Academic Journal of Chemistry
ISSN(e): 2519-7045, ISSN(p): 2521-0211
Vol. 5, Issue. 8, pp: 116-121, 2020
URL: https://arpgweb.com/journal/journal/20
DOI: https://doi.org/10.32861/ajc.58.116.121

Academic Research Publishing Group

Original Research | Open Access

Determination of Proximate Composition and Anti-Nutritional Content of Cassava in Jimma Zone Ethiopia

Adugna Bayata
Ethiopian Institute of Agricultural Research, EIAR Jimma Agricultural Research Center, JARC Department of Natural Resource Management, Ethiopia
Email: adubay2013@gmail.com

Article History
Received: 23 October, 2020
Revised: 29 November, 2020
Accepted: 26 December, 2020
Published: 30 December, 2020

Abstract

Cassava is a dominant staple food for many developing countries, particularly, in humid and sub-humid tropics. In this study, the proximate composition and cyanide content of cassava tuber grown in Jimma Zone were investigated. Cassava samples were collected from five selected Woredas (Districts) of the Zone, where the plant usually grows. Nutritional compositions such as crude fat, protein, and fiber as well as cyanide contents were considered in this study. Accordingly, the crude fat, protein, and fiber content of the studied cassava root ranged from1.38-3.06%, 1.32-1.90%, and 1.58-2.96%, respectively. The results of the nutritional composition of analyzed cassava root samples were rich in crude fat, protein, fiber, and carbohydrate. The level of cyanide gives its value compared to the limits set by the World Health Organization was low and it may not cause harmful effect on human health.

Keywords: Cassava tuber; Nutritional compositions; Cyanide.

1. Introduction

Cassava (*ManihotesculentaCrantz*) is a woody shrub native to South America [1]. The plant is known by its edible starchy tuberous root. It is a drought tolerant, staple food crop grown in tropical and subtropical areas where many people are afflicted to under nutrition, making it a potentially valuable food for developing countries [1].

It is widely used in food security because; its mature edible tuber can be stored in the ground for up to three years. As a result, it represents a household food bank that can be drawn upon when adverse climatic condition limits the production of other foods. Because of its capability in producing efficient food energy, availability throughout the year, tolerance to extreme stress conditions, and suitability to present farming and food systems in Africa, cassava plays a role to alleviate the African food crisis [2].

Traditionally, cassava tubers are processed by various methods into numerous products and utilized in various ways according to local customs and preferences [3]. In some countries, the leaves are consumed as vegetables, and many traditional foods are processed from cassava tubers and leaves. It is common to African, as rice to Asian, or wheat and potatoes are to European farmers [3]. These days, it is used as staple food and animal feed in tropical and subtropical Africa, Asia, and Latin America, with an estimated cultivated area greater than 13 million hectares, of which more than 70 % is in Africa and Asia [3]. Its mature tubers can maintain nutritional value for a long time without water and can grow in areas that receive just 400 mm of average annual rainfall [4, 5].

Cassava is a dicotyledonous plant belonging to the botanical family Euphorbiaceous and has some inherent characteristics which make it attractive to the smallholder farmers [6]. Although its introduction period is not yet known, it is widely grown in south, south west and western part of Ethiopia [7]. Its use as a potential food crop in Ethiopia has been appreciated since 1984 famine [8]. In Ethiopia, cassava is usually consumed by boiling the tuber. Cassava is the third most important source of calories in the tropics and the sixth most important food crop after sugar cane, maize, rice, wheat and potato, in terms of global annual production [9]. Because of its versatile nature, cassava is referred as the drought, war and famine crop to several developing countries. Thus, it is the important crop to improve food security in a time of climate change [10-12]. There are several indigenous cultivated or semi-cultivated root and tuber crops in Ethiopia. These crops have an important place in the diet of the population. Tuberous roots of the plant which can be retrieved from the soil up to three years after maturity. Cassava tuber is the main consumable part as food product allowing crops to be abandoned during periods of agricultural and social instability. This provides an important form of insurance against social disruption, prolonged droughts, or other periods of stress and unrest. Besides, its production also does not need the use of large amounts of agricultural inputs such as fertilizers, water and pesticides. Cassava is known in Jimma in different names and called as "Muka Furno". For Ethiopians, the consumption of cassava as food is of immense importance and regarded as the food security crop for millions of people. But the nutrient content of cassava tubers, which are cultivated in Ethiopia, has not been addressed so far. Currently, some cassava collection, introduction and evaluation productivity works have been initiated by the Ethiopian Institute of Agricultural Research (EIAR) [13]. However, the nutritional composition, mineral and heavy metal as well as cyanide content of the collected and introduced accessions have not been properly evaluated and remain unknown to both consumers and producers. Since the nutritional value of cassava root from different districts of Jimma Zone in location and variety was not considered; it is necessary to analyze their nutritional values. The present study was, therefore, planned to assess the nutritional and anti-nutritional composition and level of some selected mineral and heavy metals of cassava in Jimma Zone

