Evaluation Of Vitamins And Minerals Of Gari Produced From Trifoliate Yam *(Dioscorea Dumetorum)* and Cassava *(Manihot Esculenta).*

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ABSTRACT

Trifoliate yam (*Dioscorea dumetorum)* is a high yielding but underexploited yam species despite being nutritionally superior to other yam species. This study therefore aimed at producing and evaluating the vitamin and mineral content in gari from trifoliate yam (*Dioscorea dumetorum*) and cassava (*Manihot esculenta*). Gari was produced from trifoliate yam and cassava tubers at different ratios 100:0, 90:10, 80:20, 70:30, 60:40, 50:50 respectively and 100% cassava used as a control. Vitamins, minerals and sensory evaluation of garri was done using standard methods. The results of the mineral analysis showed phosphorus was the most abundant mineral with values ranging from 225.67-305.01 mg/100 g. The sodium, magnesium, manganese, copper and zinc values ranged from 213.78-291.38 mg/100 g, 114.13-205.56 mg/100 g, 1.13-2.37, 0.52-0.93 ppm and 0.66-1.21 ppm respectively. Vitamin A ranged from 0.09-1.53 mg/100 g, vitamin B1, vitamin B2, vitamin B3, vitamin B9 and vitamin E ranged from 0.16-0.19 mg/100 g, 0.24-0.29 mg/100 g, 0.27-0.63 mg/100 g, 0.66-1.27 mg/100 g and 0.26-0.30 mg/100 g respectively. From the sensory results, sample IBK (50:50%) was scored best in all the quality attributes However, samples IBK (50:50), RAG (60:40), GRA (70:30), and OLA (80:20) yielded good quality granules with sensory attributes, nutritional content and was generally accepted. From the results obtained in this work, trifoliate yam tuber addition in garri production can be said to increase the vitamins and the mineral content of the product.

Keywords: Vitamins, Minerals, Gari, Trifoliate Yam, *Dioscorea Dumetorum*, Cassava, *Manihot Esculenta*

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1. INTRODUCTION

Trifoliate yam, (Dioscorea dumetorum Pax), belongs to the family Dioscoreaceae and genus Dioscorea (Obidiegwu *et al.,* 2020). It originated in tropical Africa and occurs in both wild and cultivated forms but its cultivation is still restricted to the West and Central Africa (Siadjeu *et al*. 2018).

In Nigeria, its local names include; Esuru (in Yoruba), Ona (in Ibo) and Kosanrogo (in Hausa). It has been reported to be the most nutritious and one of the most important of the eight yam species commonly grown and consumed (Siadjeu *et al.*, 2016; Siadjeu, Mayland-Quellhorst and Albach, 2018). It is a good source of phyto-proteins (9.6%), fairly balanced in essential amino acids (chemical score of 0.94), carbohydrate, vitamins and minerals for human nutrition. It has starch grains that are smaller, more soluble and more digestible than those of other yam species (Otegbayo *et al*., 2018). Agronomically, *D. dumetorum* is high-yielding, with yield of 40 tons/hectare recorded in agricultural stations (Siadjeu *et al.* 2018). A novel bioactive compound *dioscoretine* has been identified in *D. dumetorum*, which can be used as a hypoglycemic agent in anti-diabetic medications (Obidiegwu *et al.,* 2020).

However, despite this superiority in nutritional quality, the crop is gradually being extinct because of non-exploitation of its potentials. Very few farmers are growing trifoliate yam in recent times and in yam markets, little or no trifoliate yam is displayed or sold (Iwuchukwu and Okwor, 2017). The major factor responsible for the neglect of the crop is the rapid post-harvest hardening of tubers which begins within 24 hours after harvest and the consequent hard- to-cook characteristics (Siadjeu *et al.* 2021). *D. dumentorum* had also been reported *to contain* bitter toxic alkaloid called dihydroscorine which is poisonous which can be reduced or eliminated by soaking and fermentation (Omefe *et al.,* 2021).

Garri is a granular food product produced by grating cassava roots into a mash, fermenting and de-watering the mash into a wet cake, and roasting the wet material into gelatinized particles. Garri has a slightly sour taste and it could be white or cream depending on the variety of cassava used and the processing method adopted. The particle size of garri may vary from 0.6 to1.1 mm depending on the method of production and the preferences of the targeted consumers (James *et al.,* 2012). Traces of vitamins A and B are also present with a significant amount of vitamin C in the yam tissues. Garri produced from cassava has been reported to have low content of vitamins and minerals. This study is therefore aimed at evaluating the vitamin and mineral content of garr produced from trifoliate yam tubers *(D. dumetorum*) and cassava tuber (*Manihot esculenta*).

