© 2019 IJSRSET | Volume 6 | Issue 4 | Print ISSN: 2395-1990 | Online ISSN : 2394-4099
Themed Section : Engineering and Technology
DOI : https://doi.org/10.32628/IJSRSET196422

Impact of Farming Methods on Some Anti-nutrients, Nutrients and Toxic Substances of Cassava Roots

Akpokodje O. I.[1], Uguru H.[2*]
[1]Department of Civil Engineering Technology, Delta State Polytechnic, Ozoro, Nigeria
[2]Department of Agricultural and Bio-Environmental Engineering Technology, Delta State Polytechnic, Ozoro, Nigeria
*Corresponding author. Email: erobo2011@gmail.com

ABSTRACT

This study was carried out to evaluate the effect of farming methods (organic and convectional) on some nutrients and heavy metals contents of cassava roots. Two cassava cultivars (TME 419 and pro vitamin A) were planted, employing organic and convectional farming methods. Within the organic farming, organic soil amendment was carried out, while in the convectional farming, synthesize fertilizers (NPK 15:15:15 and Maxi Calmag) were used. The organic amendment (compost manure) was formulated from poultry waste, cattle dung and wood sawdust in the ratio of 50%:25%:25% (volume to volume). The two cassava cultivars were planted and closely monitored for 10 months, applying all the relevant agronomic in relation to each farming method. Chemical analyses of the soil and cassava roots were carried out in accordance to standard methods. From the results, the farming methods had significant ($p \leq 0.05$) effect on all the parameters (nitrate, copper, lead, iron, calcium and potassium) studied in the two cassava cultivars. The average nitrate content of the convectional cassava roots was 248.84 mg/kg, which was higher than the 108.59 mg/kg recorded in the organic cassava roots. In addition, the organic cassava roots had lower average calcium content (646.47 mg/kg) Compared to the convectional cassava roots (1788.36 mg/kg). However, significantly lower lead and copper contents of organic cassava roots were recorded, when compared with conventional cassava roots. The lower content of nitrate (a toxic substance) and other heavy metals (copper and lead) in the organic cassava roots, than in the convectional cassava roots shows the relevance of organic farming in modern agriculture.

Keywords : Cassava Roots, Convectional Farming, Organic Farming, TME 419 Cassava, Pro Vitamin A Cassava

I. INTRODUCTION

Cassava (Manihot esculenta Crantz) is a popular staple crop in most Africa and Latin America countries, extensively cultivated for its edible starchy root, a major source of carbohydrates [1]. Cassava root contains about 0.5% crude fat, 3% crude proteins, and about 80% carbohydrate. Carbohydrate content in cassava root is higher than in potato tuber, but less than in wheat, rice, yellow corn, and sorghum [2]. The leaves of bitter cassava cultivar are used to treat hypertension, headache, and pain [1]. Fresh cassava roots contain toxic substances (linamarin, hydrocyanic acid, etc.), which can be rendered harmless through adequate processing like boiling, roasting, soaking or fermentation. There are several cassava cultivars which are differentiated by their botanical characteristics, levels of their hydrocyanic acid and linamarin in their roots and leaves [3]. Concentration of toxic substances found in the cassava roots and leaves are highly dependent on environmental factors (rainfall, sunlight, temperature, etc.), soil type and farming method. According to FAO data, about 292 million tonnes of cassava roots were harvested in the world in 2017, with Africa accounting for more than 178 million tonnes of the world production, and Nigeria being a major producer, produced 59.49 million tonnes of cassava roots in 2017 [4].

Conventional farming is the farming system which makes use of synthetic fertilizers, pesticides and herbicides, accounting for about 98% of the world's total food production [5]. Chemicals and genetically modified organisms make maintenance of conventional systems relatively simple for farmers. In a conventional system, farmers can apply pesticides and herbicides to crops at a much more efficient rate if they are made up of just one type of plant, but this has a number of unintended consequences. Since the goal of conventional agriculture is to maximize yields, environmental health and biodiversity are usually not preserved [6]. According to Worthington [7] Potassium fertilizer has the ability to reduce the magnesium content and indirectly the phosphorus content of some plants. This is because the amount of phosphorus absorption by some plants is highly dependent on magnesium, as lesser magnesium is absorbed; lesser phosphorus is absorbed as well. Conventional fertilizers dissolve readily in soil water presenting plants with large quantities of known nutrient(s).