Cassava has nutritional value a drought tolerant crop which can be grown on infertile soils. Its composition depends on the specific tissue and factors, such as geographic location, variety, age of the plant, and environmental conditions. Cassava is the most important tropical root crop and it ranks fourth on the list of major food crops in developing countries, after rice, wheat and maize. It is an important food crop for about500 million people; in some countries, it provides over 50% of the average daily caloric intake [14]. In Ethiopia, people consume and cultivate the plant without having detailed and enough scientific evidences on the nutritional and anti-nutritional values of this plant.

Cassava (*ManihotEsculentaCrantz*) is cyanide containing food crop used by many indigenous peoples. The exact amount of cyanide in cassava varies and dependent on many factors like plant genetics, plant part, degree of processing, environmental conditions, soil, water, location and season in which the plant grows. Processing situations can alter the cyanide content of this plant, that it is released to the air in the form of gas [15]. Linamarin and Lotustralin is the toxic chemical that contains CN ion attached. Cassava contains toxic elements which can damage human kidney, liver and brain parts related to pituitary glands which are accumulated on its peel or surface [16].

A food safety problem with cassava is that cassava tubers contain considerable quantities of cyanide which occurs in the form of cyanogenic glycosides, primarily linamarin and a small amount of Lotustralin Uyoh, *et al.* [17]. These cyanogenic glycosides break down to release toxic hydrogen cyanide gas during digestion. The consumption of cassava can therefore be harmful to human health. Despite the presence of these naturally occurring toxins, millions of people all over the world have been safely consuming cassava for hundreds of years. The on-going challenge is to ensure that the presence of these cyanogenic glycosides are minimized through proper understanding and possibly control of factors that affect cyanogenic glycoside content of cassava. Roots and leaves contain the highest amount of linamarin [18].

The study could enable cassava producers and consumers to know the nutritional, selected heavy metals, and cyanide composition of different cassava varieties of the area. It increases the awareness of the consumers to selectively use the cassava varieties that are rich in nutritional composition, in order to maintain and sustain food security. The finding could also be used as the background information by researchers who want to undergo further research on nutritional composition of the plant. The composition of cassava depends on the specific tissue and on several factors, such as geographic location, variety, age of the plant, and environmental conditions. The nutritional value of cassava root is important because they are the main part of the plant consumed in developing countries [19].

2. Objectives

The main objective of this study was to investigate the proximate compositions and cyanide content of cassava roots of Jimma Zone, Oromia Regional State, Ethiopia

2.1. Specific Objective

To investigate the moisture, ash, crude protien,crude fiber and crude fat content of cassava tubre's varieties cultivated in the selected woreda's of Jimma Zone

To analyze the level of cyanide in the varieties and compare the variation of nutritional and cyanide compositions among the cassava varieties as well as with standards

3. Materials and Methods

3.1. Sample Collection Site

Cassava samples were collected from five Woredas of Jimma zone; Mana with altitude of (1786 m), Sakachekorsa (2107 m), Dedo (2096 m), Sokoru (1620 m), Gomma (1805 m), above sea level were selected purposively and representative samples were obtained randomly. Two varieties were collected from Gomma Woreda (white and red), but only the white variety was collected from the other four Woredas. Cassava is more produced at those selected Woreda's than other Woreda's of the Zone.