2. MATERIALS AND METHODS

Materials

The tubers of trifoliate yam used for this research were obtained at maturity from a farm at Ifaki-Ekiti, Ekiti State, Nigeria. The raw cassava was freshly purchased at Lagos State Polytechnic, Ikorodu Campus Farm.

Method

Production of Granules (Garri-Like Product)

The method according to Wasiu *et al.* (2021) was adopted with modifications. The freshly harvested tuber of trifoliate yam and fresh wholesome cassava, were conveyed to the Food Processing laboratory at Lagos State Polytechnic Ikorodu Nigeria. Thereafter, the yam tubers were sorted to remove bruised and unwholesome tubers. The selected tubers of the hardened tubers were thoroughly washed with clean water, peeled, washed and grated using a mechanical grater used for garri processing, the grated mash of trifoliate yam tuber and cassava tuber was collected in perforated polypropylene bags in different ratios; 100:0, 90:10, 80:20, 70:30, 60:40, 50:50 and 100% cassava respectively. It was allowed to ferment for four (4) days.

The bags were tightly tied and placed in an adjustable hydraulic press machine. Dewatering and the pressed cassava cake mash was then pulverized and sifted using the mechanical grater to produce wet cassava mash which was introduced into a deep roasting pan to produce the garri. The garri products were cooled in an aluminum tray and packaged differently in sterilized ziploc for storage and analyses.

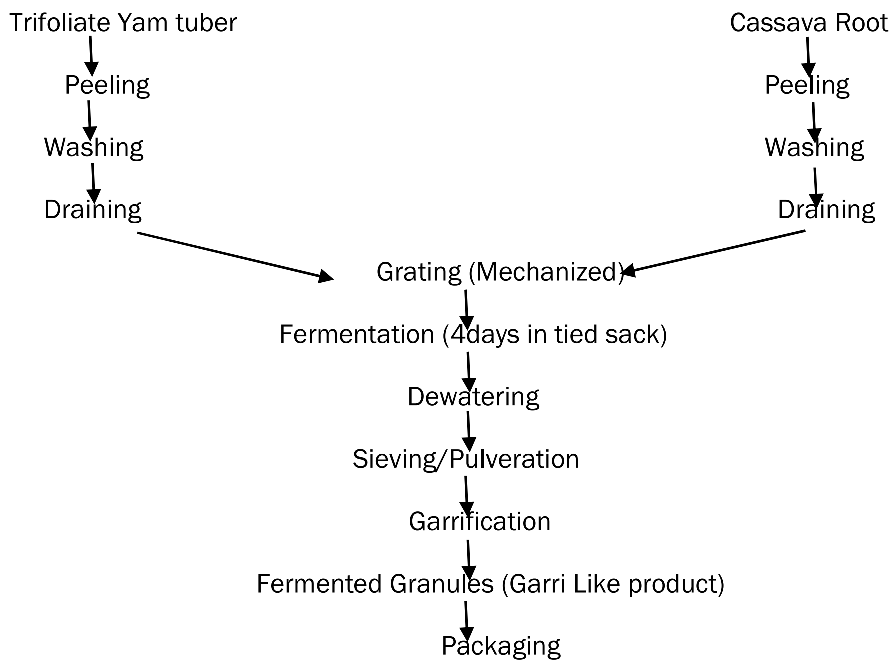

Fig 1: Flow Chart for the Production of Garri from Trifoliate Yam and Cassava Tuber.
Source: (Wasiu *et al.,* 2021).

Table 1:Proportion of Trifoliate Yam *(D. dumentorum)* and Cassava Tuber to produce garri

Codes	Trifoliate yam(dioscorea dumetorum)	Cassava
IYA	100%	0%
ACE	90%	10%
OLA	80%	20%
GRA	70%	30%
RAG	60%	40%
IBK	50%	50%
GOS	0%	100%

Determination of Mineral Content:

The mineral analysis of the garri samples were determined by the method described by AOAC (2005). The samples were ashed at 550°C. The ash obtained was boiled with 10 mL of 20% hydrochloric acid in a beaker and then filtered into a 100 mL standard flask. The filtrate was made up to the mark with de-ionized water. The minerals sodium (Na) and potassium (K) were determined from the solution using the standard flame emission photometer. NaCl and KCl were used as the standards (AOAC, 2005). Phosphorus was determined calorimetrically using the spectronic 20 (Gallenkamp, UK; Kirk and Sawyer) with KH_2PO_4 as the standard. Calcium (Ca), magnesium (Mg), and iron (Fe) were determined using an atomic absorption spectrophotometer (AAS, Model SP9, Pye Unicam Ltd, Cambridge, UK). All values were expressed in mg/100 g.