Organic farming system is an alternative farming method developed to reduce environmental and human health impacts of conventional farming system. Organic farming is gaining broad recognition as a system that complies well with sustainability, an overarching principle that can drive agriculture activities in the years to come [8]. The distinguishing feature of organic farming over conventional (inorganic) farming is the soil fertility management practices. In organic farming, the addition of organic matter to the soil, in the form of plant and animal wastes, preserve the soil structure and provide food for soil microorganisms [7]. Farming practices such as crop rotation, planting of cover crops, and the addition of organic manures (farmyard yam, green or compost) are used to maintain soil fertility in organic farming. The main advantage of the organic farming systems is increased organic matter levels in soil, which beneficially affects the aggregation of soil particles [9].

In recent years, organic farming has gained popularity due to an increase in consumer demand for organically grown foods and desire of growers to sustain and improve the soil [10]. According to Toor [11] organically cultivated tomatoes had higher level of total phenolics than conventional cultivated tomatoes. But some researchers have faulted the positive aspects of organic farming. Brandt and Molgaard [12] reported that organic grown crops contain fewer phytonutrients, although they contained more defensive secondary metabolites, which can be harmful to health in large amounts. While Maggio [13] stated that organic produce farm products are often exposed to infections and pests, which cannot be suppressed efficiently. According to [14], organic grown crops produce poor level of polyphenolic compounds, especially flavonoids and phenolic acids, which in small amounts have been proven to have a beneficial effect on human beings.

The nutritional values of the different cassava cultivars roots have been well investigated, but only few researches had been done on the effects of farming methods (organic and conventional) on the anti-nutritional and nutritional contents of the cassava roots. Therefore, the objective of this study was to evaluate the impact of farming methods on one anti-nutrient (Nitrate), nutrients (Calcium and Potassium) and heavy toxic metals (Iron, Copper and Lead) of two cassava cultivars, namely TME 419 and pro vitamin A. This study would help to determine which farming method is more appropriate in the production of cassava roots for human consumption.

II. METHODS AND MATERIAL

2.1 The study area

The study was carried out at the research station of Delta State Polytechnic Ozoro, Nigeria. Ozoro is located in the rain forest vegetation region of Nigeria, on latitude 5.544 N, longitude 6.232 East and altitude 14 Meters (45.93 Feet) above sea level. Rainfall distribution pattern in this region is bimodal with peaks in July and September and a short dry spell around mid-August [15].

2.2 Composting of the organic manure

The compost manure was composed with a mixing ratio of 50%:25%:25% (volume to volume), of poultry waste, cattle dung and wood sawdust, using passively aerated static pile method. The composing materials were obtained from the animal farm of Delta State Polytechnic, Ozoro, Nigeria, and a timber market located at Ozoro, Delta State, Nigeria.

2.3 Soil sampling and analysis

Topsoil (0-20 cm depth) samples were randomly taken from the experimental field before the land preparation. The collected soil samples were air dried in the laboratory under ambient temperature (26±5°C), and sieved with a 2mm stainless steel sieve. Soil physicochemical and heavy metals analyses were carried out on the soil samples in accordance to standards [16].

2.4 Plants of interest

The two cassava cultivars, TME 419 and pro vitamin A, stems were obtained from the Department of Agricultural Technology, Delta State Polytechnic, Ozoro, Nigeria.

2.5 Experimental setup

Field experiment was conducted to evaluate the effects of farming methods (organic and conventional) on one anti-nutrient (Nitrate), nutrients (Calcium and Potassium) and heavy metals (Iron, Lead and Copper) contents of the two cassava cultivars. The soil amendment management (SAM) lasted for 10 months, during which the cassava plants were closely monitored. The experimental field was divided four main blocks. One cassava cultivar was planted on each block as indicated in Table 1, and spaced 1 m apart in a square grid.

Table 1: Experiment setup

Block	Farming method	Cassava cultivar
Block1	Organic	Pro vitamin A
Block 2	Organic	TME 419
Block 3	Conventional	Pro vitamin A
Block 4	Conventional	TME 419

2.6 Organic farming method

Under the organic farming method, compost manure was incorporated into the soil at the rate of 500kg/ha, three weeks before planting. This was to enable the compost manure to release its nutrients into the soil before planting of the cassava stems, because compose manure usually release their nutrients slowly into the soil. At three months after planting, another batch of compost manure was applied to the cassava at the rate of 300kg/ha. Weeding was done manually with a hoe, and no pesticide was applied.

