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MICROBIOLOGICAL PROFILE, SHELF STABILITY AND SO PHYSICOCHEMICAL PROPERTIES OF FERMENTED FLOUR FR DIFFERENT SWEET POTATO CULTIVARS

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ABSTRACT

Sweet potato flour was produced after fermentation of two cultivars (TIS87/0087 and TIS 2532.OP.1.13) of sweet potato (Ipomoea batatas) roots for 24h. The microbiological profile, pH and titratable acidity (TA) of the fermenting medium were assessed. The proximate composition and shelf stability of the ambient stored flour samples were also determined. Bacteria isolated from the fermenting medium were Lactobacillus plantarum, Streptococcus spp, Bacillus spp and Staphylococcus aureus while the fungal isolates included Penicillium spp. Rhizopus stolonifer, Aspergillus niger and yeast Saccharomyces cerevisiae. The Total Viable Count of both cultivars during fermentation differed significantly ($P<0.05$) only at 0h of fermentation. However, for TIS 87/0087 it ranged from 3.40 – 4.60 log_{10} cfu g^{-1} and 3.54 to 4.64 log_{10} cfu g^{-1} for TIS 2532.OP.1.13 cultivar. The lactic acid bacteria counts ranged from 2.40 to 3.60 log_{10} cfu g^{-1} for cultivar TIS87/0087 and 2.54 to 3.64 log_{10} cfu g^{-1} for cultivar TIS 2532.OP.1.13. The TA for both cultivars were observed to have increased from 0.51% to 4.96% for TIS 87/0087 and 0.40% to 4.04% for TIS 2532.OP.1.13 as fermentation progressed in relation to fall in pH. The proximate composition of flours from TIS87/0087 and TIS 2532.OP.1.13 showed low moisture content (10.76% and 11.37%), high dry matter (89.24% and 88.66%), carbohydrate (81.25% and 81.01%), protein (5.16% and 5.09%), fiber (0.76% and 0.64%) and crude lipid (0.68% and 0.47%) respectively. However, the protein and crude lipid content of TIS 87/0087 flour were higher. The fermented flour had an acceptable microbial load limit (<5log_{10} cfu g^{-1}) and shelf life stability for 3 months under ambient storage. The fermented TIS 87/0087 flour can be recommended for incorporation into instant food and bakery products.

Keywords: Sweet potato, Fermentation, pH, Microbial flora, Flour, Physicochemical, Shelf stability.

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Contribution/ Originality

This study is one of the few studies which have investigated the recent Sweet potato cultivars in Nigeria, but in this, using fermentation process to improve the nutritional and microbial quality of the flours. The study had shown that the fermented flours had high nutritional and low microbial qualities.

1. INTRODUCTION

Sweet potato (*Ipomoea batatas* (L.) Lam) is an extremely important crop in different parts of the world and has become a high value and feed crop grown in diverse ecologies (Firon *et al*., 2009) in sub Saharan Africa, where it plays a food security role. In comparison with other tubers, sweet potato contains an average amount of protein and carbohydrates mainly starch. The tuber is rich in Vitamin C with Vitamin A and B being present in significant amounts. Sweet potatoes also have white, yellow or orange flesh (Rose and Vasanthakalam, 2011).

Furthermore, sweet potatoes are highly cherished by children because of their sweet taste and can be suitable candidates for use as base for formulation of flour for infant complementary feeding (Yadang *et al*., 2013).

In the tropics, sweet potatoes are usually eaten straight from the farm after boiling, roasting or frying and occasionally peeled, cut into slices, dried into chips and ground into flour. However, with increased consumer interest in fermented foods due to the belief that they are natural and healthy foods (Ray, 2004) and the bulkiness and perishability of harvested sweet potato, there is the need to diversify the processing methods to include fermentation of the tuber before flour production.

At present, there seem to be no adequate literature on the use of fermentation to improve the nutritional quality of sweet potato flour especially on that of the recent cultivars available in South-east Nigeria. The objectives of this study were to determine the microbiological profile of different sweet potato cultivars during fermentation and that of the fermented flour. In addition, to determine the physicochemical properties and shelf stability of the fermented flour samples.

2. MATERIALS AND METHODS

Mature roots of TIS 2532.OP.1.13 and TIS 87/0087 cultivars of sweet potato were harvested from the Production field of National Root Crops Research Institute (NRCRI) Umudike, Nigeria and taken to the Laboratory for processing.

3. PREPARATION OF SWEET POTATO ROOTS FOR FERMENTATION

The sweet potato roots were peeled manually and washed with clean tap water. The washed roots were cut into chips of (2.5-3.0) mm thickness, oblong shaped, with the use of a manual chipping machine (Fusion Brand, Model FX – 528 Heenan, China).

The chips of each of 10kg variety were put into two basins of same volume and diameter (25litres and 54cm) respectively and properly labeled. They were soaked in water (1:2 ratio) and allowed to ferment for 24 h at ambient temperature. At 0h and 4 h intervals for 24h period

samples were taken from the fermenting medium for determination of pH, titratable acidity and microbial counts.