Determination of Vitamin Content

Determination of Vitamin A

The experiment was carried out in the dark to avoid photolysis of vitamin.0.5 g of sample was homogenized and saponified with 2.5 ml of alcoholic potassium hydroxide in water bath at 60^{o}c for 30 minutes. The saponified extract was transferred to a separating funnel containing 10 ml of petroleum ether and mixed well. The lower aqueous layer was then transferred to another separating funnel and the upper petroleum layer extract was repeated until the aqueous layer becomes colorless. A small amount of anhydrous sodium sulphite was added to the petroleum ether extract to remove excess moisture. The final volume of the petroleum ether was noted.

Determination of Vitamin B group

The vitamin B group was determined according to AOAC (2005). The samples (2 g) was placed in 25 mL of H_2SO_4 (0.1 N) solution and incubated for 30 min at 121°C. Then, the contents were cooled and adjusted to pH 4.5 with 2.5 M sodium acetate, and 50 mg Takadiastase enzyme was added. The preparation was stored at 35°C overnight. The mixture was then filtered through a Whatman No. 4 filter, and the filtrate was diluted with 50 mL of pure water and filtered again through a micropore filter (0.45 μm). About 20 microliters of the filtrate was injected into the HPLC system. Quantification of vitamin B content was accomplished by comparison to vitamin B standards. Standard stock solutions for thiamine, riboflavin, niacin, pyridoxine, and cobalamin were prepared. Chromatographic separation was achieved on a reversed phase- (RP-) HPLC column (Agilent ZORBAX Eclipse Plus C18; 250 × 4.6 mm i.d., 5 μm) through the isocratic delivery mobile phase (A/B 33/67; A: MeOH, B: 0.023 M H_3PO_4, pH = 3.54) at a flow rate of 0.5 mL/min. Ultraviolet (UV) absorbance was recorded at 270 nm at room temperature.

Determination of Ascorbic Acid (Vitamin C) Using Spectrophotometer:

Ascorbic acid was determined according to each method extract (20 mg) was extracted with 10 ml of 1 percent metaphosphoric acid (union) for 45 min at room temperature and filter through whatman no 4 filter paper. The filterate (1 ml) was mixed with 9 ml of 2,6 dichloroindophenol (Sigma)and the absorbance was measured within 15 secs at 515 nm against a blank content of ascorbic acid was calculated on the basis of the calibration curve.

Statistical Analysis:

All analysis was conducted in triplicate. Data obtained for the mineral, vitamin and sensory analysis of the sample were subjected to one-way analysis of variance (ANOVA) and difference among and means was determined using Duncan multiple range test. Statistical package for social science (SPSS) Version 16.0 (SPSS Inc, Chicago, USA) was used to analyze the data and $p < 0.05$ was considered to be statistically significant. Results were expressed as mean $\pm$ standard deviation.

3. RESULTS

Results and Discussion

Vitamin Composition of Garri Produced from Trifoliate Yam and Cassava

The vitamin composition of the garri produced from trifoliate yam and cassava is shown in Table 2. Vitamins are essential substances for the normal functioning and development of the body.

