PJN
ISSN 1680-5194
ansinet.com/pjn

PAKISTAN JOURNAL OF NUTRITION

Science Alert
scialert.net

ANSInet
an open access publisher
http://ansinet.com

OPEN ACCESS Pakistan Journal of Nutrition

ISSN 1680-5194
DOI: 10.3923/pjn.2023.45.51

Research Article
Effect of pH and Duration of Fermentation on the Quality Characteristics of Garri

[1]C.A. Ozoh, [2]C. Imoisi and [1]J.U. Iyasele

[1]Department of Chemistry, University of Benin, P.M.B.1154, Benin City, Nigeria
[2]Department of Industrial Chemistry, Mewar International University, KM 21, Abuja-Keffi, Expressway, Masaka, Nasarawa State, Nigeria

Abstract

Objectives: This study aimed to assess the effect of pH and duration of fermentation on the organoleptic and the physicochemical properties of garri. **Materials and Methods:** Cassava roots (TMS 30572) were peeled, washed, grated and divided into five portions, WG, RG, G5, G7 and G9 with sample G5, G7 and G9 having pH 5, 7 and 9 respectively. **Results:** The pH of the media between 4.19-9.00 was monitored. Mash samples WG, RG, G5, G7 and G9 at 24 hrs had pH 5.09, 5.20, 4.88, 4.70, 4.41 respectively was compared with pH 5.29, 5.31, 5.00, 7.00 and 9.00 obtained at 0 hr. The starch contents of garri for sample WG, RG, G5, G7 and G9 obtained at 24hours were 26.77, 26.99, 26.61, 25.38 and 24.12%, respectively and compared with 27.21, 27.20, 27.24, 27.19 and 27.17% obtained at 0 hr. Concentration of HCN obtained for the garri samples at 48 hrs were 7.48, 6.48, 7.51, 4.12 and 3.97 mg kg^{-1} for WG, RG, G5, G7 and G9, respectively compared with 12.77, 12.78, 12.75, 12.67 and 12.62 mg kg^{-1} obtained at 0 hrs. General acceptability of the garri samples at 48 hrs were 3.72, 3.97, 3.70, 4.25 and 4.40 for WG, RG, G5, G5 and G9, respectively compared with 3.20, 3.45, 3.18, 3.16 and 3.18 obtained at 0 hr using hedonic scale 1-5. **Conclusion:** Sample G9 had better functional and sensory properties of garri compared to other samples.

Key words: Cassava pulp, cassava roots, cyanogenic glycoside, fermentation, garri production

Citation: Ozoh, C.A., C. Imoisi and J.U. Iyasele, 2023. Effect of pH and duration of fermentation on the quality characteristics of garri. Pak. J. Nutr., 22: 45-51.

Corresponding Author: C. Imoisi, Department of Industrial Chemistry, Mewar International University, KM 21, Abuja-Keffi, Expressway, Masaka, Nasarawa State, Nigeria Tel: No: 07030746386

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Cassava roots are highly perishable and cannot be kept in fresh condition for more than a few days after harvest[1]. Farmers have developed several processing methods for stabilizing cassava and reducing its toxicity[2]. In order to extend the shelf life of the roots, cassava is dried in a variety of ways in different parts of the world to meet the local needs, taste, tradition and storage requirements[2,3].

Fermentation, which is part of almost all of these processes, is widely used to transform and preserve it because of its low technology and energy requirements and the unique organoleptic qualities of the final product[4].

In fermentation, enzymes produced by living microorganisms change the chemical composition of food. It is a food processing technique practiced by man for centuries in various part of the world especially Africa[5]. There are many types of food fermentation, including natural and controlled fermentations, which involve yeast, fungi and bacteria of different species and genera[6,7]. In addition to causing desirable changes in food, these microorganisms are also responsible for undesirable changes such as bad flavours and spoilage[6]. The acceptability of a product is primarily determined by its flavour components, which can be desirable or undesirable depending on the fermentation process[8].

