



ASSESSMENT OF STORAGE QUALITY OF YELLOW LAFUN PRODUCED WITH *Weissella koreensis*

FAWOLE, A. O. ^{1*}; OGUNGBEMI, K. ²; OKEDARA, E. O. ¹; KOLAPO, A. L. ³; FATOKI, O. A. ¹

¹Department of Biology, The Polytechnic, Ibadan, Nigeria; ²Chemistry/Biochemistry Unit; Nigerian Stored Products Research Institute, Ibadan, Nigeria; ³Department of Biological Sciences, Augustine University, Nigeria

*Corresponding author: abosedefawole@yahoo.com

Abstract

Lafun is made through submerged fermentation and traditionally processed using spontaneous fermentation involving random microorganisms. This traditional method can sometimes result in inconsistent product quality and potential safety issues. Improper use of packaging materials can also affect the storage of Lafun. Therefore, this study aimed to investigate the fermentation of yellow cassava (TMS-IBA 01137) roots using a starter culture, Weissella koreensis, and to assess the quality of specific packaging materials. The samples were stored in four different packaging materials: Transparent Ziploc bag (ZT), Opaque Ziploc bag (ZO), Transparent vacuum-sealed bag (VT), and Opaque vacuum-sealed bag (VO), for 90 days after processing. The microbial counts, functional properties, proximate composition, carotenoid content, and sensory properties of the stored samples were determined every 30 days. The results showed that the samples in Ziploc materials had the highest bacterial (6.8–7.5 Log CFU) and fungal (7.0–9.0 Log CFU) counts. The highest moisture content was detected in transparent packaging materials (ZT= 9.7%; VT= 10.9%). There were no significant changes in the ash, fibre, and carbohydrate levels across all the samples at 30 and 60 days and no difference in fibre content at 90 days. At the end of the study, lafun in ZT had the least protein content (1.7%). The carotenoid content level decreased significantly in the transparent packaging materials within 30 days of storage (0.9 - 0.4 µg g⁻¹). The sample in ZO had the highest swelling power (9.2%) and starch solubility index (7.3%). The samples stored in vacuum-sealed materials had the highest overall liking and purchasing intent by 90 days. Vacuum packaging was found to effectively maintain yellow lafun storage stability attributes.

Keywords: Improved cassava variety; Control fermentation; Yellow lafun; Storage; Packaging materials

INTRODUCTION

Since immemorial, cassava has been used as raw material to make several food products, including *lafun*, *gari*, *kokonte*, *fufu*, and *agbelima* (Udoro et al., 2021; Oyewole, 1991). Cassava products are processed differently in Africa to suit different purposes and meet people's daily dietary

requirements. *Lafun* is a cassava-based fermented food product traditionally consumed in West Africa, especially in Nigeria and Benin's western states (Falade and Akingbala, 2010). It is produced through the submerged fermentation process of peeled cassava tubers, where the carbohydrates are anaerobically or partially aerobically



decomposed by the action of certain microorganisms (Olawoyin, 2023). Fermentation usually takes 3-5 days (Oyewole and Odunfa, 1992; Ray *et al.*, 2007). The water-softened fermented tubers are then dried and ground into a fine powdery form, later made into consistent stiffened dough with boiling water and consumed with any choice of soup (Fawole, 2019; Oyewole and Afolami, 2001; Fawole and Kolapo, 2022).

Cassava fermentation requires starter cultures to maintain uniformity in quality and safety measures. Since lactic acid bacteria have many functions, including lowering anti-nutritional factors and generating antimicrobial compounds that increase food safety, they are frequently used in fermentation (Fawole, 2019; Kostinek *et al.*, 2007). Lactic acid fermentation involves chemical breakdown and utilisation of raw carbohydrate substrate by the actions of Lactic acid bacteria (LABs), microorganisms that synthesise lactic acid as their primary metabolic product (Mathur *et al.*, 2020). LAB genera involved in lactic acid fermentation

include *Carnobacterium*, *Enterococcus*, *Lactobacillus*, *Weissella*, *Lactococcus*, *Vagococcus*, and *Leuconostoc* (Stiles, 1997). LABs are versatile. They are often used as starter cultures in food processing industries to enhance finished products' quality, consistency, health benefits and shelf life (Caplice, 1999; Kostinek *et al.*, 2005).

In previous studies, packaging has been generally linked to the storability extension of food products (Opara and Mditshwa, 2013). Using suitable packaging materials reduces food

contamination from the infiltration of undesirable microorganisms and foreign matter such as debris and sand. This causatively extends the storability of food products and invariably increases their shelf life (Anyogu *et al.*, 2021). Achi and Akomas (2006) opined that the quality and edibility of most fermented cassava-based food products are further affected by storage conditions, moisture content, and water activity after they have been processed into finished products.