2.7 Inorganic farming method

Under the conventional faring method, NPK 15:15:15 fertilizer was used as the amendment to improve the soil fertility. The fertilizer was applied at the rate of 200 kg/ha at the point of planting, and repeated five months after planting at the rate of 100 kg/ha. In addition, Maxi Calmag (manufactured by SQN, Santigo Chile) soil amendment was applied to the cassava plants at 6 and 30 weeks after planting, at the rate of 6 kg/ha through foliar application. Insects were controlled with systemic insecticides, while weeds control was carried out by using selective herbicides

2.9 Cassava roots sampling

The two cassava cultivars were harvested at 10 month maturity age. The cassava roots were manually peeled and inspected to remove all pests infested and rotten roots. After this, they were randomly selected, and taken to the laboratory for chemical analyses.

2.10 Cassava roots chemical analysis

The following nutrients (Potassium and Calcium), heavy metals (Iron, Copper, and Lead), and anti-nutrient substance (Nitrate) were analyzed for in the cassava roots. The nitrate content of the cassava roots was determined by the colourimetric method [17]. The (Fe, Cu, Pb, K and Ca) concentration in the cassava roots were determined using the atomic absorption spectrophotometer, in accordance to standard methods [18]. During the chemical analyses of the cassava roots, 10 g of the ground dried cassava sample was poured into a beaker, and digested with 15ml of concentrated acids mixture (HNO_3, HCl, and H_2SO_4, in the ratio of 5:1:1) at 80^{o}C in a water bath until a transparent solution appeared [18]. After that the digested sample was allowed to cool at room temperature, and filtered with whatman No1 filter paper. The filtrate was then diluted with distilled water up to the 100 ml mark of a volumetric flask, before it was analyzed with the atomic absorption spectrophotometer to determine the Fe, Cu, Pb, K and Ca concentrations.

2.11 Experimental design and statistical analysis

A randomized design was used on a factorial scheme of 2 x 2 x 3, which is, two cassava cultivars, two farming methods, and three replicates. The results gotten from this research was subjected to analysis of variance (ANOVA) using the Statistical Package for Social Statistics (SPSS version 20). The means will then be separated using the Duncan's Multiple Range Test at 95% significance level.

III. RESULTS AND DISCUSSION

Results of the soil analysis before the cassava cultivation are presented in Table 2. In addition, Table 2 shows the nutrients contents of the compost manure used as soil amendment in the organic farming.

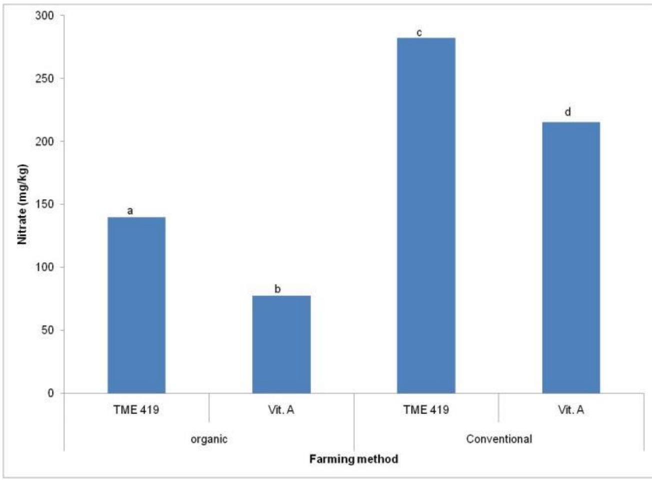
Table 2: Physicochemical properties and heavy metal of the soil and the compost manure

Parameter	Value	
	Soil sample	Compost manure
Physicochemical properties		
pH (H_2O)	7.01	8.12
Nitrate (mg/kg)	4.303	12.120
Sodium (mg/kg)	1.223	21.920
Calcium (mg/kg)	450.748	953.614
Magnesium (mg/kg)	418.24	1721.32
Potassium (mg/kg)	1227.55	9851.44
Heavy metals		
Copper (mg/kg)	2.511	8.774
Lead (mg/kg)	≤0.001	0.431
Iron (mg/kg)	1456.43	3412.23

The results of the study presented in Figures 1 to 5 showed wide variations in the nutritional and heavy metals composition of the cassava roots in the two cassava cultivars studied.