Nwachukwu and Edwards[9] reported that fermentation softens the fermenting mash thereby facilitating the liberation of hydrogen cyanide. As a result of fermentation, roots become softer. The disintegration of tissue structure brings linamarin into contact with linamarase, which is located in the cell walls[10] and hydrolyzes into glucose and cyanohydrins, which easily break down to ketone and HCN[11] hence, in cassava, cyanogenic glucosides can be reduced through fermentation.

In Nigeria, garri and fufu are the most important cassava food products. Of all these, in West Africa, cassava is eaten in roasted form, granular product is prepared from peeled, grated and fermented cassava roots, known as garri[12]. Garri is the most commonly consumed fermented cassava products in Nigeria, accounting for 70% of all cassava production[13]. Garri is consumed by several millions of people in the African continent, especially in the West African sub region[14-16]. Roots are fermented, peeled and grated for Garri processing followed by dewatering, sieving and frying. The type of garri, depends on the processing method, the grain size and the region where it is grown. It has the same processing method but its taste, pH and toxicity is affected by the duration of fermentation. According to Ikujenlola and Opawale[17], the extent of fermentation affects pH.

As a result of fermentation, volatile compounds are produced that give garri its unique flavour, which essentially affects its taste[18]. Most of the juice from the cassava pulp is expressed during this period. The fermentation time is critical, a short fermentation time can lead to an incomplete detoxification process, resulting in a potentially toxic product, whereas a long fermentation time can result in a strongly sour product and the texture will be poor[19]. Garri is fermented for different periods of time by commercial processors in Nigeria. Collard and Levi[20] reported that the sourness of garri influences its acceptability and is directly related to the degree of fermentation. The cyanogenic glucoside content of garri is an important quality parameter, due to its toxicity, if consumed in excess of 30 ppm[21]. If fermentation process is adequate, the cassava roots will be detoxified from about 300 mg hydrogen cyanide (HCN) per kg fresh weight of cassava to 10 mg kg^{-1} [22]. A rapidly growing population in developing countries has made it necessary to accelerate cassava fermentation in order to produce quality garri. This study, therefore, aimed to assess the effect of pH and duration of fermentation on the organoleptic and the physicochemical properties of garri.

MATERIALS AND METHODS

Study area and sites: Benin City is located at 6.34°N latitude and 5.63°E longitude and it is situated at elevation 88 m above sea level. The population of Benin city is 1,125,058, making it the most populous city in Edo State (Nigeria).

Cassava roots procurement: Only 3 kg of cassava tubers of cultivar TMS 30572 were harvested at Crop Science Departmental farm, Faculty of Agriculture, University of Benin, Nigeria. The freshly harvested roots were immediately used for the production of garri.

pH adjustment: Only 0.1 M sodium carbonate (Na_2CO_3) and 0.1 M orthophosphoric acid were used to adjust the pH of the cassava mash to 5, 7 and 9 using a digital pH meter.

Method of garri production: Garri was prepared according to the method described by Vasconcelos *et al.*[18]. The freshly harvested roots were peeled, washed under running tap water and grated with commercial mechanical graters. The grated pulp (mash) was divided into five portions, 250 g each. The first portion was used as control and nothing was added to it (WG). Palm oil was added to the second portion (RG) at the rate of 10 mg g^{-1} and thoroughly mixed. The third (G5),

fourth (G7) and fifth (G9) portions were adjusted to pH 5, 7 and 9, respectively. Each of the portions was put into woven polypropylene sacks and left for fermentation. Fermentation lasted for 0, 24, 48, 72 and 96 hrs (using the natural microflora) at ambient temperature before pressing out the juice. During these periods of fermentation, a small quantity of each mash was taken daily to determine the pH.

After the fermentation process they were sifted to remove larger chunks of fibres. The fermented mash was roasted in an open pan greased with palm kernel oil, while stirring continuously with a broken piece of calabash. The roasted granules (garri) was then sieved with a mesh (2 mm), packed into woven polypropylene sacks and labelled (RG, WG, G5, G7 and G9) for analysis. For the four days that the fermentation lasted, a quantity from each mash was taken, sieved, fried and analysed.