4. DETERMINATION OF THE PHYSICOCHEMICAL PROPERTIES OF SAMPLES

4.1. pH Measurement

One hundred (100 ml) of an aliquot of the sample was dispersed into a 250ml beaker. The pH of the sample was determined using a pH meter (model HANNA pH 211). The pH meter was used after its initial standardization using appropriate buffers of pH 4.2, 7.0 and 9.2 respectively (Oyewole and Odunfa, 1990).

4.2. Determination of Titratable Acidity (%)

The acidity method described by Achi and Akubor (2000) was used with modification and result expressed as percentage lactic acid. The titration of 50ml of the fermenting medium (steep water) with NaOH using phenolphthalein as indicator was done until the end point (pink colour) was reached. The concentration (% Lactic acid) produced was calculated using the formula, TN/V.

Where,

T = Titre value of NaOH used

N= Normality of NaOH used (0.02N)

V = Volume of sample used 50ml. The result was then recorded for the individual samples as % lactic acid.

5. ISOLATION AND ENUMERATION OF BACTERIA AND FUNGI POPULATIONS DURING FERMENTATION AND AT STORAGE

At 4h intervals, five (5ml) of the fermenting medium was collected from each of the samples and dispersed into 45ml of sterile distilled water in the test tube as aliquots. The mixtures were shaken to homogenize. Serial dilutions were carried out using 10 – fold dilutions. The pour plate method as described by Ezeama (2007) was carried out.

Tryptone soy Agar (TSA) was used for enumeration of total aerobic bacteria. The plates were incubated at 35 - 37°C for 24 to 48h. De Mann Rogosa and Sharp Agar (MRS Agar) was used for isolation of lactic acid bacteria. The plates were incubated at 30° C for 3 days.

After incubation, colony forming units ($\log_{10}$ cfu g^{-1}) were estimated using colony counter. Colonies were purified by sub-culturing on fresh Tryptone soy Agar and Gram-stained for morphological examination and biochemical tests: (catalase, coagulase, oxidase, citrate, glucose, sucrose, mannitol, lactose, maltose and inositol) were used for characterization and identification of the isolates as described by Buchanan and Gibbons (1975). Colonies of the fungi emerging within 2-5 days of incubation were identified under the light microscope(x40) and recorded using the scheme of Barnett and Hunter (1990). Each experiment was in triplicates.

6. SWEET POTATO FLOUR PRODUCTION

Sweet potato flours were produced from each of the sweet potato cultivars using the processing methods described by Aniedu and Oti (2007). At the end of the 24h fermentation, the water was drained off from the fermented chips. The softened chips were oven-dried at 55^{0}C for 24h in an electric oven (Gallenkamp model v-160). After oven-drying, the dried chips were milled using hammer mill and sieved with Muslim cloths. The flow chart for the production of sweet potato flour is shown in Fig 1. The flours obtained from the varieties were properly packaged and sealed in polyethylene bags of 100g each and stored at ambient temperature (28±2 ^{0}C) for 3 months. Portion of the samples were taken for proximate analysis and microbial counts at 0, 1, 2, and 3 months.

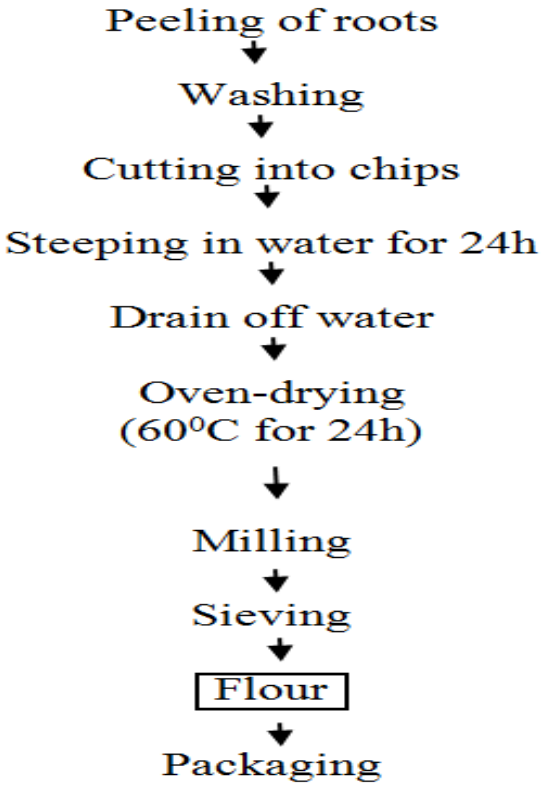

Fig-1. Flow chart for processing sweet potato roots into flour.