3.2. Sampling and Sample Pretreatment

Locally grown representative cassava tuber samples were collected randomly using traditional materials to dig out the soil and knife to remove the peel in the morning from five selected Woredas of Jimma Zone to determine their nutritional value, to investigate the level of anti-nutrients. All the analyses were conducted in triplicate on cassava root. After collection, the samples were washed with tap water to remove soil and the outer part was peeled mechanically using knife and transported to the laboratory, soaked overnight in plastic pot [20] and then, dried at room temperature, 22.5 ^{o}C. The dried samples were ground using mortar and pestle. The samples were made ready for analysis in triplicate.

3.3. Instruments and Apparatus

Different equipment such as analytical balance (Crystal) to weigh the sample and chemicals, digestion tube to digest the sample, Near Infrared spectroscopy (6500/3), furnace for ashing (Karl Kolb) to determine protein and fiber, drying oven (Memmert) for drying purpose, fume hood were used for this work

3.4. Reagents and Chemicals

Analytical and reagent grade chemicals used during the analysis of the sample were; sulphuric acid, H_2SO_4 (98%, Indian), hydrogen peroxide,(England)H_2O_2 (30%), nitric acid (England), HNO_3 (69%), sodium hydroxide, NaOH (Indian), boric acid, H_3BO_3(Indian), methyl orange (Indian)

3.5. Determination of the Crude Protein Using Kjeldahl Method

The method consists of heating a substance with H_2SO_4 which decomposes the organic substance by oxidation to liberate the reduced nitrogen as ammonium sulphate [21]. A mass (0.5g) of sample was weighed and transferred to digestion tube. 2 mL of H_2SO_4, and selenium was added as a catalyst to the sample and digested for 3 hrs as recommended per the procedure. Acid digest samples were transferred to Kjeldahl flask and 20 mL boric acid solution was measured to Erlenmeyer flask and two drops of indicator solution was added and placed under the condenser. 75 mL of NaOH (40%) was poured to the distillation flask containing digests, distillation flask to the holder was fitted and the distillation was started, 80 mL of distillate was collected and the receiver flask was removed. The distillate was titrated against 0.1 N H_2SO_4 and the volume of 0.1 N H_2SO_4 consumed was recorded and %N was determined. Crude protein was calculated from percentage of nitrogen (CP = 6.25*%N), crude protein

3.6. Determination of the Moisture

Moisture content is one of the most commonly measured properties of food materials. It was determined by the following procedures [22]. The wet sample was weighed (g) and recorded. Wet sample was dried in dry oven to a constant weight, at 105 ºC and each sample was cooled and the weight (g) was taken. The percentage of moisture was calculated

3.7. Determination of Crude Fat and Crude fiber by Near Infrared Spectroscopy

Dried ground sample loaded to the sample holder was scanned by near infrared spectroscopy. Spectral data of sample was obtained by Near Infrared spectrometer and percent of crude fat and fiber were determine [23]

3.8. Determination of Ash

A ground sample 2 g was weighed into a porcelain crucible, W_a and the sample was transferred into the muffle furnace set at 550^0C and ashed for 4 hrs. The crucible and its content were weighed after ashing, W_b. The percentage ash was calculated [24]

$$\% \text{ ash} = (W_b \div W_a) \times 100$$

Wb-crucible + sample after ashing, g
Wa- weight of empty crucible, g

3.9. Determination of Carbohydrate

The total carbohydrate content determined by difference method using the following formula
% carbohydrate = 100 - (ash% + moisture% + crude fat% + crude protein% + Crude fiber %)