Lafun, a good source of carbohydrates and one of the staple meals of many homes in Nigeria, sadly, has been identified with many constraints. The major downside is the traditional ways of processing and primitive storage techniques, which have threatened the existence of lafun in the modern food chain. It has also limited the product's marketability outside the shores of the producing regions. Although many researchers have fermented white cassava roots using starter cultures, this work addressed the stability of lafun produced with yellow cassava roots (a provitamin A-enhanced variety of cassava) fermented with *Weissella koreensis*. The aim is to present the best packaging material(s) to extend the product's shelf life.

MATERIALS AND METHODS

Samples collection

Cassava roots (TMS-IBA01137) were sourced from the International Institute of Tropical Agriculture, Ibadan, Nigeria. These roots are improved cassava variety fortified with vitamin A, hence the yellow colour. *Weissella koreensis* was obtained from the culture



collections of the Food and Nutritional Sciences Department, University of Readings, United Kingdom. The strain was stored in 2 mL cryovials with 140 μ l of Dimethyl sulfoxide (DMSO) and 1860 μ l of cultured broth. Upon arrival in Nigeria, the strain was immediately stored in a -80 °C freezer and maintained in cultured broth throughout the experiment.

Preparation of samples

Preparation of cassava tubers

Cassava roots fortified with Vitamin A were washed, sorted, peeled, cut into 2 cm pieces, rewashed, and packed in a sterile bowl. (Fawole, 2019).

Preparation of yellow lafun

The prepared cassava tubers (23 kg) were steeped in sterile water (2300 mL) inside a drum with a tight cap. Twenty-three millilitre of a stock culture of *W. koreensis* with a density of 2.17×10^6 cells/mL was then added to the sterile water (inoculum size = 2.17×10^4). The set-up was left to ferment under anaerobic conditions for three days, with the temperature and pH checked daily. Thereafter, it was oven-dried in a fabricated multipurpose oven, milled, and stored. The samples are stored in vacuum-sealed opaque and transparent nylons and Ziploc bags (n=4).

Total viable count

Each sample (1 mL) was suspended in 9 mL of sterile water and homogenised for 2 min. Then, a serial dilution was prepared ranging from 10^{-1} to 10^{-9} . From the dilution factor 10^{-3} , 10^{-5} , and 10^{-7} , 0.5 mL were taken and inoculated aseptically into already solidified Plate Count Agar for viable bacteria count. Viable fungi count was done on Potatoes Dextrose Agar and Coliform on Eosin Methylene Blue Agar using the same method.

Determination of functional properties of yellow lafun

Swelling power and starch solubility index

Swelling power and starch solubility index were determined (Leach et al., 1959). The sample (1 g) was weighed into a conical flask containing 15 mL of distilled water. The mixture was placed on a low-speed shaker for about 5 min and heated in a water bath for 4 min at 80°C. The resulting gel and distilled water (7.5 mL) were centrifuged for 20 min at 2200 rpm. The supernatant was decanted and dried at 100–105 °C to constant weight. Finally, the swelling power and starch solubility index were calculated using the following equations:

$$\text{Swelling Power} = \frac{\text{Weight of the wet sediment (g)}}{\text{Weight of the sample (g)}} \times 100 \quad \text{Eq. 1}$$

$$\text{Starch Solubility index} = \frac{\text{Weight of soluble (g)}}{\text{Sample weight (g)}} \times 100 \quad \text{Eq. 2}$$

Proximate content determination

Moisture content (MC)

MC determination was carried out using the air oven method (AOAC, 2010).

Crucibles were washed, dried, and cooled. The sample (5 g) was placed in the crucible and dried in an oven (BST/HAO-1123) at 105 °C to a



constant weight. Moisture content was obtained by calculating weight loss.

$$\text{Moisture content \%} = \frac{(\text{Weight Loss}) \times 100}{(\text{Weight of Sample})} \quad \text{Eq. 3}$$

Ash content

The sample (5 g) was weighed into a crucible with a lid (W1). The organic matter was charred by igniting the sample over a low flame with the lid off. The crucible was heated to 600 °C in a Guangzhou Medsinglong

muffle furnace (model MSL/200B) for 6 h until the sample was reduced to ashes. The sample was moved directly into desiccators, allowed to cool, and then weighed immediately, giving the value of W2 (AOAC, 2010).

$$\text{Ash \%} = \frac{(W2-W1) \times 100}{(\text{Weight of Sample})} \quad \text{Eq. 4}$$