Fermentation rate analysis: All conditions were the same for the 5 cassava samples and the rate of fermentation of each was monitored by determining the decrease in the pH of each sample daily.

Sensory evaluation of garri samples: For practical convenience, the panelists were selected from the university environment. The panel of 15 untrained but familiar with garri masters and 400 level chemistry students evaluated its aroma, colour, particle size, texture and overall acceptability. The parameters were rated on a hedonic scale of 1-5 where 1 was very poor, 2 poor, 3 average, 4 good and 5 very good[23]. Garri samples (20 g each) were presented in cups as dry granules, for evaluation. Evaluation involved:

- Testing for colour: by visual inspection: Testing for aroma/smell: By sniffing two or more times of each sample provided
- Testing for particle size and texture: Size distribution of garri particles was determined on sieves with openings of 1.70 mm respectively, while texture was determined by touching and feeling samples on the hands
- The data obtained from hedonic scale were analyzed using the one way analysis of variance (ANOVA)

pH determination: Only 10 g of each sample was put into a 200 mL beaker and 100 mL of distilled water was added. The pH was analysed using a standardized pH meter. Triplicate values were obtained and the mean value was taken as the pH value.

Total titratable acidity (TTA): The FAO[24] method was used to determine the titratable acidity percent. Five grams of the sample was dissolved in a beaker and made up to 100 mL with distilled water and allowed to stand for 30 min. The solution was filtered with whatman filter paper. After this, 25 mL of the filtrate was titrated against 0.1 M NaOH, using phenolphthalein as indicator. The end point was obtained when the colour became colourless. The mean (TTA) was obtained from triplicate determination.

Swelling index: The method of Okolo and Makanjuola[25] was followed with slight modification to obtain swelling index. Only 10 g of the sample was transferred into a clean, dried, calibrated measuring cylinder. The garri was gently levelled by tapping and the initial volume was recorded. Then 50 mL of distilled water was poured into the measuring cylinder containing the sample and allowed to stand for 4 hrs. The value for Swelling Index (SI) was taken as the multiples of the original volume.

Starch content determination: The starch content was determined by the iodine colorimetric method (Iodine binding method) as described by Jarvis and Walker[26]. Afterward, 1.0 g of garri sample was weighed and transferred into a l00 mL volumetric flask.

Cyanide content determination: Estimation of Hydrocyanic acid content was estimated using silver nitrate volumetric analyses[27,28] for both garri and raw cassava mash.

RESULTS AND DISCUSSION

The fermentation processes took place in an acidic, neutral and alkaline environment (pH 9-5). Although, this fermentation process is inexpensive and simple, it involves a complex microbial process and is not durable[29]. As a result of grating, the cassava pulp lost its structural integrity, which enhanced contact with endogenous enzymes and created a large surface area for the activities of microbes. At various stages of this study, pH and the duration of fermentation (Fig. 1-4) influenced the reduction of starch and cyanogenic glycosides. Similar results were reported in some previous studies of cassava fermentation[30,31]. During the procedures, the pH may have decreased due to an increase in the organic acids produced by lactic acid bacteria which contribute the most dominant microflora[31]. In sample WG, natural fermentation of cassava mash may involve undesirable microorganisms, resulting in a decrease in pH and the

