.00^{d}	1.73±0.04^{d}	1.05±0.01^{b}	2.90±0.01^{b}	83.70±0.19^{a}	351.11±0.63^{a}
	Sun Dried	9.45±0.19^{a}	1.35±0.02^{c}	2.35±0.09^{b}	1.08±0.00^{a}	3.00±0.01^{a}	82.78±0.28^{cd}	350.25±0.73^{a}
Kello	Boiled - Sun Dried	8.73±0.11^{b}	2.41±0.14^{a}	1.70±0.09^{d}	1.00±0.00^{c}	2.66±0.07^{c}	83.51±0.08^{ab}	349.77±0.69^{a}
	Soaked - Sun Dried	8.71±0.17^{b}	2.10±0.10^{b}	1.64±0.08^{d}	0.97±0.01^{d}	2.69±0.02^{c}	83.89±0.28^{a}	350.86±0.95^{a}
	Sun Dried	8.55±0.12^{b}	2.56±0.10^{a}	2.63±0.00^{a}	1.00±0.00^{c}	2.70±0.01^{c}	82.72±0.18^{d}	350.38±0.72^{a}
CV (%)		1.72	6.42	4.34	0.38	1.07	0.28	0.25

Where, CV = coefficient of variation; values are mean ± SD and mean values followed by the same letter in a column are not significantly different at 5% level of significance.

The crude fibre content of the soaked and sun dried cassava (2.69% and 3.00% respectively) were somehow greater than the value reported by [25] which ranges from 1.70 to 1.75 % but somehow comparable (1.8 to 2.7 %) with the value reported by [21]. In this study, cassava samples contain low concentrations of fat, ranging from 0.97 to 1.08%. The result obtained in this study is greater than the results for both Qulle and Kello varieties of cassava flour reported by [26], which is 0.2 %. The values obtained for carbohydrate (83.89% and 82.72% for soaked and sun dried respectively was high and it indicates that the processed cassava is good sources of energy and capable of supplying the daily energy requirements of the body [27]. Both cassava varieties were found to be good sources of carbohydrate. The percentage of carbohydrate found in this study is corroborating with the report of [28] which ranges from 80 to 90% on a dry matter basis. Similarly, in this study, the calculated average energy value of cassava was 350.53 kcal/100g; which reveals that as cassava is a good source of energy. The energy content of both cassava varieties were less than the value presented in food composition table by [29], which is 580 kcal/100g.

Ascorbic acid, pH and selected mineral compositions (dry weight basis) of cassava are shown in **Table 2**. The results showed that there were significant differences ($p < 0.05$) in the compositions except in the Calcium and Iron contents for Qulle variety which was not affected by processing methods. In this study, minerals like Calcium, Phosphorus and Iron contents were higher in Kello variety however less in Ascorbic acid contents compared to Qulle variety. The significant differences in mineral composition among the cassava varieties in this study could be attributed to cultivar [30]. The mineral compositions of the boiled and soaked cassava tubers were slightly lower than the sun dried samples, probably due to leaching [20] reported that heat processing might release some nutrients in food samples**.** The most abundant of the minerals was phosphorus followed by calcium, and Iron in that order. The ascorbic acid content of cassava samples obtained were 14.33 and 16.45 mg/100 g (dry weight). Boiling and soaking significantly ($p<0.05$) reduces the ascorbic acid contents than the sun drying in both varieties. This could probably due to the sensitivity of vitamin C to heat and easily leaches into water. The present result of ascorbic acid is less than the report of [31] which is between 15 to 45 mg/100 g.

Table 2. Effects of varieties and processing methods on Ascorbic acid, pH and minerals of cassava

Variety	Processing method	Vitamin C (mg/100g)	pH	Calcium (mg/100g)	Phosphorus (mg/100g)	Iron (mg/100g)
Qulle	Boiled - Sun Dried	14.33±0.50^{c}	6.27±0.12^{b}	11.98±0.03^{c}	33.82±0.23^{d}	0.53±0.03^{c}
	Soaked - Sun Dried	14.44±0.33^{c}	6.23±0.06^{b}	11.64±0.04^{c}	34.57±0.51^{cd}	0.53±0.01^{c}
	Sun Dried	16.45±0.74^{a}	6.53±0.15^{a}	12.03±0.06^{c}	35.50±0.50^{c}	0.54±0.01^{c}
Kello	Boiled - Sun Dried	14.23±0.58^{c}	6.10±0.10^{b}	14.70±0.26^{b}	38.89±0.84^{b}	0.67±0.01^{b}
	Soaked - Sun Dried	14.20±0.29^{c}	6.13±0.12^{b}	14.86±0.33^{b}	38.41±0.52^{b}	0.66±0.04^{b}
	Sun Dried	15.83±0.29^{b}	6.53±0.06^{a}	15.50±0.50^{a}	39.97±0.35^{a}	0.74±0.04^{a}
CV (%)		1.78	1.67	2.00	1.43	4.28

Where, CV = coefficient of variation; values are mean ± SD and mean values followed by the same letter in a column are not significantly different at 5% level of significance.

