Science Journal of Analytical Chemistry
2019; 7(4): 83-91
http://www.sciencepublishinggroup.com/j/sjac
doi: 10.11648/j.sjac.20190704.12
ISSN: 2376-8045 (Print); ISSN: 2376-8053 (Online)

Review on Nutritional Value of Cassava for Use as a Staple Food

Adugna Bayata

Ethiopian Institute of Agricultural Research, Jimma Agricultural Research Center, Department of Natural Resource Management, Jimma, Ethiopia

Email address:
adubay2013@gmail.com

To cite this article:
Adugna Bayata. Review on Nutritional Value of Cassava for Use as a Staple Food. *Science Journal of Analytical Chemistry*. Vol. 7, No. 4, 2019, pp. 83-91. doi: 10.11648/j.sjac.20190704.12

Received: July 1, 2019; **Accepted**: September 6, 2019; **Published**: September 27, 2019

Abstract: Cassava is emerging as a dominant staple food, primarily in the humid and sub-humid tropics of many African countries. It has high nutritional value and used by people where food scarcity is adverse and people are afflicted with under nutrition. Cassava roots and leaves are used as sources of carbohydrate, protein, vitamins and minerals. Cassava also contains some anti-nutrients that have an effect on human health when ingested in high amount. But, proper cooking and soaking overnight can detoxify the anti-nutrients before using for nutrition purposes. Bio-fortification, which increases protein, mineral and vitamin contents of cassava, is also utilized to minimize the anti-nutrient and carcinogenic content of the plant. The protein content of cassava could be improved by fortifying its powder with other crops with high protein content.

Keywords: Cassava, Staple Food, Anti-nutrient, Food Scarcity, Adverse

1. Introduction

Cassava (*Manihot esculenta Crantz*) is a drought tolerant, staple food crop grown in tropical and subtropical areas where many people are afflicted with under nutrition and thus, it could be used as potentially valuable food source for developing countries. It is a perennial woody shrub extensively cultivated as an annual crop for its edible starchy tuberous root.

Cassava (*Manihotesculenta*Crantz), native to Latin America, is increasingly grown in tropical and subtropical areas. It is the main source of calories in the tropics and income for small-scale farmers [1]. As has been Asian farmers are known by rice and European farmers are by wheat as well as potatoes African farmers are known by cassava [2]. Cassava (manioc or yucca, with various spellings) is drought tolerant and its mature roots can maintain their nutritional value for a long time without water and thus, it may represent the future of food security in some developing countries. These days, tropical and subtropical countries of Africa, Asia, and Latin America used for feeding of animal with an estimated total cultivation area greater than 13 million hectares, of which more than 70% is in Africa and Asia [2]. Now days, it is a dietary staple in many African countries and is rich in carbohydrates, calcium, vitamin B, C, and essential minerals.

In Ethiopia, this crop has been cultivated in the southern and southwestern regions for decades as an alternative food insecurity crop [46, 47]. 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. 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, or tef [48].

The nutrient composition of the plant differs based on its variety and age of the harvested crop, and soil conditions, climate, and so on. The main aim of this seminar is to review the nutritional value of Cassava and improving its nutrient content through bio-fortification.

2. Literature Review

Cassava *(Manihot esculenta* Crantz) is a root and tuber crop that has been identified as important food, especially in

Africa. In areas where cassava is a main staple, people have developed ways for its processing into storable products such as tapioca, starch, dough and gari. It plays a major role in efforts to alleviate the African food crisis because of its efficient production of food, year round availability and tolerance to extreme stress conditions [3].

Cassava has some inherent characteristics which makes it attractive, especially to the smallholder farmers in Ghana [4].

Figure 1. *Cassava plant.*

Figure 2. *Cassava root.*

Cassava is the third most important food in the tropics, after rice and maize. Its importance derives from the fact that its starchy, tuberous roots are a valuable source of cheap calories, especially in developing countries where calorie deficiency and malnutrition are widespread. Cassava alone provides the major source of dietary calories for about 500 million people, many of them in Africa [5]. Of all the tropical root crops, cassava is the most widely distributed and cultivated root crop in different parts of Africa [6]. It is particularly important in those areas where food supply is constantly threatened by environmental constraints such as drought and pest outbreaks, because of its ability to grow under conditions considered as suboptimal for the majority of food crops. It can be harvested any time from 6 to 24 months after planting and can be left in the ground as a food reserve for household food security in times of famine, drought and war.

Currently, cassava is the largest source of carbohydrates for human food in the world, and it has a high growth rate under optimal conditions and the tuberous roots as well as the leaves are used as human food, animal feed and industrial products [7−10].

Cassava roots contain high energy and high levels of some vitamins, minerals and dietary fiber, and contain no trypsin inhibitor, but create a problem due to presence of cyanide which is removed by postharvest treatments and cooking [11]. The edible green leaves of cassava are a good source of protein, vitamins and minerals and are often used to augment the rural diet [12]. Despite its importance, the research to improve cassava has lagged behind than that of other crops such as rice, wheat, maize, and potatoes.

Its use as a potential food crop in Ethiopia has increased during and after the 1984 famine [13]. In Ethiopia, cassava grows in vast areas mainly in Southern Region [14]. The average total coverage and production of cassava per annum in Southern region of Ethiopia is 4942 hectares with the yield of 53036.2 tones [15]. Although its first introduction into the country is not yet known, the crop had been growing in south, south west and western part of Ethiopia for several years [16]. It is increasingly becoming a source of industrial raw material for production of starch, ethanol, waxy starch, bio-plastics, glucose, bakery and confectionery products, glue among others.