Crude fat

The crude fat percentage of the sample was determined using the Soxhlet extraction method (AOAC, 2010). Firstly, a known weight of the sample was taken and weighed into a filter paper, which was then neatly folded. This was placed inside a pre-weighed thimble (W1). The sample-containing thimble (W2) was carefully placed within the Soxhlet apparatus and a reflux extraction was

conducted using petroleum ether boiled at 40 °C ± 10 °C for a duration of 6 h. Once the extraction was complete, the thimble was dried in an oven for approximately 30 min at a temperature of 100 °C to eliminate any remaining solvent. The thimble was cooled in a desiccator and weighed (W3). The fat extracted from the sample was calculated using the equation below:

$$\% \text{ Fat (w/w)} = \frac{(\text{Loss in weight of sample}) (W2-W3) \times 100}{(\text{Original weight of sample}) (W2-W1)} \quad \text{Eq. 5}$$

Crude protein

The crude protein content was determined using the micro Kjeldahl method. Sample (1 g) was mixed with H₂SO₄ and Kjeldahl catalyst and heated until a clear solution was obtained. The

solution was cooled, diluted, and distilled. The liberated ammonia was trapped in boric acid solution, and the resulting solution was titrated against 0.1 M HCl until the first permanent colour change was observed.

$$\% \text{ N} = \frac{(\text{Molarity of HCl} \times \text{Sample Titre-Blank}) \times 0.014 \times \text{DF}}{(\text{Weight of the sample used})} \times 100 \quad \text{Eq. 6}$$

% was converted to the percentage of crude protein by multiplying by 6.25.

DF is the dilution factor, % N is the percentage of nitrogen, and 6.25 is the nitrogen: protein conversion factor.



Crude fibre

A mixture of 200 ml 1.25% H₂SO₄ and fat residue was boiled for 30 min, then filtered and washed. The residue was boiled with 1.25% NaOH, filtered, washed, and dried. The organic matter was burnt in a muffle furnace and weighed to get the crude fibre (AOAC, 2010).

Carbohydrate

The percentages of moisture, ash, fat, protein, and crude fibre present in the sample were added and subtracted from 100 to estimate the percentage of carbohydrates the sample contains. The technique used for assessment in this case is known as the estimation by difference.

Determination of carotenoid content of samples

Total carotenoids (TC) in fermented cassava (*lafun*) were determined through a spectrophotometric method (AOAC, 2000). A 12.5 mL solvent mixture (20 mL ethanol, 30mL n-Hexane, and 2 mL 2% NaCl) was used to extract a 2.5 mg sample, which was then transferred to a separating funnel and allowed to stand for 10 min. The upper layer of hexane was gathered, and its absorbance was assessed at 436 nm using Spectrumlab 22PC10069. TC was calculated using the formula below:

$$\text{TC (mg g}^{-1}\text{)} = \frac{A_{436} \times \text{volume made up (ml)} \times 1000}{2500 \times \text{sample weight (g)}} \%$$

Eq. 7

Sensory evaluation of fresh and stored samples

The study involved 20 participants with varying male-to-female ratios. The

evaluation was done using quantitative descriptive analysis. The participants were presented with freshly prepared samples and asked to score liking and purchase intent using a 5-point scale (1-extremely like, 2-Moderate like, 3-indifferent, 4-Moderate dislike 5-extremely dislike).

Statistical analysis

The SPSS general linear model procedure was utilized to analyse mean, standard error of the mean (SME), and standard deviation (SD) data. The significance level employed for the statistical analysis was $p < 0.05$, while the results were graphically represented using the GraphPad Prism software.

RESULTS

Total viable count

The total viable count is a microbiological procedure that estimates living microorganisms in a given sample. The viable bacteria, fungi, and coliform estimates were determined in *lafun* produced with yellow cassava roots and *Weissella koreensis*, stored in different packaging materials. While no growth was observed on EMB for coliform count throughout storage duration, Fig. 1A & B, respectively, showed viable bacteria and fungi counts of samples with respect to packaging materials and storage duration. There was a significant and proportional increase in microbial loads of samples in transparent Ziploc and opaque Ziploc bags (both for bacteria and fungi viable counts) as storage duration increased. Contrarily, there was a decrease in

microbial loads of samples in Vacuum bags at storage day 30, which later increased as storage duration increased. However, on day 90, only samples in Vacuum opaque bags had significantly reduced microbial loads (bacteria and fungi) compared to fresh samples (day 0).