6.1. Determination of Shelf Stability of the Sweet Potato Flour

The bacterial and fungal counts of both varieties were determined by pour plate techniques as described by Ezeama (2007). The samples of 5g each were dispersed into 45ml of sterile distilled water in test tubes as aliquots. The mixtures were shaken to homogenize. Serial dilutions were carried out using 10-fold dilutions and appropriate aliquots used to determine the total viable count (TVC) on Tryptone soy agar (TSA) and Potato Dextrose agar (PDA) for fungal count. Discrete colonies on the plate based on their cultural and morphological characteristic were sub cultured. Biochemical tests and identification were also carried out.

6.2. Nutrient Composition of Stored Sweet Potato Flours

The AOAC (1990) method was used for the analysis of moisture, carbohydrate and protein content. The method described by Pearson (1975) was also used for crude lipid and crude fibre while ash content was determined as described by Onwuka (2005).

7. STATISTICAL ANALYSIS OF DATA

Statistical package for social science version 15, software package was used for the statistical analysis of variance (ANOVA) on data obtained. Mean separation was done using Duncan multiple range test to determine the significant difference P =0.05 (Steel and Torrie, 1980).

8. RESULTS AND DISCUSSION

Table 1 shows the total viable counts (TVCs) during the fermentation of sweet potato cultivars. The TVCs was highest at 12h fermentation time irrespective of cultivars with the values at 0h ranging from 3.40 – 3.54 $\log_{10}$ cfu g^{-1} for TIS 87/0087 and TIS 2532.OP.1.13 respectively, 6.60 to 6.64$\log_{10}$ cfu g^{-1} at the 12h respectively. The TVCs increased with fermentation time up to 12h and subsequently showed a slight decrease at 16h, 20h, and 24h of fermentation for both varieties respectively. This increase may be due to ready availability of adequate nutrient for microbial growth and proliferation. However, the decrease in population may probably be due to depletion of available nutrient and production of toxic products in the fermentation media. Similar reports were made by Lawal *et al.* (2009) during their studies on fate of pathogenic bacteria during fermentation of cereal porridge and Efiuvwevwere and Ezeama (1996) on fermentation of rice for *masa* production. At 0h, the total viable counts (TVC) for both cultivars were significantly different ($P<0.05$) and at 4h,8h,12h,16h,20h, and 24h, the counts were not significantly ($P>0.05$) different between the cultivars. This may be due to adaptation of the various microorganisms after the 4h of fermentation leading to the same rate of proliferation thereafter.

Table 2 shows the lactic acid (LAB) profile during fermentation of sweet potato cultivars. The highest count of LAB was recorded for both samples at 12h of fermentation and the least count at 0h of fermentation. The pH at 4h may have been optimal or favorable for growth for both cultivars. The result indicated LAB fluctuated in numbers during fermentation period irrespective of cultivars. The LAB count ranged from 2.40 to 3.60 $\log_{10}$ cfu g^{-1} for TIS 87/0087 and 2.54 to 3.64 $\log_{10}$ cfu g^{-1} for TIS 2532 OP.1.13 by 12h of fermentation. There existed an increase in LAB up to the 12h of fermentation and subsequent decrease in LAB population until the 20h of fermentation. The decrease in population of LAB up to the 20h of fermentation may be as a result of further decrease in pH as evidenced in (Fig. 2) which may have been unfavourable to the LAB population. However, adaptation mechanism of the LAB may have led to their population increase after 20h of fermentation. There was significant difference ($P<0.05$) among the lactic acid bacteria during the fermentation of the sweet potato cultivars TIS 87/0087 and TIS 2532.OP.1.13. The microorganisms present in the fermentation medium of both sweet potato cultivar are presented in Table 3 and 4. The bacteria isolates were *Staphylococcus aureus*,

Lactobacillus plantarum, *Streptococcus* spp *and Bacillus cereus*. The mycoflora include, *Aspergillus niger*, *Rhizopus stolonifer*, *Penicillium* spp *and Saccharomyces cerevisiae*.

Table 3 and 4 shows the occurrence of microorganisms during the fermentation of sweet potato cultivars (TIS 87/008 and TIS 2532.OP.1.13). A diverse group of microorganisms were isolated during the fermentation. These include *Staphylococcus aureus*, *Bacillus cereus*. *Lactobacillus plantarum*, *Streptococcus spp*, *Aspergillus niger*, *Rhizopus stolonifer and Saccharomyces cerevisiae*. The presence of *Staphylococcus aureus* from both cultivars at 0h of fermentation may be attributed to poor hygiene of food handlers and equipment used during processing. Similar results have been reported by Okolcha and Ajide (2006) that isolation of *Staphylococcus aureus* in food are due to the poor hygiene of food handlers, water and utensils used. Furthermore, the presence of *Staphylococcus aureus* has been associated with fermented foods of plants origin especially vegetable products (Adams and Moss, 1995). At 12h fermentation time, the *Aspergillus niger*, *Penicillium* spp, *Rhizopus stolonifer* and *Saccharomyces cerevisiae* were isolated. The presence of *Aspergillus niger*, *Rhizopus stolonifer* and *Penicillium* spp have been reported as an indication of contamination as they are common spoilage organisms of carbohydrate containing food (Onovo, 2006). The absence of important food pathogen such as *Staphylococcus aureus* and *Bacillus cereus* towards the end of the fermentation is highly revealing as the final product is likely to be safe. *Staphylococcus aureus* is a poor competitor and low pH inhibits their growth. Furthermore, the absence of these pathogen may be due to the presence of LAB which had been known to exhibit antagonistic activity against many pathogenic microorganisms (Savadoyo *et al*., 2004; Adesokan *et al*., 2008). The absence of moulds and yeasts at the beginning and up to the 8h of fermentation may be attributed to the high pH of the medium (Fig.2) which did not favour their growth. With the decrease in pH after the 8h, the moulds and yeasts became prominent thereby showing their acid tolerant nature.