Despite its great potential to make different food recipes, in Ethiopia most of the cassava produced is consumed only by boiling the tuber and supplied with sauce of hot pepper/chili (personal observation). Currently, some cassava collection, introduction and evaluation works have been initiated by the Ethiopian Institute of Agricultural Research (EIAR).

The nutritional value of the roots is important because, they are the main part of the plant consumed in developing countries. Cassava roots and leaves which constitute 50% and 6% of the mature plant, respectively, are the nutritionally valuable parts of the plant [17]. The edible starchy flesh comprises some 80% to 90% total weight of the root with water forming the major components. The water content of cassava ranges from 60.3% to 87.1%, moisture content for cassava flour varies from 9.2% to 12.3% and 11% to 16.5% [18-21]. Water 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 [22]. Cassava contains about 1-2% protein which makes it a predominantly starchy food. The protein content is low at 1% to 3% on a dry matter basis and between 0.4 and 1.5 g/100 g fresh weight [12, 20]. In contrast, maize and sorghum have about 10 g protein/100 g fresh weights [23]. As human food, it has been criticized for its low and poor quality protein content, but the plant produces more weight of carbohydrate per unit area than other staple food crop under comparable agro-climatic conditions.

Cassava is an energy dense food and therefore ranked high for its calorific value of 250×10^3 cal/ ha/day as compared to 176×10^3 for rice, 110×10^3 for wheat, 200×10^3 for maize, and 114×10^3 for sorghum [24]. The root is a physiological energy reserve with high carbohydrate content, which ranges from 32% to 35% on a FW basis, and from 80% to 90% on a dry matter basis [23, 19]. Raw cassava root has more carbohydrate than potatoes and less carbohydrate than wheat, rice, yellow corn, and sorghum on a 100 g basis [23].

The lipid content in cassava roots ranges from 0.1% to 0.3% on a fresh weight basis, it ranges 0.1% to 0.4% and 0.65% on a dry weight basis [20, 25]. This content is relatively low compared to maize and sorghum, but higher than potato and comparable to rice. The lipids are either non-polar (45%) or contain different types of glycolipids (52%). The glycolipids are mainly galactose diglyceride. The predominant fatty acids are palmitate and oleate [26].

Cyanide is the most toxic factor restricting the consumption of cassava roots and leaves. There are three different forms of cyanogens present in cassava root and leaves, these are linamarin, acetonehydrin (lotaustralin) and free HCN. The linamarin and lotaustralin undergo a sequential enzymatic breakdown and the final form is toxic free cyanide. The total of these three forms is called Cyanogenic potential. Cyanogenic glycosides are effective defense agents against generalist herbivores including humans [27]. Cassava leaves have a cyanide content ranging from 53 to 1,300 mg/kg of DW [28, 29] and cassava root parenchyma has a range of 10 to 500 mg/kg dry matter, both of these are much higher than what is recommended [30]. Bitter cassava varieties, have cyanide levels higher than the FAO/ WHO (1991) recommendations, < 10 mg/kg dry matter, to prevent acute toxicity in humans.

Several health disorders and diseases have been reported in cassava eating populations. Consumption of 50 to 100 mg of cyanide has been associated with acute poisoning and has been reported to be lethal in adults [31]. The consumption of lower cyanide amounts are not lethal but long term intake could cause severe health problems such as tropical neuropathy, glucose intolerance, and, when combined with low iodine intake, goiter and cretinism [32, 33].

The nutritional composition of cassava is dependent of specific tissue and on several factors like geographic location, variety, age of the plant and environmental conditions. The roots nutritional value is important because, they are the main part of the plant consumed in developing countries.

2.1. Macronutrients

Cassava root is an energy dense food and it produces about 250,000 calories/hectare/d, which ranks it before maize, rice, sorghum, and wheat [24]. Roots contain small quantities of sucrose, glucose, fructose, and maltose [17]. It has two varieties, bitter and sweet. The sweet variety contains up to 17% sucrose and small amounts of dextrose and fructose [20, 24]. The cassava variety and age determines its fiber content in the root. Usually its content does not exceed 1.5% in fresh root and 4% in root flour. Essential amino acids, such as methionine, cysteine, and tryptophan, are very low in the root and arginine, glutamic acid, and aspartic acid are found in abundant [34]. About 50% of the crude protein in the roots consists of whole protein and the other 50% is free amino acids (predominantly glutamic and aspartic acids) and non-protein components such as nitrite, nitrate, and cyanogenic compounds.