The proximate composition of freshly processed and stored yellow lafun

The percentage proximate composition of freshly prepared *lafun* was compared with the stored

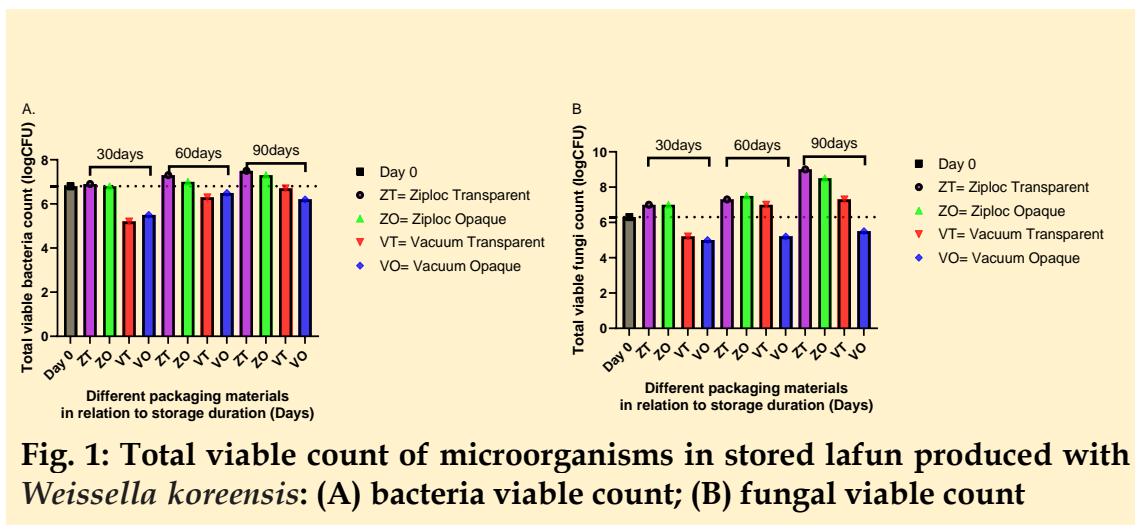


Fig. 1: Total viable count of microorganisms in stored lafun produced with *Weissella koreensis*: (A) bacteria viable count; (B) fungal viable count

samples for 90 days using different packaging bags (Fig. 2). There was an increase in moisture content of the stored samples in all packaging bags as storage duration increased (Fig. 2A). At day 90, the sample stored in vacuum transparent bags had the highest value of moisture (11%) content, while those stored in the vacuum opaque had the lowest (7%). By day 90, the sample stored in the opaque Ziploc had the lowest value of crude lipid (2%) compared to the value obtained from the fresh sample (4%) (Fig. 2B). While values for others were not significantly different from those of fresh sample ($p < 0.05$), except vacuum transparent stored sample which had the highest percentage of crude lipid (6%). All the samples had an increase in ash content, which was significantly

different from the fresh sample at day 30 but were not different from each other (Fig. 2C). At day 90, opaque Ziploc and vacuum opaque were no more significantly different from the fresh value (2%). However, transparent Ziplocs and transparent vacuum-sealed increased in value, with transparent Ziplocs having the highest percentage value of around (7%). All the stored samples in different packaging materials had significant decreases in crude fibre value at days 30 and 60 (Fig. 2D). While this decrease was maintained for opaque vacuum-sealed even at day 90 (2%), others had a significant increase in value (3%). Aside from samples stored in vacuum transparent bags, which had relatively the same value of 2% crude protein with the day 0 sample throughout

storage duration, others had significantly increased values but later reduced and became relatively the same in value with fresh sample at day 90 of storage duration (Fig. 2E).

The fresh sample (day 0) had a carbohydrate (CHO) composition of 87% (Fig. 2F). There was no significant difference ($p < 0.05$) in the value of all packaging materials with fresh sample

values at days 30 and 60. However, the CHO values of all the stored samples decreased at day 90 of storage. Transparent Ziploc and transparent vacuum-sealed had the lowest value of 75% CHO composition, while opaque Ziploc and opaque vacuum had relatively the same value of 84% carbohydrate composition.