Table 2: Vitamin Composition of Garri Produced from Trifoliate Yam and Cassava

Sample	Vitamin E (mg/100g)	Vitamin A (mg/100g)	Vitamin B1 (mg/100g)	Vitamin B2 (mg/100g)	Vitamin B3 (mg/100g)	Vitamin B9 (mg/100g)	Vitam (mg/1
IYA	0.27 ± 0.00^{c}	0.09 ± 0.02^{b}	0.19 ± 0.00^{a}	0.28 ± 0.01^{bc}	0.50 ± 0.00^{ab}	0.66 ± 0.07^{e}	0.07±
ACE	0.30 ± 0.00^{a}	0.14 ± 0.02^{b}	0.19 ± 0.00^{a}	0.29 ± 0.01^{ab}	0.63 ± 0.00^{a}	1.27 ± 0.09^{a}	0.07±
OLA	0.26 ± 0.00^{d}	0.32 ± 0.05^{b}	0.18 ± 0.00^{b}	0.25 ± 0.01^{d}	0.43 ± 0.00^{ab}	0.86 ± 0.03^{d}	0.06±
GRA	0.28 ± 0.00^{b}	1.53 ± 0.06^{a}	0.19 ± 0.00^{a}	0.29 ± 0.01^{a}	0.31 ± 0.28^{b}	1.13 ± 0.08^{b}	0.07±
RAG	0.27 ± 0.00^{c}	0.21 ± 0.01^{b}	0.19 ± 0.00^{a}	0.24 ± 0.00^{d}	0.39 ± 0.01^{ab}	0.99 ± 0.06^{c}	0.06±
IBK	0.27 ± 0.00^{c}	0.11 ± 0.02^{b}	0.18 ± 0.00^{b}	0.29 ± 0.01^{a}	0.59 ± 0.00^{a}	0.69 ± 0.08^{e}	0.06±
GOS	0.27 ± 0.00^{c}	0.22 ± 0.29^{b}	0.16 ± 0.00^{c}	0.26 ± 0.01^{c}	0.27 ± 0.19^{b}	0.18 ± 0.04^{f}	0.08±

*Mean ± standard deviation with same superscripts along the column are not significantly different at ($p>0.05$)

KEY

IYA	100% Trifoliate yam				
ACE	90% Trifoliate yam	10% Cassava	OLA	80% Trifoliate yam	20% Cassava
GRA	70% Trifoliate yam	30% Cassava	RAG	60% Trifoliate yam	40% Cassava
IBK	50% Trifoliate yam	50% Cassava	GOS	100% Cassava	

Table 3: Mineral Composition of Garri Produced from Trifoliate Yam and Cassava

Sample	Sodium Na Mg/100g	Magnesium Mg Mg/100g	Manganese Mn Mg/100g	Copper Mg/100g	Zinc Zn Mg/100g	Phosphorus P Mg/100g
IYA	291.38 ± 0.70^{a}	126.13 ± 0.74^{e}	2.26 ± 0.02^{b}	0.66 ± 0.01^{d}	0.66 ± 0.01^{e}	296.67 ± 0.01^{b}
ACE	216.15 ± 0.21^{f}	155.29 ± 0.02^{c}	1.24 ± 0.01^{f}	0.55 ± 0.01^{e}	0.86 ± 0.01^{c}	260.34 ± 0.01^{e}
OLA	255.81 ± 0.02^{d}	114.13 ± 0.04^{f}	2.37 ± 0.00^{a}	0.52 ± 0.00^{e}	0.58 ± 0.01^{f}	295.11 ± 0.15^{c}
GRA	213.78 ± 0.01^{g}	163.70 ± 0.28^{b}	1.58 ± 0.01^{d}	0.78 ± 0.01^{b}	0.73 ± 0.01^{d}	305.01 ± 0.01^{a}
RAG	280.26 ± 0.03^{b}	205.56 ± 0.02^{a}	1.13 ± 0.01^{g}	0.93 ± 0.01^{a}	1.04 ± 0.02^{b}	289.42 ± 0.12^{d}
IBK	261.61 ± 0.02^{c}	155.05 ± 0.07^{c}	1.83 ± 0.01^{c}	0.72 ± 0.00^{c}	0.86 ± 0.01^{c}	251.01 ± 0.01^{f}
GOS	247.74 ± 0.37^{e}	147.14 ± 0.05^{d}	1.41 ± 0.01^{e}	0.79 ± 0.02^{b}	1.21 ± 0.01^{a}	225.67 ± 0.47^{g}

*Mean ± standard deviation with same superscripts along the column are not significantly different at ($p>0.05$)

KEY

IYA	100% Trifoliate yam	
ACE	90% Trifoliate yam	10% Cassava
OLA	80% Trifoliate yam	20% Cassava
GRA	70% Trifoliate yam	30% Cassava
RAG	60% Trifoliate yam	40% Cassava
IBK	50% Trifoliate yam	50% Cassava
GOS	100% Cassava	

4. DISCUSSION

The vitamin composition of the garri produced from trifoliate yam and cassava is shown in Table 2. Vitamins are essential substances for the normal functioning and development of the body. Vitamin A is an essential nutrient needed in small amounts by humans for the normal functioning of the visual system, growth and development, immune function and reproduction (FAO/WHO, 2000).