Table 1. *Amino acid profile of cassava.*

Amino acid	Content in roots			Content in leaves		
	%wet Wt	%dry wt	%protein	%wet Wt	%dry wt	% protein
Arginine	0.10	0.29	11.0	0.30	1.48	5.30
Histidine	0.02	0.07	2.60	0.13	0.66	2.30
Isoleucine	0.01	0.03	1.00	0.33	1.67	5.90
Leucine	0.11	0.31	11.70	0.54	2.72	9.70
Lysine	0.02	0.07	2.60	0.37	1.87	6.70
Methionine	0.01	0.03	1.00	0.07	0.36	1.30
Phenylalanine	0.01	0.03	1.00	0.18	0.92	3.30
Threonine	0.01	0.03	1.00	0.27	1.35	4.80
Tryptophan	_	0.29	0.50	0.05	0.24	0.80
Valine	0.01	0.04	1.50	0.20	0.99	3.50
Alanine	0.05	0.15	5.70	0.34 1	1.70	6.10
Aspartic acid	0.04	0.13	4.90	0.49	2.44	8.70
Cysteine	0.003	0.01	0.40	0.04	0.21	0.70
Glutamic acid	0.05	0.15	5.70	0.40	1.99	7.10
Glycine	0.003	0.01	0.40	0.35	1.73	6.20
Proline	0.01	0.03	1.00 0	0.18	0.88	3.10
Serine	0.01	0.04	1.50	0.34	1.68	6.00
Tyrosine	0.003	0.01	0.40	0.18	0.89	3.20

2.2. Minerals and Vitamins

Cassava roots have high calcium, iron, potassium, magnesium, copper, zinc, and manganese contents comparable to those of many legumes, with the exception of soybeans. The calcium content is relatively high compared to that of other staple crops and ranges between 15 and 35 mg/100 g edible portion. The vitamin C (ascorbic acid) content is also high and between 15 to 45 mg/100 g edible portions [24]. Cassava roots contain low amounts of the vitamin B, that is, thiamin, riboflavin, and niacin. The mineral and vitamin contents are lower in cassava roots than in sorghum and maize. Protein, fat, fiber, and minerals are found in larger quantities in the root peel than in the peeled root. But the carbohydrates, determined by the nitrogen free extract, are more concentrated in the peeled root (central cylinder or pulp) [34]. Table 2 shows the mineral concentration and content level of cassava roots. The highest concentration of iron, calcium and magnesium are found in cassava. Zinc is highest in Irish potato and manganese in cocoyam. Cassava and cocoyam are good sources of minerals, and African yam and Irish potato is the second. Except magnesium, water yam contains the least concentration of minerals.

Table 2. *Mineral element concentration in tubers.*

Mineral (ppm)	African yam	Water yam	cocoyam	cassava	Sweet potato	Irish potato
Manganese	0.80	0.00	1.40	0.34	0.08	0.57
Iron	0.00	0.00	1.23	18.80	0.00	3.60
Zinc	0.11	0.00	0.11	0.00	0.05	0.14
Calcium	0.32	0.10	0.39	1.11	0.06	0.09
magnesium	8.58	10.36	9.74	12.54	6.33	8.16

2.3. Processing Effects on Nutritional Value of Cassava

Cassava processing can affect its nutritional value through modification and losses in nutrients of high value. Boiled roots are more efficient than Gari and other products obtained after retting of roots of cassava in keeping nutrients of high value. Raw and boiled cassava root keep the majority of high value nutrients except riboflavin and iron, but products obtained after retting of shucked cassava roots are richer in riboflavin. *Fufu,* is a mashed cassava root product which is fermented with *Lactobacillus* bacteria [35].

*Medua-me-mbong*is cassava's root which can be prepared only by boiling and prolonged washing and it is poorest than other cassava products except in calcium content. Processed cassava root loses a major part of its dry matter, carbohydrates, protein than the boiled one. Raw cassava root contains significant vitamin C, but sensitive to heat and leaches into water; most of cassava processing techniques affect its content [36].

2.4. Processing Techniques of Cassava Root

Storing fresh cassava roots for long period of time is forbidden because, they rot within 48 hours of harvest and it should be processed to increase its shelf life of the product, reduce cyanide content and palatability. Its nutritional value can be improved through fortification with other protein rich crops [37]. The processing methods include peeling, boiling, steaming, slicing, grating, soaking or seeping, fermenting, pounding, roasting, pressing, drying, and milling.

Table 3. *Nutritional value after processing 100 g of cassava root.*

	Whole root	Peeled root	Boiled root	Baton or Chikwangue	Gari	Flour (retting & no peel)	Flour (retting & peel)	Washed cooked
Wet root (g)	100	77.0	87.6	49.2	38.5	25.3-29.6	27.9-34.0	66.80
Fat (g)	0.1	0.1	0.04	0.02	0.2	0.04 to 0.06	0.04 to 0.12	0.03
Dry matter (g)	40.0	32.3	28.3	21.6	29.7	21.3-25.6	20.8-28.7	19.0
Calories	157	127	112	86	119	85-102	83-115	76.00
Protein (g)	1	0.48	0.38	0.18	0.37	0.16-0.22	0.26-0.51	0.16
Carbohydrates (g)	37.9	31.0	27.4	21.2	28.8	20.9 to 25.1	20.3 to 28.1	18.80
Fiber (g)	1.3	0.6	0.5	0.4	0.6	0.4	0.3 to 0.6	0.30
Ash (g)	0.90	0.57	0.46	0.21	0.34	0.16 to 0.19	0.24 to 0.50	0.06
Calcium (mg)	26	13	12	7	10	6.0 to 8.0	7.0 to 15.0	11.00
Phosphorus (mg)	47	39	31	13	18	9.0 to 11.0	10.0 to 21.0	7.00
Iron (mg)	3.5	0.4	0.4	3.1	1.5	0.2 to 0.7	0.8 to 11.9	0.20
Thiamin (μg)	72	31	20	10	18	6.0 to 12.0	13	3.00
Riboflavin (μg)	34	18	16	21	15	10.0 to 12.0	8.0 to 21.0	6.00
Niacin (mg)	0.73	0.52	0.41	0.16	0.33	0. 11 to 0.18	0.17 to 0.37	0.03
Vitamin C (mg)	33	20	1	1	2	0	0	0