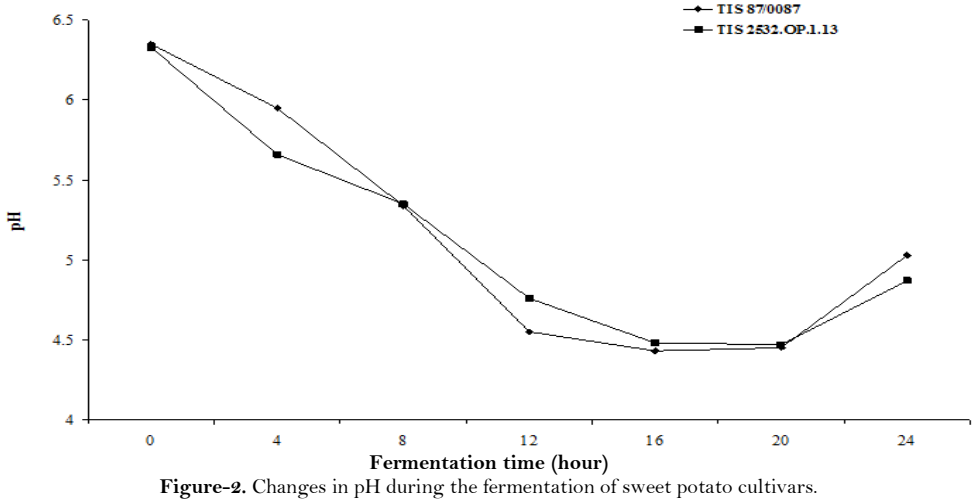

Figure-2. Changes in pH during the fermentation of sweet potato cultivars.

Figure 2 shows the pH changes during the fermentation of sweet potato cultivars for flour production. The result indicate that there was a gradual fall in pH from initial value of 6.35 for

TIS 87/0087 and 6.33 for TIS 2532.OP.1.13 at 0h to pH of 5.03 and 4.87 respectively at 24h fermentation. Similar pH values from 6.3 to 4.5 was reported by Egounlety and Syarief (1992) during the studies of *ogi* supplemented with tempe. A pH decline with corresponding rise in acidity in maize dough fermented with and without a starter culture was also reported by Annan *et al.* (2003). The range of pH obtained especially towards the end of fermentation was enough to inhibit the growth of undesirable microorganisms, since bacteria growth occurs optimally at pH values 6-7. The decrease in pH values is attributed to the production of acid (lactic acid), which is characteristic of carbohydrate food fermentations as a result of the amylolytic activity of the fermenting microorganisms. The abundant production of lactic acid, which is responsible for the unique aroma has been reported for cereal and other fermentations such as *garri*, *rice masa*, *burukutu*, *kunun – zaki* (Efiuvwevwere and Ezeama, 1996; Efiuvwevwere and Akoma, 1997).

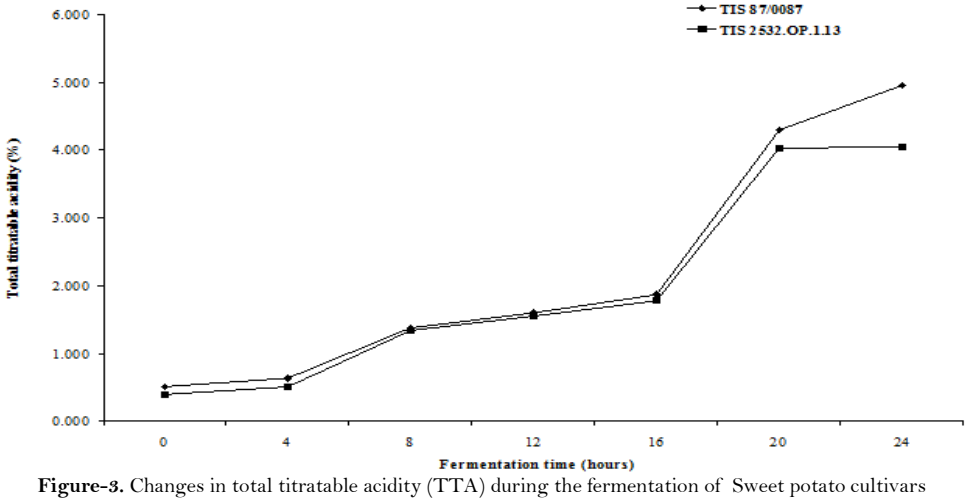

Figure-3. Changes in total titratable acidity (TTA) during the fermentation of Sweet potato cultivars