3.10. Determination of Cyanide by Titration

20 g of ground cassava tuber was transferred into a distillation flask and left to stand for 3 hrs. It was then distilled until 150 mL of the distillate was obtained as per the procedure. 20 mL of 0.02 M sodium hydroxide was added to the distillate and the volume completed to 250 mL in a volumetric flask using distilled water. Three aliquots, two of 100 mL each and one of 50 ml were obtained. 8 mL of 6 M ammonium solution and 2 mL of 5% potassium iodide were added to the 100 mL aliquots. This was titrated using 0.02 M silver nitrate and turbid color was developed which indicates the end point. Then, the weight equivalent (mg) of cyanide was determined by Association of Official Analytical Chemist AOAC-1990 as follows [25]

1 mL of 0.02 M silver nitrate = 1.08 mg HCN

4. Results and Discussion

Table-1. Proximate composition of cassava from different Woredas

Woreda		Parameters				
	Ash (%)	Crude fiber (%)	Crude Protein (%)	Crude Fat (%)	Moisture (%)	Carbohydrate (%)
MN	1.17 ± 0.29	1.69 ± 0.06	1.42 ± 0.08	1.68 ± 0.05	1.73 ±0.1	92.32 ±0.33
SQ	4.33 ± 0.76	1.58 ± 0.01	1.32 ± 0.03	1.72 ± 0.03	2.13 ±0.18	89.04 ±0.92
SK	2.17 ± 0.29	2.96 ± 0.09	1.37 ± 0.06	1.38 ± 0.10	1.67 ±0.01	90.47 ±0.15
GMW	2.00 ± 0.82	2.69 ± 0.03	1.43 ± 0.04	2.64 ± 0.05	1.91 ±0.08	89.33 ±1.08
GM R	1.83 ± 0.58	2.63 ± 0.02	1.55 ± 0.03	3.06 ± 0.07	1.80 ±0.01	89.13 ± 0.62
DD	1.33 ± 0.29	1.72 ± 0.03	1.90 ±0.05	1.76 ± 0.02	1.91 ±0.06	91.48 ± 0.32
LSD	1.12	0.08	0.10	0.19	0.24	1.27

Where; LSD- Least Significance Difference; GMW- Gomma white, GMR-Gomma red, SK- Sokoru, DD- Dedo, SQ- Sakachekorsa, MN-Mana. Values are mean ± SD of three individually analyzed triplicates (n=3), (p<0.05).

4.1. Proximate Composition of Cassava Root

The nutritional composition and anti-nutritional factors of cassava raw flour were investigated. The fiber content of Sokoru and Sakachekorsa Woredas showed highest and lowest value (2.96% and 1.58%) respectively as both samples were white. GMR was higher in the percentage of crude fiber than the GMW collected from the same Woreda. The ash value of the Woreda's cassava varied from 4.33% to 1.17% Table 1.

In this study, there was a significant difference in the protein level across each Woreda. From Table 1, the protein content of the samples collected from each Woreda was analyzed on the cassava root. The levels of protein in the cassava root ranged from 1.90% to 1.32% and were significantly different ($p < 0.05$). The mean value of protein of Dedo Woreda is higher (1.90%) when compared to other Woreda's mean value of protein. This implies that it consists of higher nitrogenous substances than the others, while the protein content of Sakachekorsa sample is smaller than all of the others; this indicates its nitrogenous substances content is lower which could be the difference in planting time difference. The mean values indicated that the protein content (%) of Mana and Sokoru Woreda has no significan**t** difference statistically.

Ash content is an indication of the mineral composition of any sample, which implies that as the ash content of a sample as the quantity of ash is directly proportional to the mineral content. The ash mean value of the Woreda sample was in the range of 4.33% to 1.33%. In this study, Sakachekorsa Woreda had the highest, at least twice the other ash contents obtained from this area as compared to other samples collected from Sokoru, Mana, dedo and Gomma. The soil in the area is acidic for all of the Woreda’s. Consuming cassava tubers collected from Sakachekorsa for food purpose gives lowest protein, fiber and fat than consuming cassava root collected from other Woreda concluded in this study except ash.