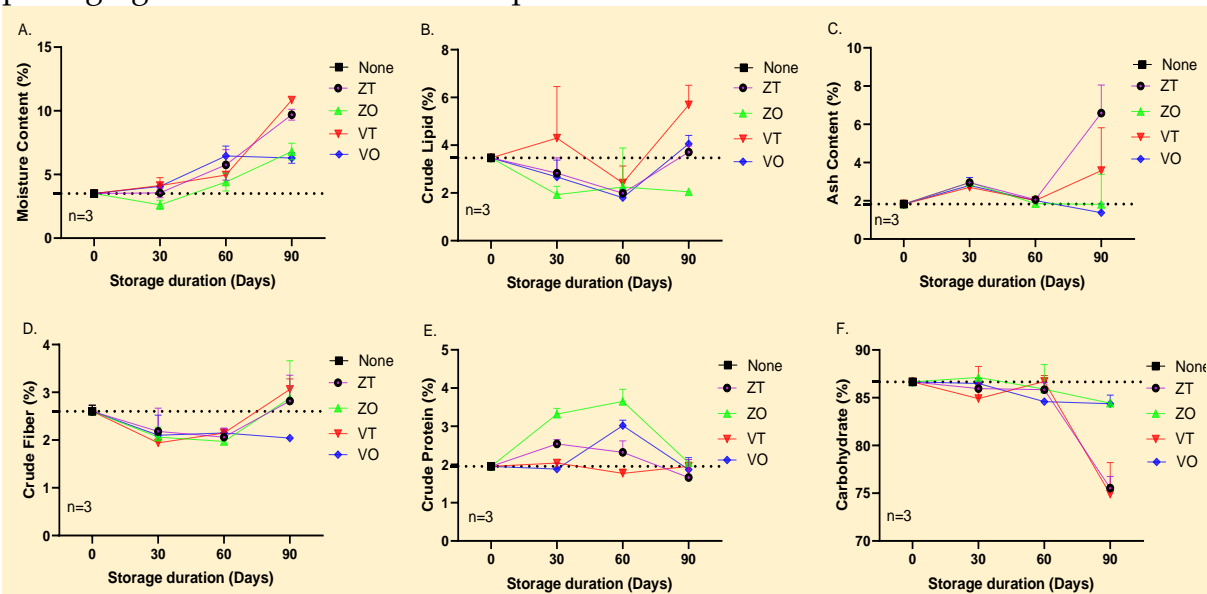


Fig. 2: Comparative analysis of the proximate composition of freshly processed and stored lafun produced with *Weissella korensis*
KEY: None = freshly prepared not yet packed; ZT= Transparent Ziploc; ZO = Opaque Ziploc; VT = Transparent Vacuum-sealed; VO = Opaque Vacuum-sealed

Carotenoid content of yellow lafun

The results of the total carotenoid content of fresh and stored yellow lafun are presented in Fig. 3. Fresh yellow lafun (day 0) had a total carotenoid content value of $0.9 \mu\text{g g}^{-1}$. As storage duration reached 30 days, this value

significantly decreased in transparent packaging materials ($0.4 \mu\text{g g}^{-1}$). The carotenoid content of all the samples dropped consistently until day 90, with the most significant fall in samples stored in transparent materials.

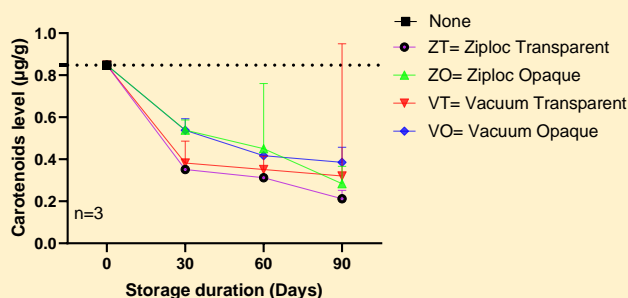


Fig. 3: Total carotenoids level of fresh and stored lafun produced with *Weissella koreensis*

KEY: None = freshly prepared, not yet packed

Functional properties of yellow lafun

Swelling power and starch solubility index of fresh and stored yellow lafun were evaluated and compared (Fig. 4). All stored samples, irrespective of packaging materials, significantly decreased in swelling power value compared to a fresh sample value of 7% at storage days 30 and 60 (Fig. 4A). While only sample stored in opaque Ziploc had a value not significantly different at day 90 to the fresh value at day zero,

vacuum opaque had the lowest value of 3%. The fresh sample (day 0) was analysed to be 4% in solubility index (Fig. 4B). There was a significant increase ($p < 0.05$) in the values of all samples stored with different packaging materials at day 60. Although these values decreased at day 90, they were still higher and significantly different from the fresh sample's value, but not significantly different from each other except for the ZT stored sample.