The value of Vitamin A ranged from 0.09-1.53 mg/100 g. The highest value was obtained in sample GRA while the lowest value was found in sample IYA. There was significant difference ($p > 0.05$) between all the samples. Vitamin A content of the garri was determined as beta-carotene. According to (Chavez *et al.,* 2004), once beta-carotene is ingested, beta-carotene is converted to vitamin a in the body. Research shows that traditional method retained beta-carotene content of garri and this could be attributed to less pressure applied to the cassava mash during dewatering which reduce leaching of beta-carotene. The result obtained in this study is similar to the results (0.37- 0.92) obtained by Augustine *et al.* (2019) who worked on evaluation of garri processed by traditional and instant mechanical methods. The recommended daily intake of vitamin A is 800 retinol equivalents (RE) for an adult woman, or 4.8 mg/day on the basis of a 6 to 1 conversion ratio of β-carotene per retinol equivalent.

The vitamin E content ranged from 0.26-0.30 mg/100 g. Sample ACE had the highest value while sample OLA has the lowest value. There was significant difference ($p > 0.05$) between all the samples. Packer (2002) suggested that vitamin E supplementation (200- 400 mg/day) may be appropriate therapeutically to moderate some aspects of degenerative diseases such as Parkinson disease, reperfusion during surgery and reduce the severity of neurological disorders. The result in this study showed that the trifoliate garri is not a good source of vitamin E. The recommended daily allowance for vitamin E ranged from 8-10 μg/day according Kamangar and Emadi (2012).

The value of vitamin B1 ranged from 0.16-0.19 mg/100 g. The highest value was found in sample ACE, IBK, GRA, and RAG while the lowest value was obtained in sample GOS. There was significant difference ($p > 0.05$) between all the samples. Research conducted on seven health young men showed that 0.3 mg thiamine per 4184 kJ met their requirements. Intakes below this amount lead to irritability and other symptoms and signs of deficiency (FAO/WHO, 2005). The result obtained in this research work is similar to the latter research. This indicated that the trifoliate garri is a good source of vitamin B1. While Anderson *et al.* (2000) reported thiamine intakes of 1.0 and 1.2 mg/day as minimal for women and men respectively.

The value of vitamin B2 ranged from 0.24-0.29 mg/100 g. Sample ACE, IBK and GRA had the highest value while sample RAG had the lowest value. There was significant difference ($p > 0.05$) between all the samples. The adequate riboflavin intake is approximately 1.3 and 1.1 mg/day for adults, male and female respectively (Roughead and McCormick, 2003) which is higher than the values obtained in this study.

The vitamin B3 ranged from 0.27-0.63 mg/100 g. The highest value was obtained in sample ACE while the lowest value was found in sample GOS. There was significant difference ($p > 0.05$) between all the samples. Recent studies suggest that 12.5 mg NEs, which corresponds to 5.6 mgNEs/4184 kJ, is minimally sufficient for niacin intake in adults (FAO/WHO, 2013).

The lower value recorded in sample GOS indicated that cassava contains low amounts of B vitamins. Vitamin B1, B2 and Vitamin B3 help to prevent or cure disease conditions of beriberi, ariboflavinosis and pellagra respectively (Gordon and Margaret, 2002). According to Gordon and Margaret (2002) the low values obtained in all the B vitamins is as a result of heat.
The vitamin B9 content ranged from 0.66-1.27 mg/100 g with sample ACE having the highest value while sample IYA had the lowest value. There was significant difference ($p > 0.05$) between all the samples. Vitamin B9 helps in DNA replication, metabolism of vitamins and amino acids, proper cell division. Folic acid also helps to reduce risk of spina bifida (neural tube defects) in neonates when taken by pregnant mothers Kunisawa *et al.* (2012). The result in this study indicated that the garri sample will be beneficial to consumers. Ascorbic acid is an effective quencher of singlet oxygen and other radicals as reported by (Oboh, 2006). It enhances absorption of inorganic iron and inhibits the formation of nitrosamines in the stomach (Bender, 2009).
The vitamin C content ranged from 0.06-0.08 mg/100g. Sample GOS had the highest value while sample IBK, OLA and RAG had the lowest value. There was significant difference ($p > 0.05$) between all the samples. Vitamin C helps in prevention of scurvy. In this study, it was observed that the garri contains appreciable amount of ascorbic acid. The vitamin C obtained in this study is lower when compared to the values (23.27-35.43 mg/AAE/mg) recorded by Augustine *et al.* (2019) for traditional and instant garri.