Moisture is an essential parameter in life maintenance and its analysis is widely used in food processing. It can also affect the processibility, shelf life, usability and quality of food and other products. In this study, the moisture level was found in the range of 2.13 % to 1.67 %. Raw cassava tuber obtained from Sakachekorsa Woreda contains highest moisture than other samples taken from all other Woredas. Sokoru samples of cassava flour showed that its moisture level is the least of all other Woredas included in this study. This could be because of the plant age. Moisture content of food is important to consider if the food is suitable before the consumption, because moisture content affects the physical, chemical aspects of food which relates to the freshness and stability for storage of the food for a long period of time**.** Moisture content determines the actual quality of the food before consumption and the subsequent processing in the food sector by the food producers. Moisture rich foods are easily susceptible to the microbial attack may get rotten and damaged. Thus the shelf life of the food material is determined by the moisture content in the food. Low moisture containing foods usually slow down growth of microorganisms hence the need for analysis and control of food moisture. As reported [26, 27] values of moisture indicated that the moisture content of cassava tuber in Jimma is lower comparatively to moisture level in cassava roots obtained from other countries.

This indicates that the cassava varieties found in Jimma are less perishable and can stay for long period of time and it is also less susceptible to microorganism reproduction.

In this study, there was high variation in crude fat content between samples collected from different Woredas Table 1. The range of variation in these parameters was from 3.06 % to 1.38%. The cassava root sample collected from Gomma Woreda was the highest of all others, while the sample from Sokoru Woreda contained lowest percentage of crude fat among all the other Woredas.

Carbohydrates are the main source of energy for our body. The mean values indicated in Table 1 show that there were significance differences among the Woreda cassava tuber in their carbohydrate content. Sample collected from Mana Woreda were highest (92.32%) in their carbohydrate contents as compared to other Woredas, while Sakachekorsa cassava root was the least (89.04%) in carbohydrate content. Gomma of white variety cassava root was higher (89.33%) in its carbohydrate content than that of the red variety from the same Woreda (89.13%). The carbohydrate content ranged from 92.32% to 89.04% as indicated in the Table 1 above. The output of this investigation implies that, the carbohydrate content of cassava from Jimma were higher than other cassava samples. Thus consuming cassava root grown in Jimma are more valuable than others indicated in different studies, as it stores more carbohydrate as well gives more energy [26].

4.2. Concentration of Cyanide

Table-2. Concentration of cyanide in cassava tuber of edible and non-edible portions

Woreda	Cyanide in edible portion, mg/kg	Cyanide in central portion, mg/kg
MN	2.16 ± 0.04	0.55±0.04
SQ	3.83 ± 0.03	0.45 ± 0.03
GMR	1.15 ± 0.04	0.39 ±0.04
GMW	1.33 ± 0.1	0.53 ± 0.05
SK	3.13 ±0.03	0.42 ± 0.03
DD	0.91± 0.08	0.63 ± 0.07
LSD	0.16	0.08

Where; LSD- Least Significance Difference; GMW- Gomma white, GMR-Gomma red, SK- Sokoru, DD- Dedo, SQ- Sakachekorsa, MN- Mana. Values are mean ± SD of three individually analyzed triplicates (n=3), ($p<0.05$). Edible portion is the part which could be consumed, while the central portion is the harden part which couldn't be eaten.