Figure 3 shows the changes in total titratable acidity during the fermentation of sweet potato cultivars. The result indicated that there was an increase in total titratable acidity from an initial value of 0.51% to 4.96% for TIS 87/0087 and 0.40% to 4.04% for TIS 2532.OP.1.13 after 24h fermentation time. For TIS 2532.OP.1.13 there was no difference in titratable acidity during the fermentation time of 20h and 24h. Similar observation had been by reported by Efiuvwevwere and Ezeama (1996); Olasupo (2001) on increase in titratable acidity during the production of *masa* from rice and *ogi* from maize grain respectively. The percentage (%) of titratable acidity appeared to increase as fermentation progressed in relation to the fall in pH.

Table 5 shows the proximate composition of the fermented and unfermented oven-dried sweet potato flours for both varieties. The result revealed that the oven-dried variety TIS 87/0087 had lower moisture content (10.76%) compared to that of TIS 2532.OP.1.13 (11.34%). Generally, low moisture content of the oven-dried flours is an indication of good stable shelf life of the flours if packaged and stored properly (Amajor *et al.*, 2011). With the moisture range (10-12%), the quality of the final product will not be adversely affected (Etudaiye *et al.*, 2009). The

result shows acceptable values of proximate composition since fermentation has nutritional advantage in a food. There was significant difference ($P<0.05$) in moistures, dry matter, ash, fibre, protein and crude lipid of both varieties of flour. The high dry matter content is an indication of desirable quality attributes and meets end users characteristic (IITA, 2005). The dry matter content is acceptable since it is a practical approach to improving the shelf life and marketability of flour (Akingbala *et al*., 1991). The high carbohydrate content (81%) and protein (5%) revealed that fermentation of sweet potato roots does not destroy the nutritional content of the roots rather it brings about a modification of the nutritional component of the roots for better usage (Uaboi Egbenni *et al*., 2008).

The proximate composition of the unfermented sweet potato flour is shown in Table 5. The result shows that the unfermented flour was lower in protein content (2-3%) than the fermented flour (5%). This led credence to the observation made by Uaboi Egbenni *et al*. (2008) that fermentation improved the nutritional content of foods. Similarly, the TIS 87/0087 flour was higher in protein (5.16%) content than the TIS 2532.OP.1.13 (5.09%). It followed the same trend on the unfermented flours. The protein content of the fermented sweet potato flour (5.09-5.16%) was higher than the unfermented sweet potato flour (2.5-3.05%). This was similar to that of Walter *et al*. (1992). The dry matter of fermented and unfermented sweet potato flour were high (88-89%). This was at variance to that of Bradbury and Holloway (1988) who reported 30% as the dry matter. It is likely that the difference was as a result of the differences in cultivars as well as location of cultivation.

Table 6 shows the total viable count (TVCs) $\log_{10}$ cfu g^{-1} of fermented and unfermented sweet potato flours stored at ambient temperature (28 ± 2^0C) for three months. The result revealed that the TVCs of the fermented sweet potato flour ranged from 3.19 to 3.93 $\log_{10}$ cfu g^{-1} for TIS 87/0087 and 3.41 to 3.98 $\log_{10}$ cfu g^{-1} for TIS 2532.OP.1.13. The TVCs was low but increased gradually with increased storage time for TIS 87/0087 and TIS 2532.OP.1.13 varieties. This could be attributed to contamination during packaging and storage condition of the products. It has been reported by Frazier and Westhoff (1997) that the number of organisms will increase if equipment is not adequately cleansed and sanitized. There was significant difference ($P<0.05$) from zero (0) month of storage to three months of storage for the cultivar TIS 87/0087 and the TIS 2532.OP.1.13 followed the same trend but had higher microbial counts than the variety TIS 87/0087, which may be attributed to storage condition of the products.