Table 3 shows the effect of variety, processing method and the combination of the two on anti-nutrient contents of cassava. Hydrogen Cyanide and Phytic acid was significantly affected ($p < 0.05$) by variety, processing method and the combination of the two. Hydrogen cyanide was concentrated in Qulle variety by 40.63% than Kello variety while phytic acid was higher in Kello by 12.92% for sun dried processing methods. The genetic differences among the cassava varieties may have accounted for the differences in the Hydrogen cyanide and phytic acid contents. Though the amount of anti – nutrients found was different due to variety, the observed value was generally low. Soaking significantly ($p < 0.05$) reduces the amount of phytic acid than the other processing methods.

The phytic acid contents of both varieties of cassava flour were found to be comparable to the values reported by [32], with approximately 624 mg/100 g. However, the phytic acid content (31.3 to 60.4 mg/100g) reported by [33], is less than that of phytate concentration determined in the present study. Similarly, the phytate concentration reported (67.4 mg/100g to 73.4 mg/100g) by [21], for cassava flour is also less than from the phytate content of the present study. Phytic acid has the ability to bind cations such

as magnesium, calcium, iron, zinc, and molybdenum and make them unavailable for human body utilization and can cause the deficiency of micro nutrients [34]. It also form stable bond with protein and may inhibit the activity of some enzymes, such as amylase and proteases [35]. However, phytic acids also have antioxidant and ant carcinogenic properties. Indeed, phytic acids can reduce free ion radical generation and thus peroxidation of membranes by complexing iron, and phytate may protect against colon cancer [36].

Table 3. Effects of varieties and processing methods on anti-nutrient contents of cassava

Variety	Processing method	Hydrogen Cyanide (mg/100g)	Phytic acid (mg/g)
Qulle	Boiled - Sun Dried	0.76±0.09^{b}	4.27±0.21^{d}
	Soaked - Sun Dried	0.35±0.03^{d}	3.44±0.03^{e}
	Sun Dried	0.96±0.06^{a}	4.92±0.01^{b}
Kello	Boiled - Sun Dried	0.36±0.02^{d}	5.07±0.15^{b}
	Soaked - Sun Dried	0.20±0.03^{e}	4.65±0.06^{c}
	Sun Dried	0.57±0.01^{c}	5.65±0.18^{a}
CV (%)		5.53	2.81

Where, CV = coefficient of variation; values are mean ± SD and mean values followed by the same letter in a column are not significantly different at 5% level of significance.

Soaking cassava roots for 48 hr reduced hydrogen cyanide contents to minimal values and the percentage of reduction being more pronounced than boiling process in both cassava varieties. The significant reduction the hydrogen cyanide content observed in this study might be explained as a result of enhanced hydrolysis process of cyanogenic glucosides by the enzyme linamarase. Similar results were reported previously by [37]. In addition, the probable justification for cyanide reduction by hydrolysis could be due to size reduction of cassava into small pieces might create easy access for contact between the enzyme and cyanogenic glycosides resulting in higher hydrolysis.

Similar results were also reported by many researchers including [38] who obtained 95.41% reduction by heap fermentation followed by sun drying. In addition, with regard to the reduction in hydrogen cyanide content during the soaking process, [39] observed that, soaking in water cause tissue cellular disruption that results in comparatively greater susceptibility to the actions of bacteria, as indicated by the fall in pH values, and the enzymes α-amalyse and endogenous linamarase. Correspondingly, in this study, the pH of soaked cassava samples were significantly reduced.

Cyanide is the most toxic factor restricting the consumption of cassava roots. Indeed, cassava, particularly its bitter varieties, has a cyanide level higher than the [40] a recommendation, which is < 10 mg cyanide equivalents/kg DM, to prevent acute toxicity in humans. The values obtained were also below the recommendation given by FAO and far below the previously published data of 10 to 500 mg cyanide equivalents/kg dry matter [41] in various food products containing cassava flours. The present study suggested that cassava tuber must be soaked for 48 hr and then drying properly in order to get maximum reduction in HCN content.

Conclusions: The finding of the current study indicates that a cassava chip of both varieties has a good source carbohydrate, energy, vitamin C and some essential mineral elements. The level of cyanide and phytic acid in the sun dried cassava sample is within the acceptable limit. With careful selection of good choice of processing method, the nutritional potential of cassava can be fully harnessed. In this present study, we recommend soaking - sun drying over boil – sun drying and sun drying as a choice of processing method, as this method significantly reduces the anti- nutrients and conserves more nutrients.

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