3.1 Nitrate (Anti-nutrient) concentration

The results of the effect of farming methods on the nitrate content of cassava roots are presented in Figure 1. As shown in Figure 1, farming methods significantly ($p \leq 0.05$) influenced the nitrate content of the cassava roots, in the two cassava cultivars. From the results, the average nitrate content of the cassava roots was significantly lower (108.59 mg/kg) in the organic farming, than the average nitrate content of the cassava roots (248.84 mg/kg) observed in the conventional farming. In terms of cassava cultivars, TME 419 cassava roots had significantly higher nitrate content than the pro vitamin A cassava roots. The higher nitrate content of the cassava roots planted under conventional farming system could be attributed to the nitrogenous (NPK 15:15:15) applied to the cassava during the growing period. The amount of nutrients and toxic substances in root and tuber crops are highly dependent the soil nutrients contents. These results are similar to the research results of vegetables [19]. They [19] reported that the mean nitrate content of vegetable grown on nitrogen treated soils was higher (101.90 mg/kg) when compared to vegetables planted on the control soils (85 mg/kg). Application of nitrogen fertilizer and other chemical amendments to the soil has been found to elevate the nitrate content of the plants that were grown on them [20;21]. Nitrate levels in cassava roots decreased with the maturity of the plant [21], *IAC 289-70* cassava root had the lowest nitrate content at 17 months maturity age than 15 months maturity age. A study reported that leafy vegetables harvested during the sunny period of the day recorded the lowest nitrate concentration in the leaves [22]. Medical researches results had showed that high nitrate concentration in plant's tissues is toxic to human beings. According to [23; 24] higher nitrate concentration is responsible for methaemoglobineamia, gastric cancer and many other diseases. Speijers [25] reported that the risk of human beings developing stomach cancer is strongly correlated to the nitrate content of drinking water and the occurrence of atrophic gastritis, and that nitrate ingested into the body is converted by the saliva and the gastrointestinal tract to toxic nitrite substance [26; 27].

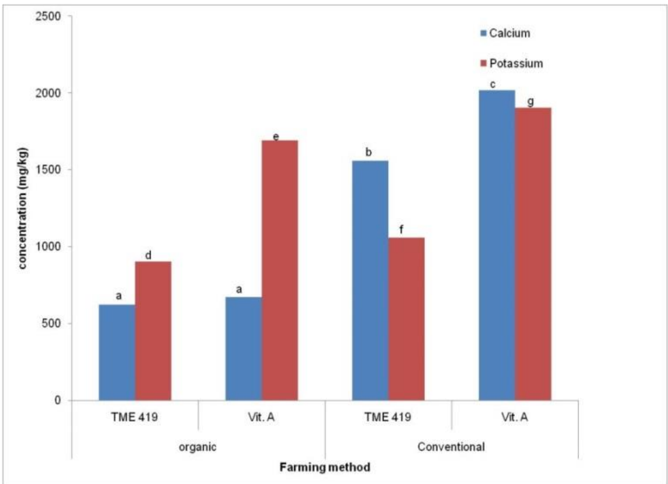


Different letters on columns represent statistical differences ($p \leq 0.05$) using Duncan's multiple range test.