Table 7 shows the total fungal count (TFC) $\log_{10}$ cfu g^{-1} of fermented and unfermented sweet potato flours stored at ambient temperature (28 ± 2^0C). The fungal load ranged from 2.40 to 2.93 $\log_{10}$ cfu g^{-1} for TIS 87/0087 and 2.40 to 2.93 $\log_{10}$ cfu g^{-1} for TIS 2532.OP.1.13.The result showed that the total fungal count (TFC) of the sweet potato flours increased with increased storage time for both cultivars. This may be due to the storage condition. The result also showed no significant difference ($P>0.05$) of the total fungal count ($\log_{10}$ cfu g^{-1}) during the storage time for TIS 87/0087 and TIS 2532.OP.1.13. The microbial counts of the unfermented sweet potato flour increased with storage time and the flour had higher microbial load than the fermented flour. It is likely that the fermented product with its lower pH (high acidity) may have contributed

to discouraging the rapid proliferation of the microorganisms. The TVCs and total fungal counts of the sweet potato flours were within the acceptable limits (FAO, 1979) and therefore safe for human consumption, and can be recommended for incorporation in instant foods and bakery products. However, the flour can have stable shelf life for three (3) months.

9. CONCLUSION

This study has shown fermentation of sweet potato roots for flour production. The result showed that a wide diversity of microorganisms were involved in the natural fermentation process of the sweet potato cultivars for the production of flour. The microorganisms involved were *Staphylococcus aureus*, *Lactobacillus plantarum*, *Streptococcus* spp, and *Bacillus cereus* for bacteria while *Aspergillus niger*, *Rhizopus stolonifer*, *Penicillium* spp, *Saccharomyces cerevisiae* were the dominant fungi.

This study has shown fermentation of sweet potato roots for flour production and its shelf stability for three months. The total viable count (TVC) of the fermented sweet potato flours were low and safe for consumption for not more than three (3) months. The nutritional composition shows that protein content of fermented flours were higher than the unfermented sweet potato flour. However, the TIS 87/0087 variety showed better attribute of quality than the TIS 2532.OP.1.13 variety irrespective of fermentation treatment.

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Competing Interests: The authors declare that they have no competing interests.

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REFERENCES

Achi, O.K. and P.I. Akubor, 2000. Microbiological characterization of yam fermentation for yam flour (Elubo) production. World Journal of Microbiology and Biotechnology, 16(1): 3-7.

Adams, M.R. and M.O. Moss, 1995. Food microbiology. Cambridge U.K: The Royal Society of Chemists.

Adesokan, I.A., B.B. Odetoyinba and A.O. Olubanimiwa, 2008. Biopreservative activity of lactic acid bacteria on suya produced from poultry meat. African Journal of Biotechnology, 7(20): 3796-3800.

Akingbala, J.O., B. Oguntimehim and A.B. Abas, 1991. Effects of processing methods on the quality and acceptability of fufu from low cyanide cassava. J. Sci. Food Agric, 5A(1): 151-154.

Amajor, J.U., E. Oti and E.E. Amajor, 2011. Study on the application of traditional and improved processing techniques in the production of sweet potato flours. Nigeria Agricultural Journal, 42: 104-109.

Aniedu, C. and E. Oti, 2007. Sweet potato-based recipes: Extension bulletin. Umudike, Nigeria: National Root Crops Research Institute.

Annan, N.T., L. Poll, S. Sefa-Dedeh, W.A. Plahar and M. Jakobsen, 2003. Volatile compounds produced by lactobacillus fermentum, saccharomyces cerevisiae and Candida krusei in single starter culture fermentations of Ghanaians maize dough. Journal of Applied Microbiology, 94(3): 462-474.

AOAC, 1990. Official methods of analysis of the association of official analytical chemists. In: K. Helrich, Eds. 15th Edn., Arlington, VA: Association of Official Analytical Chemists, Inc.

Barnett, H.I. and B.B. Hunter, 1990. Illustraed genera of the imperfect fungi. 4th Edn., USA: Burgress Publishing Co.

Bradbury, J.H. and W.D. Holloway, 1988. Chemistry of tropical root crops: Significant for nutrition and agriculture in the pacific. Australin Centre for International Agricultural Research (ACIAR) Monograph Series, No. 6 Canberra, Australia. ACIAR.

Buchanan, R.E. and N.E. Gibbons, 1975. Bergeys manual of determination bacteriology. Baltimore: Williams and Wikins Company.

Efiuvwevwere, B.J.O. and O. Akoma, 1997. The effects of chemical preservatives and pasteurization on the microbial spoilage and shelf-life of Kunu-Zaki. Journal of Food Safety, 17(3): 203-213.

Efiuvwevwere, B.J.O. and C.F. Ezeama, 1996. Influence of fermentation time and indigenous tenderizer (Kanwa) on the microbial profile, chemical attributes and shelf life of rice masa (A Nigerian Fermented Product). Journal of the Science of Food and Agriculture, 71(4): 442-446.

Egounlety, M. and R. Syarief, 1992. Study on the supplementation of ogi with tempe. Nigerian Food Journal, 10: 92-102.

Etudaiye, H.A., T.U. Nwabueze and L.O. Sanni, 2009. Quality of fufu processed from cassava mosaic disease (CMD) resistant varieties. African Journal of Food Science, 3(3): 061-067.

Ezeama, C.F., 2007. Food microbiology: Fundamentals and applications. Lagos, Nigeria: Natural Prints Limited.