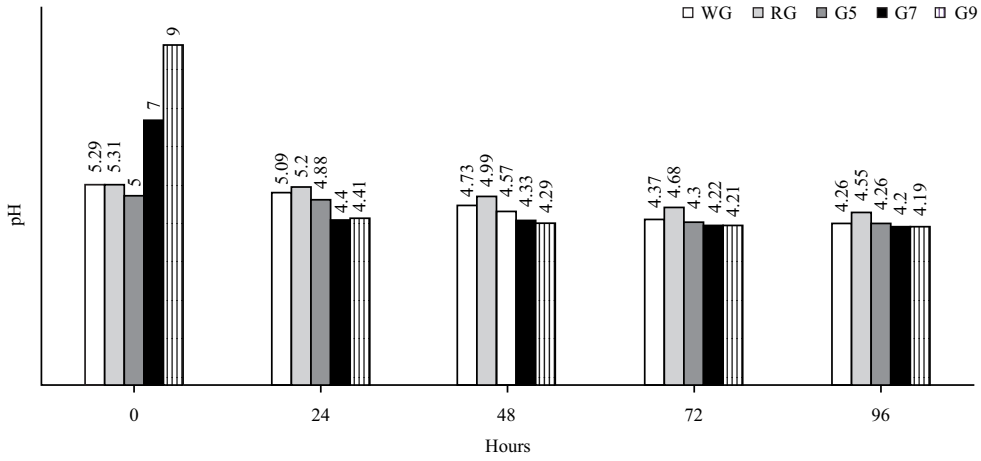

Fig. 1: pH values during the fermentation of cassava mash for garri production

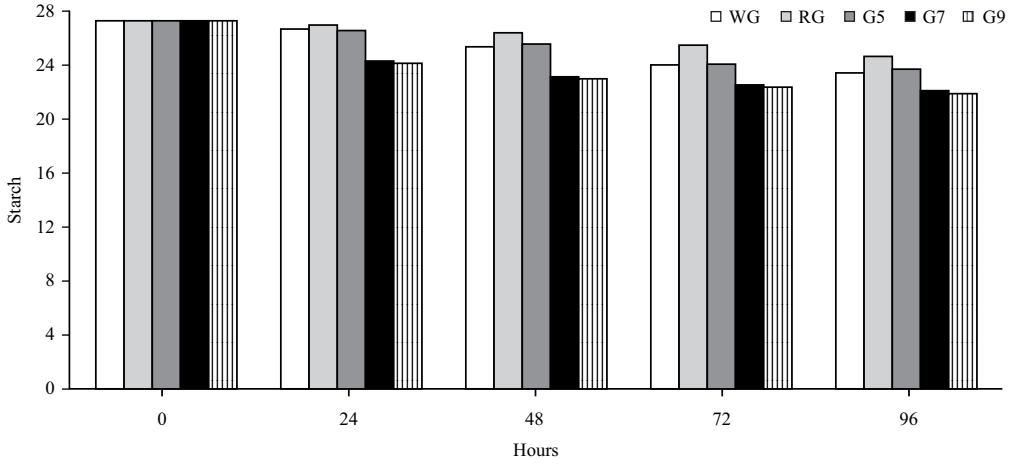

Fig. 2: Starch content of garri samples

production of offensive odours. However, the fermentation process was faster in G9, an alkalin`e medium. This may indicate the suitability of such environs for fermentative microbes. Fermentation of G9 reduced the fermentation time drastically from 96-24 hrs, resulting in a drop in pH.

In G9, pH values of the mash decreased with increasing fermentation duration, indicating that fermentation is faster in an alkaline medium than in a neutral (G7) and acidic medium (G5). As the pH of tuber paste decreases during fermentation[32] organic acids such as lactic acid and acetic acid accumulate due to the fermentation activity of microorganisms in cassava[33].

The starch content of G7 and G9 decreased rapidly, while WG, G5 and RG decreased gradually but more after 48 hrs which could be because the simple sugars are initially used by fermentative bacteria to produce ethanol, lactic acid and CO_2 before the more complex starch is processed[34].

Fomunyam *et al.*[35] stated that fermentation is the major factor responsible for reducing cyanide content. The sharp decrease in cyanide concentration was observed in G9 and G7, it may be due to the fact that the media created favourable environment that makes fermentation more rapid.

G9 had its highest peaks and most acceptable at 48 and 24 hrs, WG had its highest peaks at 72 and 96 hrs. RG was distinguished from the other samples from 0h due to its colour.