2.5. Nutritional Value of Cassava Leave

Despite being nutritionally promising, cassava leaves are containing endogenous anti-nutritional factors, which may limit their nutritive value. The presence of tannins in cassava leaves is thought to be a contributing factor to the low net protein utilization. Tannins have ability to form insoluble complexes with proteins thus interfering with the digestion process by inactivating the enzymes [38]. Cassava leaves contain high levels of cyanogenic glucosides than the amount present in the roots which is powerful inhibitor of enzyme catalyzed reactions and traditional processing methods such as pounding and grinding bring about cyanide reduction.

2.6. Protein and Carbohydrates

Depending on the variety of cassava, the age of the plant, and the proportional size of the leaves and stems, nutrient composition of cassava leaves vary both in quality and quantity. They are rich sources of protein, minerals, vitamins B1, B2, and C, and carotenoids. The crude protein content is comparable to that of fresh egg (10.9 g/100 g) and the amino acid profile of cassava leaf protein is well balanced compared to that of the egg [34, 39]. Cassava leaves have higher essential amino acid content than soybean protein and they are sources of minerals like Ca, Fe, Mg, Mn and Zn [24]. The carbohydrates in cassava leaves are mainly starch, with amylose content varying from 19% to 24% [34].

Table 4. *Comparison of carbohydrate in cassava leaves and others.*

Items	Carbohydrate (g/100g)
Cassava leaves	7 - 18
Green snap beans	7.1
Carrots	9.6
Green soybeans	11.1
Green leaf lettuce	2.8
New Zealand spinach	2.5

2.7. Minerals and Vitamins of Cassava Leaves

Cassava leaves contains high minerals such as iron, zinc, manganese, magnesium, and calcium. Some variation in amino acid content of leaves may be attributed to differences in maturity of leaf, sampling, analytical methods used and ecological conditions. Cassava leaves are richer in thiamin (vitamin B1, 0.25 mg/100 g) than legumes and leafy legumes, except for soybeans (0.435 mg/100 g) Table 2.

The leaves have more thiamin than other several animal foods including fresh egg, cheese, and 3.25% fat whole milk.

2.8. Cassava and Selected Anti-nutrients

On analysis of nutritional value of cassava, its roots are good in carbohydrate and its leaves are good in minerals, vitamins and fiber sources for humans. Even though it is good in nutrients, it contains anti-nutrients that are toxic and interfere with the digestibility and uptake of some nutrients.

The most toxic substance restricting consumption of cassava roots and leaves is cyanide. The cyanide level contained in cassava leaves ranges from 53 to 1300 mg/kg dry matter [28]. Consumption of 50 to 100 mg of cyanide is acute, poisonous and lethal to adults. Lower consumption of cyanide is not lethal but long term intake can cause severe health problem like tropical neuropathy [40]. People ingesting cyanide and high amounts of nitrates and nitrites have the risk of developing stomach cancer. Cassava eating individuals have a high amount of thiocyanate in the stomach due to cyanide detoxification by the body, which may catalyze the formation of carcinogenic nitrosamines [29]. Phytate is another anti-nutrient found in cassava, (624 mg/100 g) roots which binds cations like Mg, Fe, Ca, Zn, Mo interfering with mineral absorption, utilization which may affect its requirement and bind proteins preventing their enzymatic digestion [41, 42].

Oxalates are anti-nutrients affecting Ca and Mg bioavailability and form complexes with proteins, which inhibit peptic digestion. Oxalate ranges from 1.35 to 2.88 g/100 g dry matter for cassava leaf meal [29].

2.9. Bio-fortification and Processing Methods to Improve the Nutritional Value of Cassava

Fortification is the practice of deliberately increasing the content of an essential micronutrient that is vitamins and minerals (including trace elements) in a food, so as to improve the nutritional quality of the food supply and provide a public health benefit with minimal risk to health [43].

Bio-fortification is the process by which the nutritional quality of food crops is improved through agronomic practices, conventional plant breeding, or modern biotechnology. It differs from conventional fortification in that bio-fortification aims to increase nutrient levels in crops during plant growth rather than through manual means during processing of the crops. Bio-fortification may therefore present a way to reach populations where supplementation and conventional fortification activities may be difficult to implement and/or limited [37].

2.10. Bio-fortified Cassava, Vitamin A and Protein Value

Cassava roots, containing crude protein about 1.5%, are low in protein and some essential amino acids. Many strategies have been proposed to improve the protein content of and the composition of amino acids that can be used for consumption purposes. Researchers have tried to improve the nutritional value of cassava by crossbreeding wild type varieties. Hybrids showed promising outcome regarding protein content compared to typical cassava cultivars [43].