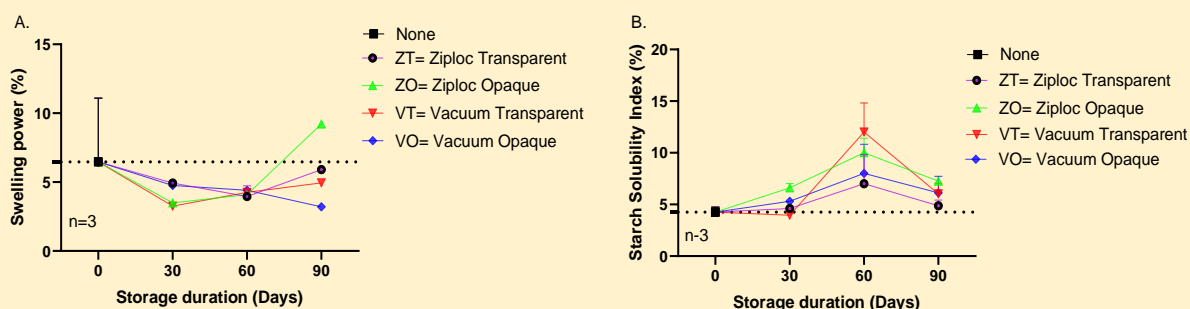


Fig. 4: Evaluation of functional properties of fresh and stored lafun produced with *Weissella koreensis*

Sensory evaluation

Different sensory attributes of both fresh and stored yellow lafun samples were tested among randomly selected consumers, and their responses on a 5-point hedonic scale were presented in Fig. 5. The attributes tested were

overall liking (A), appearance liking (B), odour liking (C), and texture liking (D). Consumers' intents for consumption and purchase were also evaluated and presented in E and F. Although there were varied responses and degrees of likeness, there was no

significant difference ($p < 0.05$) in all responses obtained on attributes and intents of consumption and purchase for fresh and stored samples

until day 90. Yellow lafun in vacuum-sealed materials has the best overall and texture liking, consumption and purchase intent.

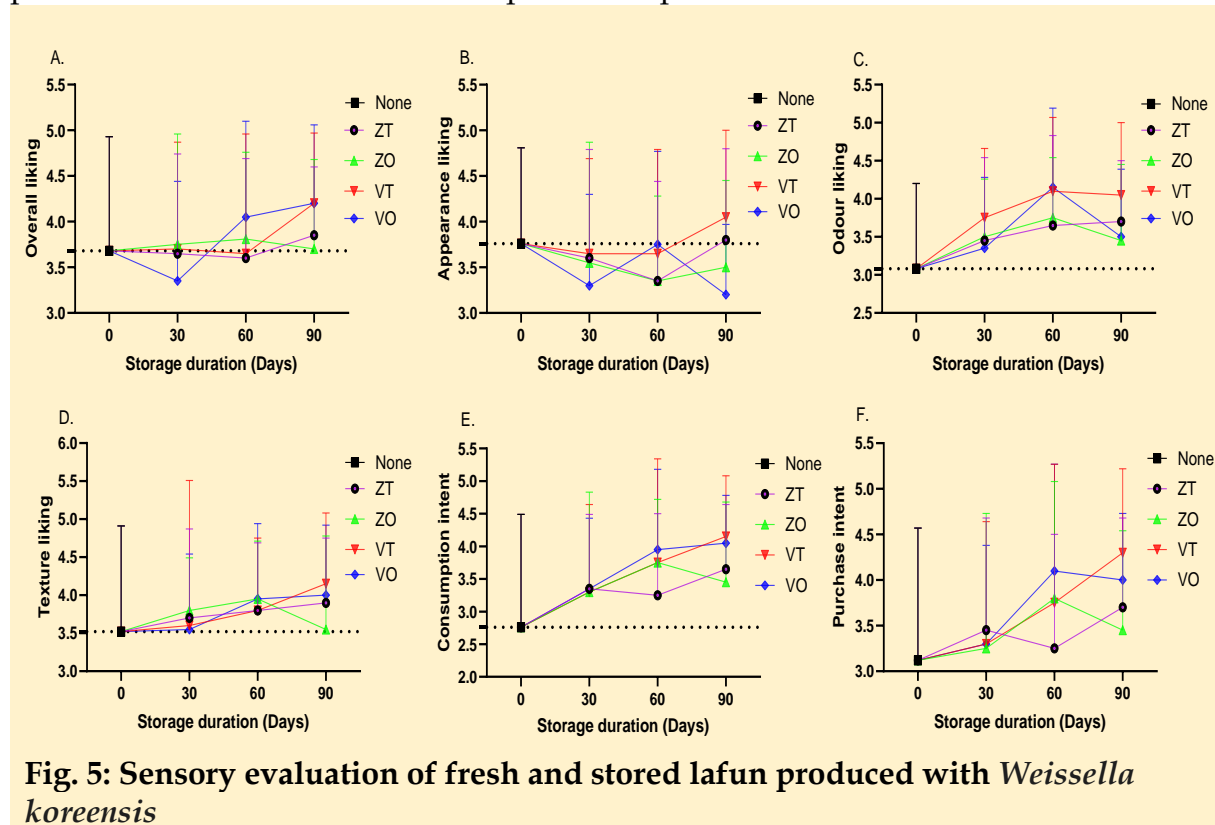


Fig. 5: Sensory evaluation of fresh and stored lafun produced with *Weissella korensis*