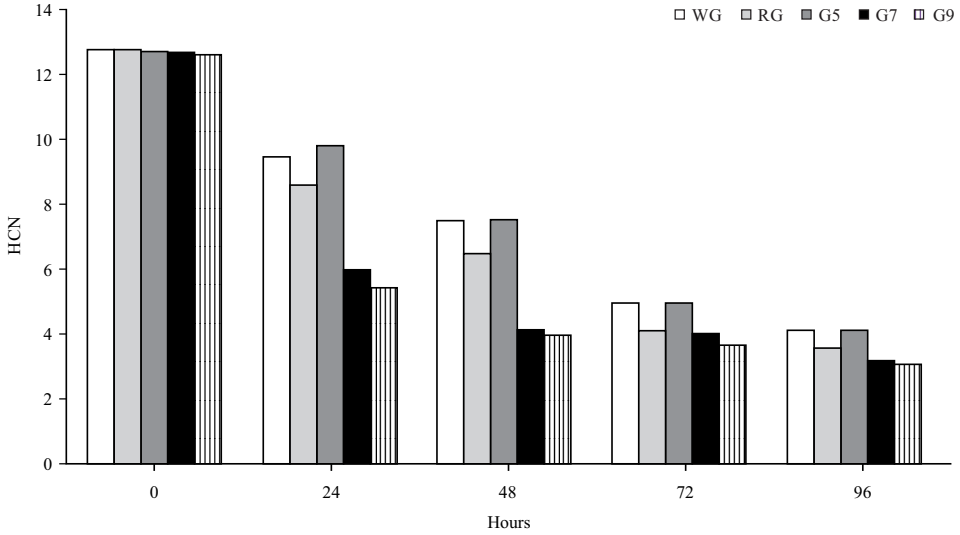

Fig. 3: HCN content of the garris

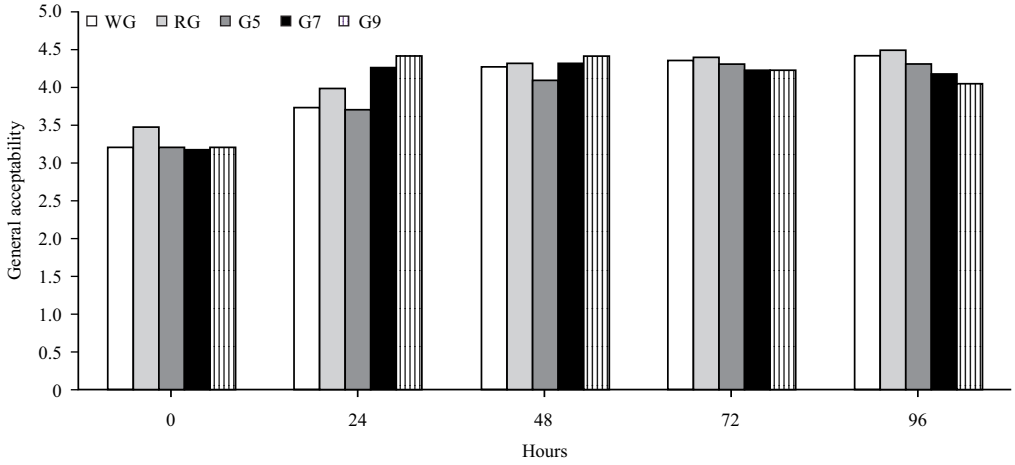

Fig. 4: General acceptability of garri samples

The sensory properties of the alkaline medium had its highest peaks at 24 and 48 hrs while the control had its peak at 72 and 96 hrs. After 96 hrs, RG (red garri) probably had a good acceptance due to the colour. There could be a reason for this since the pH and TTA of G9 at 24 and 72 hrs were approximately the same as those of the control sample at 72 and 96 hrs.

CONCLUSION

Treatment of cassava mash with alkaline medium (pH 9) increased the fermentation rate of cassava garri significantly. As a result, starch and cyanide content in the garri were reduced under a shorter period time compared to the control. The pH, functional and sensory properties were improved for the treated samples (G7 and G9) compared to the control (WG). Duration of fermentation of cassava garri had a highly significant effect on functional and sensory properties, As duration of fermentation increases, moisture content, ash content, crude fibre, crude protein, HCN and swelling index increase as well, whereas, starch, HCN and crude fat decreased for both treated and control samples. This study has discovered that pH 7 and 9 of cassava mash increased the rate of fermentation and improved the quality of garri but does not reduced the starch content of garri beyond the documented level.