Figure 1: Nitrate concentration in cassava roots

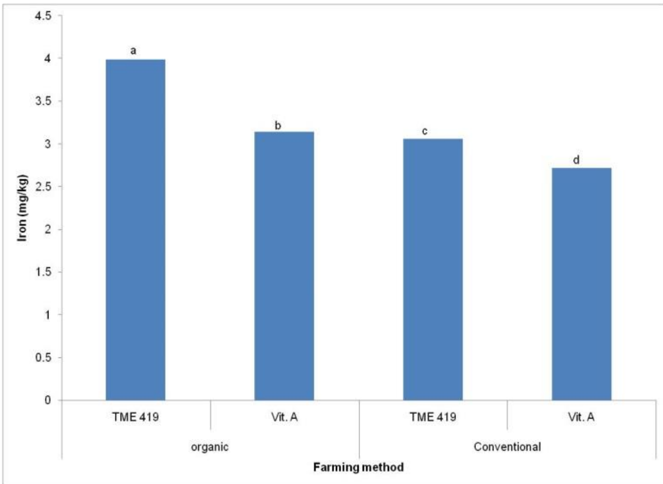
3.2 Cassava roots nutrients content

From the results of the study presented in Figure 2, there were significant ($p \leq 0.05$) differences between the nutrients content of organic and conventional cultivated cassava roots. Data analysis showed that NPK 15:15:15 fertilizer and other chemical amendment significantly ($p \leq 0.05$) elevated the calcium content of the cassava roots; while the compost manure significantly ($p \leq 0.05$) elevated the potassium content of the cassava roots. The chart in Figure 2 showed that TME 419 cassava roots had lower calcium and potassium content than the pro vitamin A cassava roots. According to [28], the potassium concentration of cassava depends on the specific tissue (root or leaf), as well as the geographic location, variety, age of the plant, and environmental conditions.



Different letters on columns represent statistical differences (p ≤ 0.05) using Duncan's multiple range test.

Figure 2: Nutrients concentrations of cassava roots



Different letters on columns represent statistical differences (p ≤ 0.05) using Duncan's multiple range test.

Figure 3: Iron concentration of cassava roots

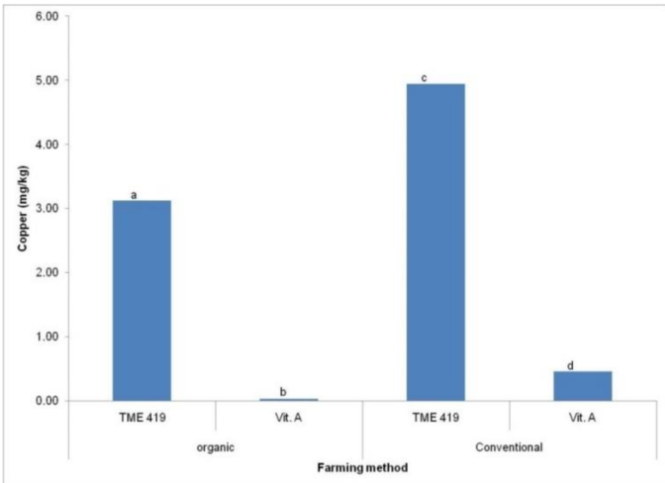
3.3 Cassava roots heavy metals content

Iron content

In terms of the iron content of the cassava roots, the results presented in Figure 3, showed that farming method had significant ($p \leq 0.05$) effect on the iron content of the cassava roots. From the results, the iron content in the organic cassava roots was significantly ($p \leq 0.05$) higher than the iron content in the conventional cassava root (Figure 3). Within cassava cultivars, it was observed from the results presented in Figure 3 that the TME 419 cassava roots contains significantly ($p \leq 0.05$) higher iron content than the pro vitamin A cassava roots, even with the same farming method. High intake of iron in human beings can cause ailment. The results of this study were lower than results [29] obtained for cassava roots and yam tuber. According to [29] the iron concentration in cassava roots was 10 mg/kg, while 11 mg/kg of iron concentration was recorded in yam tubers.

Copper content

Regarding the copper concentration in the cassava roots, the results presented in Figure 4, showed that farming period and cassava cultivar had significant ($p \leq 0.05$) effect on the copper concentration of the cassava tubers. The chart in Figure 4 further showed that the organic cassava roots had lower copper concentration than the conventional cassava roots. In terms of the cassava cultivar, the applied fertilizer and Maxi Calmag amendments significantly ($p \leq 0.05$) increased the copper content of the cassava roots both in the TME 419 and pro vitamin A cassava cultivars. The average copper concentrations recorded in the organic cassava roots were 3.13 mg/kg and 0.001 mg/kg for the TME 419 and pro vitamin A cassava cultivars respectively. While cassava roots harvested from the conventional farming recorded copper concentrations of 4.94 mg/kg and 0.46 mg/kg for the TME 419 and pro vitamin A cassava cultivars respectively (Figure 4). The difference in the copper content of the two cassava cultivars could be attributed to their different genetic makeup of the cassava cultivars. Similar results were obtained by Ajiwe *et al.* (2015) and 29] on cassava roots. Ajiwe [30] reported copper concentration of cassava roots within the range of 10 mg/kg and 27 mg/kg; while [29] recorded cassava roots copper concentration of 5.00 mg/kg.