DISCUSSION

The effect of different packaging materials on the microbial stability of yellow lafun stored for 90 days was monitored. Results showed a general increase in microbial counts (bacteria and fungi) of all samples stored with different packaging materials as the days of storage increased. However, this increment seemed not to pose any health threat as no coliform growth observed. The increase in microbial load could be because of the samples' proportional increase in moisture content as storage duration progressed. This seemed so, as vacuum opaque material with the least percentage of moisture content at day 90 of storage duration also had

the least microbial count. This discovery agrees with the findings of Ogugbue and Gloria (2011) that most cassava products are hygroscopic and can absorb moisture, which, in turn, encourages the growth of microbes. In another study, Czerwiński et al., 2021, opined that packaging bags have different permeability levels to atmospheric conditions, gases, and environmental changes, based on treatment and type of materials they are made of, which in turn influence microbial populations. Packaging materials used in this storage experiment can be categorised into two classes: Vacuum/non-vacuum treated and transparent/opaque materials. Even though lafun is hygroscopic, the



moisture content of all the samples stayed within the standards for cassava flour throughout the study period. According to Sanni et al. (2005), the analytical characteristics of cassava flour to be used as a composite should be a maximum of 12% moisture, 0.7% ash, 1.5% fibre, and 1% protein. Codex Standard (1989) also set a standard of 13% moisture, 2% fibre and 3% ash for edible cassava flour. The percentage of ash and crude fibre contents also stayed within standards for up to 60 days but increased by 90 days for all samples except the one stored in vacuum opaque material. Although crude protein increased in some samples at 30 and 60 days, the percentage in all samples was within standards by 90 days.

Chetan et al. (2019) regarded vacuum packaging as one type of modified atmosphere packaging and noted that volatile substances cannot evaporate when packaged in a vacuum-sealed material. The findings of this study agree with the authors that dry food items stored in vacuum-sealed materials could be much shelf stable. Additionally, the carotenoid levels of the samples in vacuum-sealed materials were competitively high. Vacuum packaging was observed to be far more effective at maintaining the product's physicochemical and storage stability attributes. This assertion played out in the sensory evaluation of samples and explained why participants' intention to consume and purchase was higher for the vacuum-packed samples.

Unless enriched, lafun, as a cassava-based food product, is rich in carbohydrates (Padonou and

Hounhouigan, 2009) and is mostly consumed for this purpose. However, an increase in microbial populations of stored samples, which is often aided by their water activity, increases microbial metabolic activities. The volume of microorganisms thus influences proteolytic and lipolytic activity that degrades crude protein and crude lipid of stored samples (Agrahar-Murugkar and Jha, 2011; Butt et al., 2006). Therefore, storing hygroscopic food products like lafun in air-tight packages is essential to prevent hydration and maintain the product's core nutrients.

CONCLUSION

Considering all essential parameters to the edibility and acceptability of yellow lafun, the overall evaluation of different packaging materials used to store the product over 90 days in this experiment indicated and projected vacuum-sealed opaque bags as the most probably suitable material out of four packaging materials tested. Vacuum opaque bags could considerably increase the shelf life of yellow lafun. This would ensure the availability of quality lafun. Although the microbiological assessment was free of coliform presence, the characterisation and identification of microorganisms found in stored yellow lafun would be necessary for future experiments.

REFERENCES

- Achi O. K. and Akomas N. S. (2006) Comparative Assessment of Fermentation Techniques in the Processing of Fufu, a Traditional Fermented Cassava