FAO, 1979. Food and nutrition paper 14/4 manual of food quality control 4. (Microbiological Analyses). Rome Italy: FAO.

Firon, N., A. LaBonte, C. Villordon, J.K. McGregor and E. Pressman, 2009. Botany and physiology: Storage roots formation and development. ln: G. Loebensteing, G. Thottappilly (Eds). The sweet potato. Heidelberg: Springer SBM. pp: 13 - 26.

Frazier, W.C. and D.C. Westhoff, 1997. Food microbiology. 7 West Patal Nugar, New Delhi 110008: Tata McGraw Hill. pp: 135-140.

IITA, 2005. Cassava illustration guidebook, growing cassava commercially in Nigeria. Ibadan, Nigeria: International Institute of Tropical Agriculture. pp: 21-22.

Lawal, A.K., O.B. Oyedoyin and O.O. Olatunji, 2009. Fate of pathogenic bacteria during fermentation of cereal porridge (Ogi) – a weaning food formula. Nigerian Food Journal, 27(1): 19 -26.

Okolcha, E.C. and J.K. Ajide, 2006. Hazards and critical control points of pounded yam (Yam Fufu) and vegetable soup prepared in a restaurant in Zaria, Nigeria. Nigeria Journal of Microbiology, 20(1): 769-781.

Olasupo, N.A., 2001. Development of starter cultures of local food fermentation in Nigeria. Journal of Research and Review in Science, 2: 199-204.

Onovo, M.O., 2006. Microbial quality of zobo. (Unpublished). A B.Sc. Project. Department of Microbiology, Michael Okpara University of Agriculture Umudike, Nigeria.

Onwuka, G.I., 2005. Food analysis and instrumentation. Theory and practice. Surulere, Lagos, Nigeria: Naphthali Prints. pp: 68-69.

Oyewole, O.B. and S.A. Odunfa, 1990. Characterization and distribution of lactic acid bacteria in cassava fermentation during fufu production. Journal of Applied Bacteriology, 68(2): 145-152.

Pearson, D., 1975. The chemical analysis of foods. Churchill: Livingston Edinburgh. pp: 155-191.

Ray, B., 2004. Fundamental of food microbiology. 3rd Edn., USA: CRC Press.

Rose, I.M. and H. Vasanthakalam, 2011. Comparison of the nutrient composition of four sweet potato varieties cultivated in Rwanda. American Journal of Food and Nutrition, 1(1): 34-38.

Savadoyo, A., A.T. Cheik, I. Quattara, H.N. Bassole and S.T. Alfred, 2004. Antimicrobial activities of lactic acid bacterial strains isolated from Burkina Faso fermented milk. Pakistan Journal of Nutrition, 3(3): 174-178.

Steel, R.G.B. and J.H. Torrie, 1980. Principles and procedures of statistics; A biometric approach. New York: McGraw Hall Publication.

Uaboi Egbenni, P.O., A.O. Sabande, P.N. Okolie, O. Teniola and C. Ofodiogo, 2008. Proximate composition of whole, dehulled and fermented beniseed sesame indicum with associated bacterial species. Nigeria Food Journal, 26(1): 55-64.

Walter, A.H., K.B. Conrad and P.A. Lovetan, 1992. Sweet potato technology for 21st century. Alabama: Tuskegee University.

Yadang, G., I.L. Mbome and R. Ndjouenkeu, 2013. Changes in amylase activity, hot paste viscosity and carbohydrates during natural fermentation of sweet potato (Ipomoea Batatas). Food Sci and Technol, 4(8): 188-194.

Table-1. Total Viable Count (log_{10} cfu g^{-1}) during the fermentation of sweet potato cultivars.

Fermentation Time (h)	Cultivars	
	TIS . 87/0087	**TIS . 2532. 0P. 1. 13**
0	3.40 ± 0.82^{f}	3.54 ± 1.14^{e}
4	3.93 ± 1.41^{d}	3.98 ± 1.82^{d}
8	4.29 ± 0.01^{c}	4.33 ± 0.62^{c}
12	6.60 ± 1.41^{a}	6.64 ± 0.01^{a}
16	6.56 ± 1.41^{b}	6.58 ± 1.14^{b}
20	5.62 ± 1.41^{e}	5.67 ± 1.83^{e}
24	5.89 ± 1.83^{d}	5.96 ± 1.82^{d}

Values in rows with different superscripts are significantly different ($p<0.05$).
Values are means ± SD of three independent determinations.