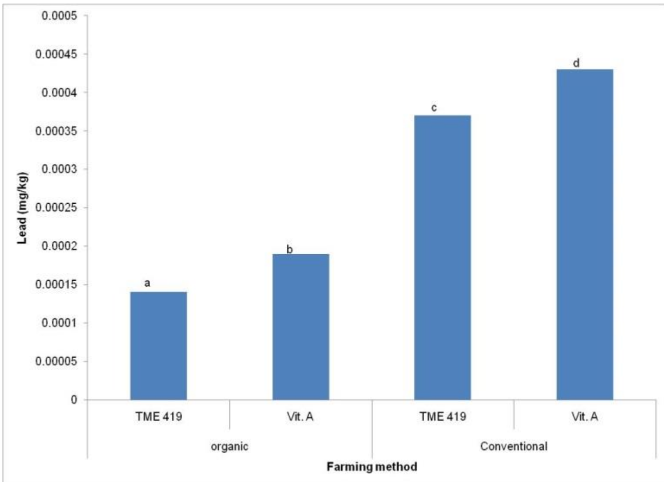


Different letters on columns represent statistical differences ($p \leq 0.05$) using Duncan's multiple range test.

Figure 4 : Copper concentration of cassava roots

Lead content

The result of the effect of farming methods on the lead content of the cassava roots is presented in Figure 5. Figure 5 showed that farming methods significantly ($p \leq 0.05$) influenced the Lead content of the cassava roots, in the two cassava cultivars. From the results, the average lead content of the cassava roots planted in the organic farm was significantly lower (0.0003 mg/kg), than the average lead content of the cassava roots (0.0004 mg/kg) harvested from the conventional farming. In terms of cassava cultivars, TME 419 cassava roots had significantly ($p \leq 0.05$) lower lead content than the pro vitamin A cassava roots. These results were lower than the results obtained by [29; 30] for cassava roots. According to [30] the lead content of cassava roots planted in neutral soil was 0.09 mg/kg, and [29] recorded 0.01 mg/kg lead concentration for cassava roots planted in natural soils. The Lead concentration of the cassava roots recorded in this study, for both cassava cultivars were far below the WHO permissible limits of 0.30mg/kg for lead. Researches had shown that excess Lead accumulation above permissible limit (0.30 mg/kg) could cause body ailments and easily leads to the weariness of the body, tooth and bones [29; 31].



Different letters on columns represent statistical differences ($p \leq 0.05$) using Duncan's multiple range test.

Figure 5 : Lead concentration of cassava roots

Some fertilizers contain toxic heavy metals that are absorbed by the plants when they are applied to the soil. Accordimg to [32], trace mineral fertilizers and liming materials derived from industrial waste can contain a number of heavy metals. Heavy metals inhibit many enzymes and are thus able to disrupt metabolic processes, including photosynthesis in plants. Worthington [7] reported that organic crops contained significantly more vitamin C, iron, magnesium, and phosphorus and significantly less nitrates than conventional crops. Since no mineral fertilizers were used under the organic farming it was expected that organic crops would contain lower amounts of toxic heavy metals, but more researches are needed to confirm this hypothesis.

IV.CONCLUSION

The results of this study showed that farming methods had significant ($p \leq 0.05$) effect on the anti-nutrient, nutrients and heavy metals contents of cassava roots. In addition, the results obtained from this study showed variations in the nutritional and heavy metals composition of cassava roots from the two cassava cultivars. The average nitrate content of the cassava roots was higher in the conventional farm (248.84 mg/kg) than in the organic farm (108.59 mg/kg). Although, the nitrate content in the cassava roots was elevated by fertilizer and Maxi Calmag soil amendment, the nitrate content was still within the tolerable level. From the results obtained, the copper and lead contents of the cassava roots harvested from the fertilizer and Maxi Calmag amended soil were significantly higher than that on cassava roots harvested from compost manure amended soil. The level of potassium in the cassava roots harvested from the conventional farm was significantly lower than cassava roots harvested from the organic farm. While cassava roots harvested from organic farm had lower average calcium content (646. 47 mg/kg) than cassava roots harvested from the conventional farm (1788.36 mg/kg). However, the significantly higher potassium and lower nitrate, lead and copper contents of cassava roots harvested from the organic farm, when compared with the conventional farm, encourages the practice of organic farming. Since fertilizers were not applied to the soil under the organic farming, it was expected that organic cassava would contain lower amounts of toxic heavy metals, but more researches are needed to confirm this hypothesis.