RECOMMENDATION

In order to reduce the period of fermentation and to produce cassava garri of high quality, the pH of the medium should be increased to accelerate the rate of fermentation as well as decrease the toxic content of the product.

ACKNOWLEDGMENTS

The author would like to thank the Department of Chemistry, University of Benin, Benin City and to Prof. J.U. Iyasele of the Department of Chemistry, University of Benin, Benin City for his impactful, insightful and invaluable contributions.

REFERENCES

1. Leakey, C.L.A. and J.B. Wills, 1977. Food Crops of the Lowland Tropics. Oxford University Press, Oxford, UK., ISBN-13: 9780198545170, pp: 80-81.
2. Lan Caster, P.A., J.S. Ingram, M.Y. Lin and D.G. Cousey, 1982. Traditional cassava based foods: Survey of processing techniques. Eco. Bot., 36: 12-45.
3. Onwueme, I.C., 1978. The Tropical Tuber Crops: Yams, Cassava, Sweet Potato and Cocoyams. Illustrated Wiley United States, ISBN: 9780471996088, Pages: 234.
4. Daeschel, M.A., R.E. Andersson and H.P. Fleming, 1987. Microbial ecology of fermenting plant materials. FEMS Microbiol. Rev., 46: 357-367.
5. Uzogara, S.G., L.N. Agu and E.O. Uzogara, 1990. A review of traditional fermented foods, condiments and beverages in Nigeria: Their benefits and possible problems. Ecol. Food Nutri., 24: 267-288.
6. Kuboye, M.A.O., 1985. Traditional Fermented Foods and Beverages of Nigeria. Proceedings of IFS/UN workshop. Doula 225-231.
7. Reddy, N.R., M.D. Pierson, S.K. Sathe, D.K. Salunkhe and L.R. Beuchat, 1983. Legume based fermented foods: Their preparation and nutritional quality. C R C Crit. Rev. Food Scie. Nutr., 17: 335-370.
8. Reddy, N.R., 1986. Future of Legume-Based Fermented Foods. In: Future of Legume-Based Fermented Foods. Reddy, N.R. (Ed.). CRC Press 3.
9. Nwachukwu, S.U. and A.W. Edwards, 1987. Microorganisms associated with cassava fermentation for lafun production. J. Food Agric., 1: 39-42.
10. Mkpong, O.E., H. Yan, G. Chism and R.T. Sayre, 1990. Purification, characterization and localization of linamarase in cassava. Plant Physiol., 93: 176-181.
11. Cooke, R.D., 1977. An enzymatic assay for the total cyanide content of cassava (*Manihot esculenta* Grantz). J. Sci. Food Agric., 29: 345-352.
12. Asiedu, J.J., 1989. Processing of Tropical Crops. 10th Edn., Macmillan, Germany, ISBN: 9780333448571, Pages: 266.
13. IITA., 1990. Cassava in Tropical Africa: A Reference Manual. International Institute of Tropical Agriculture, Ibadan, Nigeria, ISBN-13: 9789781310416, Pages: 176.
14. Edem, D.O., J.O.I. Ayatse and E.H. Itam, 2001. Effect of soy protein supplementation on the nutritive value of 'gari' (farina) from *Manihot esculenta*. Food Chem., 75: 57-62.
15. Ogiehor, I.S., M.J. Ikenebomeh and A.O. Ekundayo, 2007. The bioload and aflatoxin content of market garri from some selected states in southern Nigeria: Public health significance. Afr. Health Sci., 7: 223-227.
16. Kostinek, M., I. Specht, V.A. Edward, U. Schillinger, C. Hertel, W.H. Holzapfel and C.M.A.P. Franz, 2005. Diversity and technological properties of predominant lactic acid bacteria from fermented cassava used for the preparation of Gari, a traditional African food. Syst. Applied Microbiol., 28: 527-540.
17. Ikujenlola A.V. and Opawale, 2007. Effects of processing on the yield and physico-chemical properties of cassava products. Adv. Mat. Res., 18-19: 165-170.
18. Vasconcelos, A.T., D.R. Twiddy, A. Westby and P.J.A. Reilly, 1990. Detoxification of cassava during Garri preparation. Int. J. Food Sci. Technol., 25: 198-203.
19. Fellows, P. and S. Azam-Ali, 2003. Small-Scale Food Processing: A Directory of Equipment and Methods. 2nd Edn., ITDG Publishing 184.
20. Collard, P. and S.A. Levi, 1959. A two stage fermentation of cassava. Nature, 183: 620-621.
21. Nwokoro, O., J.C. Ogbonna and G.N. Okpala, 2010. Simple picrate method for the determination of cyanide in cassava flour. Bio-Res., Vol. 7, 10.4314/br.v7i2.56582.
22. Imoisi, C., J.U. Iyasele, E.E. Imhontu, D.O. Ikpahwore and A.O. Okpebho, 2020. Pasting properties of composite of cassava and wheat flours. J. Chem. Soc. Niger., Vol. 45. 10.46602/jcsn.v45i6.540.
23. Larmond, E., 1977. Laboratory Methods for Sensory Evaluation of Foods. 1st Edn., Department of Agriculture Publication, Otawa, Canada, ISBN-13: 978-0662012719, Pages: 73.
24. FAO, 1970. Food and Agricultural Organization Year Book. FAO, Rome.
25. Okolo, E. and A.T. Makanjuola, 2021. Microbial evaluation of garri sold within Ahmadu Bello university main campus, Samaru - Zaria, Kaduna state. Sci. World J., 16: 259-265.
26. Jarvis, C.E. and J.R.L. Walker, 1993. Simultaneous, rapid, spectrophotometric determination of total starch, amylose and amylopectin J. Sci. Food Agric., 63: 53-57.
27. Oboh, G., A.A. Akindahunsi and A.A. Oshodi, 2002. Nutrient and anti-nutrient contents of *Aspergillus niger*-fermented cassava products (flour and gari). J. Food Comp. Anal., 15: 617-622.
28. Tanya, A.K.N., C.M.F. Mbofung and O.O. Keshinro, 1997. Soluble and insoluble fibre contents of some *Cameroonian* foodstuffs. Plant Food Hum. Nutr., 51: 199-207.
29. Njoku, V.O. and C. Obi, 2010. Assessment of some fermentation processes of cassava tubers. 2000 1: 20-25.