The concentration of cyanide in edible portion of the cassava root ranged from 3.83-0.91 mg/kg, as indicated in Table 2.The result of cyanide found in cassava root which was analyzed showed that, the level of its toxicity in Woreda samples was higher in Sakachekorsa (3.83 mg/kg) and lower in Dedo Woreda (0.91 mg/kg). The concentration of this anti-nutrient could be reduced while processing such as grinding, soaking and drying. In this study, there was significant difference in the level of cyanide between each sample collected from different Woredas as the mean values were indicated in Table 2. Results revealed that the higher in Sakachekorsa, Sokoru, Mana, Gomma white, Gomma red, and Dedo (3.83 > 3.13 > 2.16 > 1.33 > 1.15 >0.91 mg/kg) respectively. The level of cyanide in the non-edible portion of cassava root treated in this study differs significantly. When compared, the edible and central portion, the concentration of cyanide is higher in the edible part than central part. For example, in edible portion the cyanide concentration in Sakachekorsa Woreda was 3.83 mg/kg, but from the same Woreda the concentration of cyanide in central part was 0.55 mg/kg in Mana. This implies that the cyanide concentration increases from the internal part to the outer part [28]. Even though the cyanide concentration in the indicated roots of the cassava collected from Woreda was highest, it is not above the permissible limit set by World Health Organization, WHO. Compared to Ojol, *et al.* [29],(15.4-7.92 mg/kg), result reported from Nigeria, the level of cyanide determined in this study was by far lower. The statistical values indicated that there was a significant difference ($p<0.05$) in the level of cyanide concentration among the Woredas as investigated in this study. Different countries have different safe levels of cyanide, for example the acceptable limit in Indonesia is 40 mg/kg, but WHO has set safe level of cyanide to 10 mg/kg [20] . From this study the level of cyanide in samples collected from different Woredas as compared to World health organization (< 10 mg/kg) is at safe level if consumed. This could be due to the difference in the varieties of cassava, environmental condition of the area and soil type.

5. Conclusion and Recommendations

5.1. Conclusion

Cassava tuber has a major potential as a substitute for other types of flour or it can be used by mixing it with other flours. Its uniqueness to different ecological conditions gave it the most important famine crop reserve. Cassava flour has considerable values in terms of its proximate composition and mineral elements which are related to human health and food. From the selected cassava samples used in this study it is possible to conclude that:

The protein, fiber, fat and carbohydrate percentage were higher in Woreda samples differ from one Woreda to the other, which could be because of the age of the plant. The low concentration of cyanide in all these samples which are below the WHO permissible limit could make these samples to be consumed safely for its benefit to our body by processing it properly.

5.2. Recommendations

Cassava tubers are widely used for food security and it represents a basic diet of about 500 million people in the World. But in Ethiopia, till now there was no enough information regarding its proximate composition, and cyanide content level. Since Jimma agricultural research center has been performing research on the productivity of these different varieties than the nutrient composition, it is advisable to concentrate on the quality beside the productivity of these varieties. Since this study was performed on the cassava root and the result was obtained without incorporating the soil result, it is better to analyze this plant by including the soil result to see its effect at the same time. In addition, as the government has given a great concern to this crop, it is better to launch further investigation on this valuable crop to sustain food scarcity.

Reference

[1] Burrell, M. M., 2003. "Starch: the need for improved quality or quantity An overview." *Journal of Experimental Botany*, vol. 218, pp. 451-456.

[2] Hahn, S. K. and Keyser, J., 1985. "Cassava: A basic food of Africa." *Outlook on Agriculture*, vol. 4, pp. 95-100.