The mineral composition of the garri produced from trifoliate yam and cassava is presented in Table 3. Minerals are required for normal growth, cellular activity and oxygen transport (Cu and Fe), fluid balance and nerve transmission (Na and K) as well as regulation of acid-base balance (P) (Alozie *et al.,* 2017) Amoakoah *et al.* (2015) reported that mineral are essential nutrients that are needed in the body to facilitate proper functioning of certain organs. Phosphorus was the most abundant mineral with values ranging from 225.67-305.01 mg/100 g. The highest value was recorded in sample GRA while the lowest value was obtained in sample GOS. There was significant difference ($p > 0.05$) between all the samples. Phosphorus is also important in the production and maintenance of bones and teeth. It also strengthens cell wall and used to help regulate the acid/base balance in the body. Kim *et al.* (2006) reported that phosphorus is associated with amylopectin to which it is bound in the form of phosphate esters. This shows that the trifoliate yam and cassava has high value of amylopectin. The result in this study shows that the garri contains appreciable amount of phosphorus. About 800 mg of phosphorus is recommended daily (Alinnor and Akalezi, 2010).

Sodium was the next abundant mineral with values ranging from 213.78-291.38 mg/100 g with sample IYA having the highest value while sample GRA has the lowest value. There was significant difference ($p > 0.05$) between all the samples. Sodium and potassium play similar roles in regulating blood volume and pressure. They also aid in nerve transmission and muscle contraction (FAO/WHO, 2002). The recommended daily intake of sodium is 500 mg for adults and 400 mg for children which are higher than the value obtained in this study (WHO, 2002). The highest value observed in sample IYA indicated that trifoliate yam may be a good source of sodium. The magnesium content ranged from 114.13-205.56 with sample RAG having the highest value while sample OLA has the lowest value. There was significant difference ($p > 0.05$) between all the samples. The result obtained in this research work shows that trifoliate is a good source of magnesium.

The value obtained in this study is in line with the value (150.65-161.04) reported by Ilori *et al.* (2017) who worked on proximate composition, selected minerals and shelf life of garri fortified with pretreated moringa leaves but higher than the value 1.30-46.17 mg/100g recorded by Bamidele *et al.* (2014) who worked on nutritional composition of garri analog produced from cassava and cocoyam tuber.

The value of manganese ranged from 1.13-2.37. Sample OLA had the highest value while sample RAG had the lowest value. There was significant difference ($p > 0.05$) between all the samples. According to Aschner and Aschner, (2005) and Buchman (2014), manganese helps in blood clotting and homeostasis in conjunction with vitamin K. The consumption of the trifoliate garri in this study will not only increase the utilization of trifoliate yam but also provides health benefit to consumers.

The value of copper ranged from 0.52-0.93 ppm. The highest value was obtained in sample RAG while the lowest value was found in sample OLA. There was significant difference ($p > 0.05$) between all the samples. The result in this present study is slightly higher than the values (0.07-0.12 ppm) reported by Adejuyitan *et al.* (2018) who worked on garri produced from different varieties of cassava but lower when compared with the values (4.50-6.05 ppm and 4.85-5.90 ppm) reported by Ilori *et al.* (2017) for dried and wet moringa fortified garri respectively. The value of zinc ranged from 0.66-1.21 ppm. The highest value was found in sample GOS while the lowest value was found in sample IYA. There was significant difference ($p > 0.05$) between all the samples.

Zinc plays main roles in bone formation, tissue growth, brain function, growth of the fetus and child (Bagherani and Smoller, 2016). The values obtained for zinc in this study is higher to the values (0.058-0.088 ppm) reported Adejuyitan *et al.* (2018) who worked on garri produced from different varieties of cassava. The concentration of zinc is the study is in line with the values (0.47-1.82 ppm). The production of garri from trifoliate yam will increase the utilization of the trifoliate yam and thus promotes better health for consumer of this staple. All the minerals analyzed in this study were below the recommended daily allowances values.

5. CONCLUSION

Conclusion

The production of gari from trifoliate yam and cassava tubers increased the vitamin and mineral content significantly. Conclusively, trifoliate yam tubers could improve the nutritional composition of gari made from cassava and subsequently encourage the utilization of the yam tuber. Further studies should be done to improve the utility potentials of trifoliate yam tuber in processing of food products and also on the microbiological properties to ascertain its shelf stability.

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