30. Okafor, N. and A.O. Ejiofor, 1990. Rapid detoxification of cassava mash fermenting for garri production following inoculation with a yeast simultaneously producing linamarase and amylase. Process Biochem. Int., 25: 82-86.
31. Bradbury, M.G., S.V. Egan and J.H. Bradbury, 1999. Determination of all forms of cyanogens in cassava roots and cassava products using picrate paper kits. J. Sci. Food Agric., 79: 593-601.
32. Oluwole, O.B., O. Olatunji and S.A. Odunfa, 2008. Development and evaluation of a process technology for conversion of dried cassava chips into gari. J. Ind. Res. Technol., 2: 21-30.
33. Coulin, P., Z. Farah, J. Assanvo, H. Spillmann and Z. Puhan, 2006. Characterisation of the microflora of attieke, a fermented cassava product, during traditional small-scale preparation. Int. J. Food Microbiol., 106: 131-136.
34. Menser, F. and H.D. Smolnik, 1980. Processing of cassava into gariand other foodstuffs. Starch Staerke, 32: 116-122.
35. Fomunyam, R.T., A.A. Adegbola and O.L. Oke, 1981. Role of Palm Oil in Cassava Based Rations. Proceedings of the First Triennial Root Crops Symposium of the International Society for Tropical Root Crops. September 8-12, 1980 Ibadan 152-153.