Bio-fortification as a necessary vitamin A deficiency intervention, vitamin A malnutrition is widespread in the tropics, leading to irreversible blindness and severely exacerbating infectious diseases due to its essential role in the immune response. According to the WHO, an estimated million preschool children are affected by vitamin A deficiency, with 250,000 – 500,000 children becoming blind every year, half of whom die within a year [44]. Roots of commercial cassava cultivars are rich in starch, but low in proteins and micronutrients, including provitamin A carotenoids; thus bio-fortified cultivars with elevated levels of provitamin A are desirable. Vitamin A is a fat soluble vitamin playing an important role in vision, bone growth, reproduction, and in the maintenance of healthy skin, hair, and mucous membranes. Bio-fortification of staple crops with provitamin A carotenoids is an emerging strategy to address the vitamin A status of the poor. β-caroteneis contained in cassava root in small amounts, a provitamin A carotenoid, which can be converted as needed into retinal, reduced to retinol, and stored in the liver esterified to fatty acids. β-carotene bioconversion to vitamin A in the body is naturally regulated and therefore β-carotene has little potential for toxicity compared with high intake of vitamin A fortified foods

3. Materials and Methods

3.1. Apparatus/Instrument

Instruments used were Spectrophotometer, crucible, cotton wool, volumetric flask, AAS, desiccator, analytical balance, digestion tube, Soxhlet Extraction Apparatus, mortar, pestle, round bottom flask, filter paper.

3.2. Reagents/Chemicals

All the reagents and standard used in this work were of analytical grade. These were: H_2SO_4, $CuSO_4$, Na_2SO_4, boric acid, methyl red, HCl, NaOH anti-bumping chips.

3.3. Sampling and Sample Preparation

Cassava tubers were collected from a local farm and were properly washed with water, the peels were removed separately then the pulps were cut into smaller sizes. The samples were carefully labeled and oven dried at 40°C for 18 hrs. Each sample was ground to its powder form using mortar and pestle and used for analysis. All the analysis were conducted in National Research Institute of Chemical Technology (NARICT).

3.4. Determination of Moisture Content

Crucible were properly washed and allowed to dry in an air oven at 110°C for 10 min to a constant weight. The crucibles were cooled in desiccators for 30 min, then 2.0 g of sample was accurately weighed into the labeled crucibles and the crucible with the sample was placed in an oven maintained at 105°C for 14 h. The percentage moisture content was calculated.

3.5. Determination of Ash Content

Porcelain crucibles were washed and oven dried to a constant weight at 100°C for 10 min and allowed to cool in desiccators, then labeled properly. 2.0g of sample weighed into porcelain crucibles and the crucibles with the samples were transferred into a furnace, which was set at 550 ºC for 8 hours to ensure proper ashing. They were then removed and allowed to cool in the desiccators and finally weighed and ash content was calculated.

3.6. Determination of Crude Fiber

2.0 g of sample was weighed into round bottom flasks and labeled, 100 mL of 0.25 M H_2SO_4 solutions was added to the sample in the flask, and the mixtures were boiled under reflux for 30 min. The hot solutions were quickly filtered under suction and the residues were thoroughly washed with hot water until acid free. Each residue was transferred into the labeled flasks and 100 mL of hot 0.3 M NaOH solutions was added and the mixtures were boiled again under reflux for 30 min and filtered quickly under suction.

The each insoluble residue was washed with hot water and oven dried to a constant weight at 100°C for 2hrs, cooled in desiccators and samples were then incinerated. Lastly, percentage crude fiber content was calculated.

3.7. Determination of the Mineral Content

Minerals were analyzed from the triple acid digestion (wet digestion method). 1 g of sample was weighed into a 150 mL beaker, and 10 mL of conc. HNO_3 was added to each sample in the beaker and allowed to soak thoroughly. 3 mL of $HClO_4$ was added and the mixtures were heated slowly at first until frothing ceases. Heating was continued until HNO_3 evaporated the heating was stopped as charring occurred. The digests were allowed to cool and 10 mL conc. HCl was added and transferred to 50 mL volumetric flask. The volume of the solutions was made up to the mark with distilled water and minerals were measured using atomic absorption spectrophotometer.

4. Results and Discussions

The protein contents are high for non-legumes demonstrate the potential usefulness of cassava leaves as a source of protein in the tropics (Table 5). Raw cassava root are rich in carbohydrate than potatoes and less carbohydrate than wheat, rice, yellow corn, and sorghum on a 100 g basis.

Table 5. *Nutritional composition of different kinds of foods (100g) for comparison to cassava root.*

Food	Water (g)	Energy (Kcal)	Energy (KJ)	Protein (g)	Total lipid	Ash (g)	Carbohydrate by d/ce (g)	Dietary fiber (g)	Sugar (g)
Cassava, raw root	59.68	160	667	1.36	0.28	0.62	38.06	1.8	1.7
Potato, raw	79.34	77	321	2.02	0.09	1.08	17.47	2.2	0.78
Cereals									
Wheat flour, unenriched	11.92	364	1523	10.33	0.98	0.47	76.31	2.7	0.27
Bread, wheat	35.74	266	1115	10.91	3.64	2.2	47.51	3.6	5.75
Rice, unenriched	12.89	360	1506	6.61	0.58	0.58	79.34	_	_
Corn, sweet, raw	75.96	86	358	3.22	1.18	0.62	19.02	2.7	3.22
Corn, yellow	10.37	365	1527	9.42	4.74	1.2	74.26	7.3	0.64
Sorghum	9.2	339	1418	11.3	3.3	1.57	74.63	6.3	_
Vegetables (raw)									
Green beans	90.27	31	129	1.82	0.12	0.66	7.13	3.4	1.4
Carrots	88.29	41	173	0.93	0.24	0.97	9.58	2.8	4.74
Spinach	94	14	59	1.5	0.20	1.8	2.5	_	_
Lettuce, green leaf	95.07	15	61	1.36	0.15	0.62	2.79	1.3	0.78
Soybeans, green	67.5	147	614	12.95	6.8	1.7	11.05	4.2	_
Animal products									
Raw egg (white	87.57	52	216	10.9	0.17	0.63	0.73	_	0.71
Cheese, Cheddar	36.75	403	1684	24.9	33.14	3.93	1.28	_	0.52