[3] Julie, A. M., Christopher, R. D., and Sherry, A. T., 2009. "Nutritional value of cassava for use as a staple food and recent advances for improvement." *Compressive Reviews in Food Science and Safety*, vol. 8, pp. 181-194.
[4] EL-Sharkawy, M. A., 2003. "Nutritional value of cassava for use as a staple food and recent advances for improvement." *Comprehensive Reviews in Food Science and Food Safety*, vol. 8, pp. 181-194.
[5] Montagnac, J. A., Davis, C. R., and Tanumihardjo, S. A., 2009. "Processing techniques to reduce toxicity and anti-nutrients of cassava for use as a staple food." *Comprehensive Reviews. Food Science and Technology*, vol. 8, pp. 17-27.
[6] Bokanga, M., 1992. "Cassava fermentation and industrialization of cassava food production." In *Proceedings of the Fourth Symposium, Int. Symposium for Trop. Root Crops African Bulletin.* pp. 197-201.
[7] Amsalu, A., 2006. "Caring for the land best practices in soil and water conservation in beressa watershed, highland of Ethiopia." *Trop. Resource Management*, p. 76.
[8] Teshome, S., Demel, T., and Sebsebe, D., 2004. "Ecological study of the vegetation in gamo gofa zone, Southern Ethiopia." *Journal of Tropical Ecology*, vol. 45, pp. 209-221.
[9] Anna, B., Roslyn, G., Julie, C., Anabela, Z., and Timothy, C., 2010. "Cassava: The drought, war and famine crop in a changing world." *Sustainability*, vol. 2, pp. 3572-3607.
[10] Lebot, V. and Tropical, R., 2009. *Tuber crops: Cassava, sweet potato, yams and aroids; CABI*. Wallingford, UK.
[11] Nassar, N. M. A. and Ortiz, R., 2007. "Cassava improvement: Challenges and impacts." *Journal of Agricultural Science*, vol. 145, pp. 163-171.
[12] Pearce, F., 2007. *Cassava comeback*. New Scientist, pp. 38-39.
[13] Tewodros, M. and Yared, D., 2014. "Nature of gene action in elite cassava genotypes (ManihotesculentaCrantz) in South Ethiopia." *Sky Journal of Agricultural Research*, vol. 3, pp. 67-73.
[14] Cock, J., 1985. "Cassava new potential for neglected crop West-view." p. 191.
[15] Available: https://www.glutenfreegigi.com/facts-about-cassava-and-cyanide/.
[16] Available: https://www.pyroenergen.com/articles08/cassava-cyanide-poisoning.htm
[17] Uyoh, E. A., Udensi, O., Natui, V., and Urua, I., 2007. "Effect of different processing methods on cyanide content of garri from four cultivars of cassava." *Journal of Food, Agriculture and Environment*, vol. 5, pp. 105-107.
[18] Cereda, M. P. and Mattos, M. C. Y., 1996. "Linamarin, the toxic compound of cassava." *J Venom. Anim. Toxins*,
[19] Bradbury, J. H. and Holloway, W. D., 1988. "Cassava, M. esculenta. Chemistry of tropical root crops: Significance for nutrition and agriculture in the pacific." *Australian Centre for International Agricultural. Research , Monograph*, pp. 76-104.
[20] Amsalu, N. and Esubalew, G., 2011. "Soaking and drying of cassava roots reduced cyanogenic potential of three cassava varieties at jimma, Southwest Ethiopia." *World Journal of Agricultural Sciences*, vol. 4, pp. 439-443.
[21] John, K. Z., 1883. "A new method for the determination of nitrogen in organic bodies." *Analytical Chemistry*,
[22] AOAC Official Method, 1980. "Dry matter and moisture determination."
[23] Osborne, B. G., 2006. "Near-infrared spectroscopy in food analysis." *Encyclopedia of Analytical Chemistry*,
[24] AOAC official method, 1980. "Determination of Ash."
[25] Official Method of Analysis, 1985. *East Africa Crops*, vol. 15, pp. 33-38.
[26] Albert, L. C. and Klanarong, S. T. H., 2005. "Proximate composition, mineral content, hydrogen cyanide and phytic acid of 5 cassava genotypes." *Food Chemistry*, vol. 92, pp. 615-620.
[27] Madubuike, P. C., Onyema, C. T., Odinma, S. C., and Sokwaibe, C. E., 2014. "Evaluation of mineral elements, cyanide and proximate composition of cassava (mannihotesculentacrantz) from ebony state, Nigeria." *Journal of Environmental Science, Toxicology and Food Technology*, vol. 8, pp. 41-43.
[28] Tweyongyere, R. and Katongle, I., 2002. "Cyanogenic potential of cassava peels and their detoxification for utilization as livestock feed." *Veterinary and Human Toxicology*, vol. 44, pp. 366-389.
[29] Ojol, O., Ogundiran, M. B., and Adebayo, O. L., 2015. "Toxic and essential metals in staple foods commonly consumed by students in Ekiti State, South West." *Nigeria International Journal of Chemistry*, pp. 155-160.