- Product. *Pakistan Journal of Nutrition*; 5:224-229.
- Agrahar-Munigkar D. and Jha K. (2011) Influence of storage and packaging conditions on the quality of soy flour grouted Soghean. *J Food Sci Technol*; 48:325-8.
- Anyogu, A., Olukorede, A., Anumudu, C., Onyeaka, H., Areo, E., Adewale, O., ... & Nwaiwu, O. (2021). Microorganisms and food safety risks associated with indigenous fermented foods from Africa. *Food Control*, 129, 108227.
- Butt M. S., Nasir M., Akhtar S. and Sharif K. (2004) Effect of moisture and packaging on the shelf life of wheat flour. *Internet J Food Saf*; 4:1-6.
- Caplice E. and Fitzgerald G. F. (1999) Food fermentations: Role of microorganisms in food production and preservation. *Int. J. Food Microbiology*; 50, 131-149.
- Chetan N. D., Bhopal S., Rekha R. and Hiral M. (2019) Packaging techniques and packaging of dairy and food products. *Recent Technologies in Dairy Science*; 607-633
- Codex Standard. (1989). Codex standard for edible cassava flour.
- Czerwiński, K., Rydzkowski, T., Wróblewska-Krepsztul, J., & Thakur, V. K. (2021). Towards impact of modified atmosphere packaging (MAP) on shelf-life of polymer-film-packed food products: Challenges and sustainable developments. *Coatings*, 11(12), 1504.
- Falade K. and Akingbala J. (2011). Utilisation of Cassava for Food. *Food Reviews International*. 27. 10.1080/87559129.2010.518296. Health Organization; 91(7): 468-468.
- Fawole A. O. (2019). Selection of lactic acid bacteria for use as starter cultures in lafun production and their impact on product quality and safety. (Publication No. 0000 0004 8508 269X) (Doctoral thesis, University of Reading). British Library, the National Library of the United Kingdom database (ETOS).
- Fawole, A. and Kolapo, A. (2022) Optimisation of Cassava (*Manihot esculenta*) Fermentation Processes for Food-Secured Twenty-first Century Africa. In: Trends and Innovations in Food Science, Yehia El-Samragy (Ed.), ISBN: 978-1-80356-066-3, London: Intech, Available from: <https://www.intechopen.com/online-first/82180> DOI: 10.5772/intechopen.104870
- Kostinek M., Specht I., Edward V. A., Pinto C., Egounlety M., Sossa C., ... Holzapfel W. H. (2007). Characterisation and biochemical properties of predominant lactic acid bacteria from fermenting cassava for selection as starter cultures. *International Journal of Food Microbiology*, 114(3), 342-351.
- Kostinek M., Specht I., Edward V. A., Schillinger U., Hertel C., Holzapfel W. H. and Franz C. M.



- A. P. (2005). Diversity and technological properties of predominant lactic acid bacteria from fermented cassava used for the preparation of Gari, a traditional African food. *Systematic and Applied Microbiology*; 28(6), 527-540.
- Mathur H., Beresford T. P., Cotter P. D. (2020) Health Benefits of Lactic Acid Bacteria (LAB) Fermentates. *Nutrients*; 4;12(6):1679.
- Ogugbue C. J. and Gloria O. (2011) Bioburden of garri stored in different packaging materials under tropical market conditions. *Middle East J Sci Res*; 7:741-5.
- Olawoyin, R. A. (2023). Comparative Studies of Bioethanol Production From *Manihot esculenta* Peels Using *Aspergillus niger* and *Saccharomyces cerevisiae* in Submerged Fermentation (Master's thesis, Kwara State University (Nigeria)).
- Opara U. L. and Mditshwa A. (2013). A review on the role of packaging in securing food system: Adding value to food products and reducing losses and waste. *African Journal of Agricultural*; 8, 2621-2630.
- Oyewole O. B. (1991) Fermentation of cassava for 'Lafun' and 'fufu' production in Nigeria. *Food Microbiology*; 5, 125-133.
- Oyewole O. B. and Odunfa S. A. (1990). Characterisation and distribution of lactic acid bacteria in cassava fermentation for fufu production. *J. Appl. Bact*; 68: 45-52.
- Oyewole O. B. and Afolami O. A. (2001). Quality and preference of different cassava varieties for lafun production. *J. Food Technol. Afr*. 6: 27-29.
- Padonou S. W. and Hounhouigan J. D. (2009) Physical, chemical and microbiological characteristics of lafun produced in Benin. *Afr J Biotechnol*; 8(14).
- Ray R. C. and Sivakumar P. S. (2009). Traditional and novel fermented foods and beverages from tropical root and tuber crops: Review. *International Journal of Food Science and Technology*; 44(6): 1073-1087.
- Sanni, L., Maziya-Dixon, B., Akanya, J., Alaya, Y., Egwuonwu, C., Okechukwu, R., Ezedinma, C., Akoroda, M., Lemchi, J., Ogbe, F., Okoro, E., Tarawali, G., Mkumbira Patino, J. M., Ssemakula, G., & Dixon, and A. (2005). Standards for cassava products and guidelines' for export. International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria.
- Stiles, M. E. and Holzapfel W.H (1997). Lactic acid bacteria of foods and their current taxonomy. *Int. J. Food Microbiology*; 36, 1-29.
- Udoro, E. O., Anyasi, T. A., & Jideani, A. I. O. (2021). Process-induced modifications on quality attributes of cassava (*Manihot esculenta* Crantz) flour. *Processes*, 9 (11), 1891.