Food	Water (g)	Energy (Kcal)	Energy (KJ)	Protein (g)	Total lipid	Ash (g)	Carbohydrate by d/ce (g)	Dietary fiber (g)	Sugar (g)
Milk (whole)	88.32	60	252	3.22	3.25	0.69	4.52	_	5.26
Raw fish (trout)	71.42	148	619	20.77	6.61	1.17	_	_	_

The water content of cassava were compared with some foods like potato, raw egg, raw fish, milk, soybeans, carrots, green beans and lettuce, and the water content of these foods are higher than that of cassava root. Water content cassava flour was much higher than cheese, sorghum, corn, rice and wheat which are consumed by human beings frequently in different countries. Cassava root has higher energy than other sources of energy giving food components, least in protein content and it has relatively rich in sugar. The water content of cassava root is relatively at moderate level compared to others which attribute and important water to the human body for body functionality also its ash content is lower than others.

Table 6. *Mineral content of 100 g of various foods for comparison to cassava root.*

Food	Ca (mg)	Fe (mg)	Mg (mg)	P (mg)	K (mg)	Na (mg)	Zn (mg)	Cu (mg)	Mn (mg)	Se (mg)
Cassava, raw root	16	0.27	21	27	271	14	0.34	0.1	0.384	0.7
Potato, raw	12	0.78	23	57	421	6	0.29	0.108	0.153	0.3
Cereals										
Wheat flour, unenriched	15	1.17	22	108	107	2	0.7	0.144	0.682	33.9
Bread, wheat	142	3.46	48	155	184	521	1.21	0.159	1.123	28.8
Rice, white, unenriched	9	0.8	35	108	86	1	1.16	0.11	1.1	_
Corn, sweet, white, raw	2	0.52	37	89	270	15	0.45	0.054	0.161	0.6
Corn, yellow	7	2.71	127	210	287	35	2.21	0.314	0.485	15.5
Sorghum	28	4.4	-	287	350	6	_	_	_	_
Vegetables (raw)										
Green beans	37	1.04	25	38	209	6	0.24	0.069	0.214	0.60
Carrots	33	0.3	12	35	320	69	0.24	0.045	0.143	0.1
Spinach	58	0.8	39	28	130	130	0.38	0.093	0.639	0.7
Lettuce, green leaf	36	0.86	13	29	194	28	0.18	0.029	0.25	0.6
Soybeans, green	197	3.55	65	194	620	15	0.99	0.128	0.547	1.5
Animal products										
Raw egg (white)	7	0.08	11	15	163	166	0.03	0.023	0.011	20
Cheese, Cheddar	721	0.68	28	512	98	621	3.11	0.031	0.01	13.9
Milk, whole	113	0.03	10	91	143	40	0.4	0.011	0.003	3.7
Fish, trout, raw	43	1.5	22	245	361	52	0.66	0.188	0.851	12.6

Using cassava root for nutritional value is more valuable than using some cereals to obtain some minerals like Ca, K. Using the same amount of cassava root we can get almost twice Calcium (16mg/100g) mineral than egg (7mg/100g), consuming cassava root is more beneficial than raw eggs, corn, wheat and rice to get calcium that is helpful for bone strength. In addition to this someone can harvest calcium, potassium from cassava, with cheap cost than eating potato. Wheat bread gives less than half mineral to our body (potassium) as compared to cassava roots by using equal amounts. Some animal products (cheese, milk), vegetables (green beans, carrots, spinach, lettuce) and from cereals like wheat and sorghum contain higher calcium mineral than cassava when used for food purpose, but they are expensive commercially (table 6). The iron content of cassava root is less than the animal products, vegetables and cereals; consuming cassava for iron mineral is advisable to eat animal products, vegetables or cereals than cassava.

The protein content of cassava could be improved by addition of protein sources into the diet, or alternatively fermenting the cassava prior to adding it into the diet. Cassava leaves contains high minerals such as iron, zinc, manganese, magnesium, and calcium.

5. Conclusions

This review was carried out to investigate the importance and contribution of cassava in securing food scarcity and its proximate and mineral composition as it is fortified with other different flours. Cassava is good source of carbohydrate, vitamins and proteins. The minerals (micro minerals and macro minerals) are not equally distributed throughout the plant. Some valuable nutrition is accumulated in the root of the plant, carbohydrate, and others are accumulated in leaves of the plant, protein, vitamins. Cassava produces a cyanogens, which are toxic to humans and animals when consumed in high amount and processing can remove the cyanogens and anti-nutrients. But, the processing system can reduces some valuable nutritional values. Different processing methods reduce cassava's nutritional value and the cyanide content, especially when the peel is removed.

References

[1] Dixon, M. Response of Cassava Genotypes to Four Biotic Constraints in three Agro-Ecologies of Nigeria. *African Crop Sci. J.* 2002, 10, 11-21.