V. REFERENCES

[1]. Kuete, V. (2014). Physical, hematological, and histopathological signs of toxicity induced by African medicinal plants. Toxicological Survey of African Medicinal Plants, 635-657

[2]. Gil, J. L. and Buitrago, A. J.A. (2002). La yuca en la alimentacion animal. In: B. Ospina, H. Ceballos, Eds., La Yuca en el Tercer Milenio: Sistemas Modernos de Produccion, Procesamiento, Utilizacion y Comercialización, Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia: 527-569.

[3]. Ilori, O. O., Adetan, D.A,, Soji-Adekunle, A., Ojo, O. O, Adeleke, K. M. and Towoju, O. O. (2017). Influence of some physical properties of cassava tubers on mechanical compressive cracking force of TMS 30572 and TMS 4(2)1425 cassava varieties. American Journal of Food Science and Technology, 5(6):233-237

[4]. FAO. FAOSTAT database. (2019). World Cassava production. Available at: http://www.fao.org/faostat/en/#data/QC

[5]. Willer, H., and Lernoud, J. (2017). Organic Agriculture Worldwide 2017: Current Statistics; Research Institute of Organic Agriculture (FiBL): Frick, Switzerland.

[6]. Stony Brook University (2019). Sustainable Vs. Conventional Agriculture. Available at: https://you.stonybrook.edu/environment/sustainable-vs-conventional-agriculture/

[7]. Worthington, V. (2001). Nutritional quality of organic versus conventional fruits, vegetables and grains. J. Alternative Complementary Med., 7: 161-173.

[8]. Knight, K.W. and Newman, S., (2013). Organic agriculture as environmental reform: a cross-national investigation. Society and Natural Resources Journal. 26 (4), 369-385

[9]. Mader, P., Fliessbach, A., Dubois, D., Gunst, L., Fried, P. and Niggli, U. (2002). Soil fertility and biodiversity in organic farming. Science Journal 296: 1694-1697.

[10]. Dimitri, C. and Oberholtzer, L. (2009). Meeting market demand in the organic sector: handler-supplier relationships in the face of tight supply. Renewable Agriculture and Food Systems Journal, 24: 137-145.

[11]. Toor, R.K., Savage, G.P., and Heeb, A. (2006). Influence of different types of fertilizers on the major antioxidant components of tomatoes. J Food Comp Anal. 19; 20-27.

[12]. Brandt, K. and Molgaard, J.P. (2001). Organic agriculture: does it enhance or reduce the nutritional value of plant foods. Journal of the Science of Food and Agriculture. 81: 924-931.

[13]. Maggio, A., De Pascale, S., Paradiso, R. and Barbieri, G. (2013). Quality and nutritional