Table-2. Lactic acid bacteria (log_{10} $cfug^{-1}$) profile during fermentation of sweet potato cultivars

Fermentation time (h)	Cultivars	
	TIS. 87/0087	**TIS 2532.OP.1.13**
0	2.40 ± 1.13^{g}	2.54 ± 0.42^{g}
4	2.93 ± 0.99^{d}	2.98 ± 1.41^{c}
8	3.29 ± 1.69^{c}	3.33 ± 0.71^{b}
12	3.60 ± 1.56^{a}	3.64 ± 0.14^{a}
16	3.56 ± 0.71^{b}	3.58 ± 1.83^{f}
20	2.62 ± 1.27^{f}	2.67 ± 1.28^{e}
24	2.76 ± 0.98^{e}	2.79 ± 0.98^{d}

Values in rows with different superscripts are significantly different ($p<0.05$)
Values are means ± SD of three different determinations

Table-3. Occurrence of micro-organisms during fermentation of sweet potato cultivar TIS 87/0087

Isolates	Time (h)						
	0	4	8	12	16	20	24
Staphylococcus aureus	+	+	+	-	-	-	-
Lactobacillus plantarum	+	+	+	+	+	+	+
Streptococcus spp	+	+	+	+	+	+	+
Bacillus cereus	+	+	+	+	-	-	-
Aspergillus niger	-	-	-	+	+	+	+
Rhizopus stolonifer	-	-	-	+	+	+	+
Pencillium spp	-	-	-	-	+	+	+
Saccharomyces cerevisiae	-	-	-	+	+	+	+

+ = Positive, - = Negative

Table-4. Occurrence of microorganisms during fermentation of sweet potato cultivar TIS 2532.OP.1.13

Isolates	Time (h)						
	0	4	8	12	16	20	24
Staphylococcus aureus	+	+	+	-	-	-	-
Lactobacillus plantarum	+	+	+	+	+	+	+
Streptococcus spp	+	+	+	+	+	+	+
Bacillus cereus	+	+	+	+	-	-	-
Aspergillus niger	-	-	-	+	+	+	+
Rhizopus stolonifer	-	-	-	+	+	+	+
Pencillium spp	-	-	-	-	+	+	+
Saccharomyces cerevisiae	-	-	+	+	+	+	+

+ = Positive, - = Negative

Table-5. Proximate Composition (%) of the fermented and unfermented sweet potato flours

Samples	Moisture content	Dry matter	Ash	Crude fibre	Protein	Crude Lipid	Carbohydrate
F TIS 87/0087	10.76±0.06	89.24±0.05	2.07±0.04	0.76±0.01	5.16±0.00	0.68±0.01	81.25 ±0.11
U TIS 87/0087	11.83±0.00	88.17±0.00	1.20±0.00	0.68±0.03	3.05±0.07	0.30±0.01	83.30±0.03
F TIS 2532.OP.1.13	11.34±0.06	88.66±0.06	1.92±0.00	0.64±0.01	5.09±0.01	0.47±0.01	81.01±0.05
U TIS 2532.OP.1.13	11.99±0.02	87.01±0.01	1.51±0.01	0.07±0.00	2.55±0.07	0.24±0.00	83.62±0.04
F T-value (df=2)	10.253**	10.253**	5.000**	16.671**	7.000**	29.698**	2.90^{ns}
U T-value (df=2)	10.66**	9.963**	16.00**	1.00^{ns}	7.071**	11.00**	9.014^{ns}

ns =No significance difference(P>0.05)
** = Significance difference (P<0.05)
Values are means ± SD of two different determinations.
F = Fermented
U = Unfermented

Table-6. Total viable count (TVC) $\log_{10}$ cfu g^{-1} of fermented and unfermented sweet potato flour stored at ambient temperature (28±2°C).

	Varieties	
Storage time (months)	**TIS 87/0087**	**TIS 2532.OP.1.13**
0	**F** 3.19 ± 0.16^{d}	3.41 ± 0.19^{c}
	U 3.18	3.18
1	**F** 3.20 ± 0.14^{c}	3.41 ± 0.14^{d}
	U 3.18	5.40
2	**F** 3.65 ± 0.17^{b}	3.74 ± 0.13^{b}
	U 6.40	6.54
3	**F** 3.93 ± 0.01^{a}	3.98 ± 0.08^{a}
	U 3.54	7.65

Values in rows with different superscripts were significantly different (P<0.05).
Values are means ± SD of three independent determination
F = fermented flour
U = unfermented flour

Table-7. Total fungal count (TFC) $\log_{10}$ cfu g^{-1} of fermented and unfermented sweet potato flours stored at ambient temperature (28 ± 2^{0}C)

Storage time (months)		TIS. 87/0087	TIS 2532.OP.1.13
0	**F**	2.40 ± 1.41^d	2.40 ± 0.05^d
	U	2.40	2.40
1	**F**	2.54 ± 0.14^c	2.55 ± 0.00^c
	U	3.40	3.40
2	**F**	2.87± 0.05^b	2.88 ± 0.09^b
	U	4.65	4.74
3	**F**	2.93 ± 0.10^a	2.93 ± 0.07^a
	U	5.84	5.81

Values in rows with different superscripts are significantly different (P<0.05)
Values are means ± SD of three independent determinations.
F=Fermented
U= Unfermented