[2] EL-Sharkawy, M. A. Nutritional Value of Cassava for Use as a Staple Food and Recent Advances for Improvement. 2003, 8, 181-194.

[3] Hahn, S. K. An overview of traditional processing and utilization of cassava in Africa. *Outlook on Agri.* 1987, pp 110-118.

[4] Bokanga, M. Cassava Fermentation and Industrialization of Cassava Food Production. *Proceedings of the Fourth Symposium, Int. Symposium for Trop. Root Crops African Bulletin ISTR. C-AB:* 1992, 197-201.

[5] Yeoh, H. H.; Tatsuma, T.; and Oyama, N. Monitoring the cyanogenic potential of cassava: the trend towards biosensor development. *Trends Anal. Chem*. 1998, 17, 234-240.

[6] Onwueme; Sinha,. Field crop production in tropical Africa. *Tech. center for agri. and rural cooperation (CTA),* 1991, pp 159-237.

[7] Mann, C. Reseeding the green revolution. *Sci.* 1997, 277, 1038-1043.

[8] El-Sharkawy, M. A. Cassava biology and physiology. *Plant Mol. Biol*. 2004, 56, 481-501.

[9] Sheffield, J.; Taylor, N.; Fauquet, C.; Chen, S. The cassava (Manihot esculenta Crantz) root proteome: Protein identification and differential expression. *Proteomics,* 2006, 6, 1588-1598.

[10] Gbadegesin, M. A.; Wills, M. A.; Beeching, J. R. Diversity of LTR-re-trotransposons and Enhancer/Suppressor Mutator-like transposons in cassava (Manihot esculenta Crantz). *Mol Genet Genomics*. 2008, 280, 305-317.

[11] Prathibha, S.; Nambisan, B.; Leelamma, S. Enzyme inhibitors in tuber crops and their thermal stability. *Plant Food Hum Nutr.* 1995, 48, 247-257.

[12] Bradbury, J. H.; Holloway, W. D. Cassava, M. esculenta. Chemistry of tropical root crops: significance for nutrition and agriculture in the pacific. Australian Centre for Int. Agri. Research, monograph no. 6, Canberra, Australia, 1988, p 76–104.

[13] Amsalu, A. Caring for the Land Best Practices in Soil and Water conservation in Beressa Watershed, Highland of Ethiopia: *Tropical Resource Management*, Wageningen University, 2006, p 76.

[14] Mulualem, T. Production, Storage and Post-harvest utilization systems of cassava. *Lambert Academic Publishing centre, ISBN,* 2012*,* 978-3-659-24276-2.

[15] Tesfaye, T.; Getahun, D.; Ermias Sh.; Shiferaw M.; Temesgene, A.; Birhanu, Y. Current status, Potentials and challenges of Cassava production, processing, marketing and utilization*: Greener J. of Agri. Sci.*, 2013, 3, pp 262-270.

[16] Teshome, S.; Demel, T.; Sebsebe, D. Ecological study of the vegetation in Gamo Gofa zone, southern Ethiopia. *J. Trop. Ecol*. 2004, 45, 209-221.

[17] Tewe, O. O.; Lutaladio, N. The global cassava development strategy. Cassava for livestock feed in sub-Saharan Africa: Rome, Italy: FAO, 2004.

[18] Padonou, S. W., Nielsen, D. S., Akissoe, N. H. Hounhouigan, J. D., Nago, M. C. and Jakobsen, M.. Development of starter culture for improved processing of Lafun, an African fermented cassava food product. Journal of Applied Microbiology 2010, 109, 4, 1402–1410.

[19] Zvinavashe, E.; Elbersen, H. W.; Slingerland, M.; Kolijn, S.; Sanders, J. P. M. Cassava for food and energy: exploring potential benefits of processing of cassava into cassava flour and bio-energy at farmstead and community levels in rural Mozambique: Bio-fuels, Bio products and Bio refining: *J. of Dairy Sci*. 2011, 11, 3405-3415.

[20] Charles, A. L.; Sriroth, K.; Huang, T. C. Proximate composition, mineral contents, hydrogen cyanide and phytic acid of five cassava genotypes*. Food Chem*. 2005, 92, 615–620.

[21] Shittu, T. A.; Sanni, L. O.; Awonorin, S. O.; Maziya-Dixon, B.; Dixon, A. Use of multivariate techniques in studying the flour making properties of some CMD resistant cassava clones. *Food Chem.* 2007, 101, 1606–1615.

[22] Padonou, S. W.; Nielsen, D. S.; Akissoe, N. H.; Hounhouigan, J. D.; Nago, M. C.; Jakobsen, M. Development of starter culture for improved processing of Lafun, an African fermented cassava food product. *J. of Applied Micro Biol.* 2010, 109, 1402–1410.

[23] Montagnac, J. A.; Davis, CR.; Tanumihardjo, S. A. Nutritional Value of Cassava for use as a Staple Food and Recent Advances for Improvement. *Comprehensive Review in Food Sci. and Food Safety.* 2009, 8, 181-188.

[24] Okigbo, B. N. Nutritional implications of projects giving high priority to the production of staples of low nutritive quality. In the case for cassava (Manihotesculenta, Crantz) in the humid tropics of West Africa. *Food and Nutri. Bulletin.* 1980, 2, 1–10.

[25] Padonou, W.; Mestres, C.; Nago, M. C. The quality of boiled cassava roots: instrumental characterization and relationship with physicochemical properties and sensorial properties. *Food Chem*. 2005, 89, 261–270.