value of vegetables from organic and conventional farming. Scientia Horticulturae Journal 164: 532-539.
[14]. Mizrahi, A., Knekt, P., Montonen, J., Laaksonen, M.A., Heliovaara, M., and Jarvinen, R. (2009). Plant foods and the risk of cerebrovascular diseases: a potential protection of fruit consumption. The British Journal of Nutrition. 102: 1075-1083.
[15]. Eboibi, O., Akpokodje, O.I., Uguru, H. (2018). Growth performance of five bean (Phaseolus spp) varieties as influenced by organic amendment. Journal of Applied Science and Environmental Management, 22 (5): 759 - 763.
[16]. AOAC (2019). Official Methods of Analysis of AOAC INTERNATIONAL, 21st Edition. Association Official Analytical Chemists, Washington, DC., USA
[17]. Sjoberg, A.M. and T.A. Alanko, 1994. Spectrophotometric determination of nitrate in baby food: Collaborative study. J. AOAC Int., 77: 425-430
[18]. Osu, R.S., Solomon, M.M., Abai, E.J., Etim, I.G. (2015). Human health risk assessment of heavy metals intake via cassava consumption from crude oil impacted soils with and without palm bunch ash additive. International Journal of Technical Research and Applications, 3(4): 140-148.
[19]. Musa, A and Ogbadoyi, E.O (2012). Effect of Nitrogen Fertilizer on the Levels of Some Nutrients, Anti-nutrients and Toxic Substances in Hibiscus sabdariffa. Asian Journal of Crop Science, 4: 103-112.
[20]. Boroujerdnia, M., Ansari, N.A. and Dehcordie, F.S. (2007). Effect of cultivars, harvesting time and level of nitrogen fertilizer on nitrate and nitrite content, yield in romaine lettuce. Asian J. Plant Sci., 6: 550-553.
[21]. Wobeto, C., Correa, A.D., de Abreu, C.M.P., dos Santos, C.D. and Pereira, H.V. (2007). Anti-nutrients in the cassava (Manihot esculenta Crantz) leaf powder at three ages of the plant. Ciencia Tecnologia Alimentos, 27: 108-112.
[22]. Reinink, K. (1991). Genotype × Environment interaction for nitrate concentration in lettuce. Plant Breed., 107, 39-49
[23]. Anjana, S.U., Iqbal, M. and Abrol, Y.P. (2007). Are nitrate concentrations in leafy vegetables within safe limits? Curr. Sci., 92: 355-360
[24]. Prakasa Rao, E. V. S. and Puttanna, K. (2000) Nitrates, agriculture and environment. Curr. Sci., 79, 1163–1168.
[25]. Speijers, G.J.A. (1996). Nitrite (and potential endogenous formation of N-nitroso compounds), in Toxicological evaluation of certain food additives and contaminants in food, ed by World Health Organization, Food Additives Series 35, Geneva, 269-323.
[26]. Pannala, A.S., Mani, A.R., Spencer, J.P.E., Skinner, V., Bruckdorfer, K.R., Moore, K.P. and Rice-Evans, C.A (2003). The effect of dietary nitrate on salivary, plasma, and urinary nitrate metabolism in humans. Free Rad Biol Med 34:576-584.
[27]. Santamaria, P. (2006). Nitrate in vegetables: toxicity, content, intake and EC regulation. J. Sci. Food Agric., 86, 10-17.
[28]. Montagnac, J.A., Davis, C.R. and Tanumihardjo, S. A. (2009). Comprehensive reviews in food science and food safety. Institute of Food Technologists, 8. 181 - 194
[29]. Nworu, J. S, Ogbolu, B.O., Nwachukwu, S.O., Izomor, R.N., Oghonyon, E.I. (2018). Heavy metal concentrations in yam and cassava tubers from Enyigba Lead-Zinc Mining Site in South Eastern Nigeria. Journal of Applied Chemistry, 11 (10): 39-43
[30]. Ajiwe, V.I.E, Chukwujindu, K.C, and Chukwujindu, C.N. (2018). Heavy metals concentration in cassava tubers and leaves from a Galena Mining Area in Ishiagu, IVO L.G.A of Ebonyi State Nigeria. IOSR Journal of Applied Chemistry, 11(3):54-58

[31]. Ogbonna, E.C., Out, F.C., Ugbogu, C.O., Nwaugo, O.V., Ugogu, E.A., (2015), Public health implications of heavy metal contamination of plants growing in lead-zinc mining area of Ishiagu, Nigeria, Journal of Biodiversity and Environmental Sciences, 17(5): 8-18
[32]. Batelle Memorial Institute (1999). Background Report on Fertilizer Use, Contaminants and Regulations. Washington, D.C.: National Program Chemicals Division, U.S. Environmental Protection Agency,:27-51.

Cite this article as :

Akpokodje O. I., Uguru H., "Impact of Farming Methods on Some Anti-nutrients, Nutrients and Toxic Substances of Cassava Roots", International Journal of Scientific Research in Science, Engineering and Technology (IJSRSET), Online ISSN : 2394-4099, Print ISSN : 2395-1990, Volume 6 Issue 4, pp. 275-284, July-August 2019. Available at doi : https://doi.org/10.32628/IJSRSET196422
Journal URL : http://ijsrset.com/IJSRSET196422