[26] Hudson, B. J. F.; Ogunsua, A. O. Lipids of cassava tubers (Manihot esculenta, Crantz). *J. Sci. of Food and Agri.* 1974, 25, 1503–1508.

[27] Gleadow, R. M.; Woodrow, I. E.; Constraints on the effectiveness of cyanogenic glycosides in herbivore defence. *J. of Chem. Ecology*. 2002, 28, 1301–1313.

[28] Siritunga, D.; Sayre, R. T. Generation of cyanogen-free transgenic cassava. *Planta*. 2003, 217, 367–373.

[29] Wobeto, C.; Correa, A. D.; de Abreu, C. M. P.; dos Santos, C. D.; Pereira, H. V. Antinutrients in the cassava (Manihot esculenta Crantz) leaf powder at three ages of the plant. *Sci. Tech. Alimentaire*. 2007, 27, 108–112.

[30] Arguedas, P.; Cooke, R. D. Residual cyanide concentrations during the extraction of cassava starch. *Int. J. of Food Sci. and Tech.* 1982, 17, 251–62.

[31] Yeoh, H. H.; Sun, F. assessing cyanogen content in cassava based food using the enzyme-dipstick method. *Food and Chem. Tox.* 2001, 39, 649–653.

[32] Delange, F.; Ekpechi, L. O.; Rosling, H. Cassava cyanogenesis and iodine deficiency disorders. *Acta Horticulturae*. 1994, 375, 289–93.

[33] Harris, M. A.; Koomson, C. K. Moisture Pressure Combination Treatments for Cyanide Reduction in Grated Cassava. *J. of Food Sci.* 2011, 1, 20–24.

[34] Gil, JL.; Buitrago, A. J. A. La yugaen la alimentacion animal. In: Osopina B, Ceballos H, (Eds). La yugaen el tercermilénio: sistemasmodernos de produccion, procesamiento, utilizacion y comercializacion. *Cali, Colombia:* CIAT, 2002, pp 527-569.

[35] Sanni, A. I.; Morlon-Guyot, J.; Guyot, J. P. New efficient amylase-producing strains of *Lactobacillus plan tarum and l. fermentum* isolated from different Nigerian traditional fermented foods. *Int. J. Food Micro Biol.* 2002, 72, 53–62.

[36] Favier, J. C. 1977. Valeuralimentaire de deux aliments de base Africains: le manioc etlesorgho. Paris, France: ORSTOM (editions de l'Office de la Recherche Scientifiqueet Technique Outre-mer). Travauxet documents nr 67. Available from: http://www.congoforum.be/upldocs/manioc.pdf. Accessed Dec 7, 2008.

[37] Hahn, S. K. An overview of traditional processing and utilization of cassava in Africa. 1994, pp 2-8.

[38] Bate-Smith, E. C. Analysis of tannins: The concept of relative astringency. *Phyto chem*. 1973, 12, 907–912.

[39] Jacquot, R. Les facteursd'efficacit´ealimentaire. In: Nutrition et alimentation tropicales. Tome 1, AO editions. Rome, Italy: FAO, 1957.

[40] Halstrøm F, Møller KD. The content of cyanide in human organs from cases of poisoning with cyanide taken by mouth. With a contribution to the toxicology of cyanides. Acta Pharmacal Toxicol (Cph) 1945; 1: 18–28With cyanide taken by mouth, with contribution to toxicology of cyanide. *Pharmacol Toxicol* 1945, 1, 18–28.

[41] Hambidge, KM.; Miller, L. V.; Westcott, J. L.; Krebs, N. F. Dietary reference intakes for zinc may require adjustment for phytate intake based upon model predictions. *J. Nutri.* 2008, 138, 2363–2366.

[42] Marfa, E. K.; Simpson, B. K.; Idowu, J. S.; Oke, O. L. Effect of local food processing on phytate levels in cassava, cocoyam, yam, maize, sorghum, rice, cowpea, and soybean. *J. Agric Food Chem.* 1990, 38, 1580–1585.

[43] Nassar, N.; Alves, J.; De Souza, E. An interesting inter specific cassava hybrid. *Revista Ceres,* 2004, 51, 495–9.

[44] http://www.who.int/vmnis/vitamina/data/en/index.html (accessed on 11, November 2016).

[45] Tanumihardjo, S. Food-based approaches for ensuring adequate vitamin A nutrition. *Comp. Rev Food Sci. Food Safety 2008, 7, 373–381*.

[46] Taye Mengesha. Some quality changes during storage of cassava root. Afr. J. Food Tech; 2000, 5: 64-65.

[47] Desse G and Taye Mengesha. Microbial load and microflora of cassava (Manihot esculenta Crantz) and effect of cassava juice on some food borne pathogens. Afr. J. Food Tech. 2001; 6: 21-24.

[48] Desse G and Taye Mengesha. Microbial load and microflora of cassava (Manihot esculenta Crantz) and effect of cassava juice on some food borne pathogens. Afr. J. Food Tech. 2001; 6: 21-24.

[49] Taye, M. Some quality changes during storage of cassava root. The J. Food Technol. Africa, 2000, 5: 64-65.

[50] CIAT. Improved cassava gene pools. In Annual Report, Cassava Program. Centro Internacional de Agricultura Tropical, Cali, Colombia, 1995, pp. 6-17.