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Research Article

Production and Quality Assessment of *Fufu* Flour Fermented with *Saccharomyces cerevisiae* from Palm Wine

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Abstract

Aim: This study evaluated the quality of fufu flour made by fermenting yellow root cassava (Manihot esculenta Crantz) using Saccharomyces cerevisiae yeast isolated from palm wine, with fermentation periods of 2 days (POY), 3 days (FES), 5 days (SDM), and a 5-day control. *Method*: Fresh cassava roots were collected from Agbado in Ogun State, Nigeria. These were fermented for different lengths of time with the isolated yeast strain. After fermentation, the mash was pressed to remove excess water, then broken up and dried in a cabinet dryer at 66 ℃ for 48 hours. The dried cassava was milled with a hammer mill and sieved through a 250 μm mesh to produce fine fufu flour. *Results*: Among the samples, SDM showed the highest ability to absorb water (3.00 g/g) and dispersibility (79%), making it easier to rehydrate without forming lumps. Swelling capacity ranged from 3.66 to 4.48 g/g, with FES scoring the highest. Bulk density was between 0.54 and 0.62 g/ml, with SDM again having the greatest value, which suggests better packing characteristics. Color measurements revealed slight differences: POY had the brightest appearance (L* = 69.95), while SDM was the most yellow (b* = 7.15). In sensory testing, the control (FDF) scored highest for taste, flavor, texture, and overall appeal, though all samples were generally liked. Overall, fermentation with palm wine yeast improved the flour's quality, with SDM standing out as the best option.

Keywords

Cassava Fufu Flour, Saccharomyces Cerevisiae, Palm Wine Yeast, Fermentation

1. Introduction

Cassava (*Manihot esculenta* Crantz) is a key food crop across tropical Africa, where it serves as a primary source of calories for hundreds of millions estimates range between 500 million and one billion people [30]. Although the root is not particularly rich in micronutrients, it provides a substantial amount of carbohydrates, along with trace amounts of calcium, phosphorus, and vitamin C [24]. Its nutritional makeup typically includes 32-35% carbohydrates, 2-3% protein, 75-80% moisture, and smaller quantities of fat, fibre, and ash [24].

In Nigeria, cassava is a dietary staple prepared in various forms such as garri, lafun, fufu, and starch. Beyond its role in food, cassava also supports a wide range of industrial applications. It serves as a raw material in the production of

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sweeteners, adhesives, paper, textiles, ethanol, livestock feed, pharmaceuticals, and biodegradable products. Many of these value-added products are also exported, contributing to the economy.

Palm wine, commonly consumed across West Africa, is a naturally fermented alcoholic drink made from the sap of palm trees. It is milky-white in appearance and has a taste that evolves from sweet to sour as fermentation progresses [2]. In Nigeria, the sap is typically sourced from the oil palm (*Elaeis guineensis*) and raphia palm (*Raphia* spp.). The final flavour and overall quality of palm wine can vary significantly depending on the species of palm and local environmental conditions.

This traditional drink is known by different names in various cultures such as "legmi" in parts of Africa, "kallu" in South India, and "bahar" or "goribon" in Borneo [31]. Each region brings its own techniques to the production process, influenced by the local palm species and the specific part of the tree used [28]. In Mexico, for instance, beverages like pulque and tuba are produced through similarly traditional fermentation methods [13, 12].

Fufu, referred to as *utara akpu* in the Igbo language, is a carbohydrate-rich food made by fermenting peeled cassava roots. It is traditionally prepared in a moist form, with a high moisture content of about 40-50%, which makes it more prone to spoilage than drier cassava products like garri or lafun, which contain less than 10% moisture. To serve, the dough-like paste is reconstituted in boiling water and eaten with soups and stews [26]. In some areas, cassava varieties low in cyanide are cooked before being pounded into fufu [11]. A study by Achi and Akomas [1] compared traditional fermentation methods used in fufu processing. One method involves soaking whole cassava tubers before grating and fermenting, while another starts with grating the tubers first and fermenting later. Both approaches yielded acceptable results, but the grated-first method was better received by consumers. Nonetheless, traditional processing still struggles with issues like inconsistent flavour and texture, largely due to the unpredictable nature of spontaneous fermentation [22].

This study aims to assess the functional, sensory, and colour characteristics of fufu flour made from yellow-root cassava that has been fermented using *Saccharomyces cerevisiae*, a yeast strain isolated from freshly tapped palm wine over varying fermentation periods. The importance of this research lies in its effort to improve the quality and uniformity of fufu flour by using a controlled fermentation method. By introducing a specific, naturally sourced yeast, this study offers a way to reduce the inconsistencies associated with traditional fermentation. The findings could support the development of shelf-stable, commercially viable fufu flour products, helping to minimise post-harvest losses and increase food safety. These improvements are particularly relevant for small-scale processors, food industries, and nutrition initiatives in communities that depend heavily on cassava.

2. Materials and Methods

2.1. Materials and Sources

Freshly tapped palm wine and cassava roots were purchased from vendors at Agbado Market in Ogun State. Additional materials used in yeast isolation, such as Potato Dextrose Agar (PDA) and lactic acid, were procured from Ojota Market in Lagos. All laboratory equipment and consumables were sourced from the Food Technology laboratories.

2.2. Sample Collection

Palm wine samples were collected in sterile containers and transported immediately, on ice, to the microbiology laboratory for yeast isolation under aseptic conditions.

2.3. Yeast Isolation

One milliliter of fresh palm wine was serially diluted in sterile peptone solution up to a 10^{-4} dilution. Aliquots from this dilution were plated in duplicate on PDA supplemented with 0.1% lactic acid (to suppress bacterial growth). The plates were incubated at ambient temperature for 5-7 days. Distinct yeast colonies were subcultured by streaking onto fresh PDA plates until pure cultures were obtained, which were then stored under refrigeration for further use [17].

2.4. Microscopic Characterisation of Yeast

A small portion of the yeast culture was placed in a drop of lacto-phenol cotton blue on a microscope slide, and examined under a light microscope at 40× magnification to observe cellular morphology [17].

2.5. Preparation of Cassava and Fermentation

The method described by Aniedu and Oti [8] was adapted to convert cassava roots into fufu flour. Ten kilograms of fresh roots from each cassava variety were peeled, cut into ~7 cm segments, and washed. The grated cassava was homogenized with the isolated yeast and soaked in water for 48 hours. The fermented mash was pressed in clean cloth sacks to expel water, then broken apart and dried in a cabinet dryer at 66℃ for 48 hours. The dried particles were milled using a hammer mill and passed through a 250 μm mesh sieve to produce fine fufu flour. The flour was packaged in transparent polyethylene bags and stored until further testing. Figure 1 is the flow chart for the production of fufu while Table 1 shows the formulation of the fufu samples.

Fresh cassava tubers
↓
Peeling
↓
Washing
↓
Size reduction
↓
Isolated yeast inoculated from palm wine
↓
Steeping/Fermentation (48hrs)
↓
Squeezing/decanting
↓
Pressing into ball
↓
Drying (660c for 48hrs)
↓
Sieving
↓
Fufu flour
↓
Packaging
↓
Fermented fufu flour

Figure 1. *Flow chart for the production of fufu flour.*

Modified method of Aniedu and Oti [8].

Table 1. *Formulation of the Fufu Flour Sample.*

Samples	**Fermentation (days)**
POY	2 days
FES	3 days
SDM	5 days
FDF	5 days

FDF: Fufu fermented for 2 days; POY: Fufu fermented for 3 days; FES: Fufu fermented for 5 days; SDM: Fufu fermented for 5 days

2.6. Functional Properties of Fufu Flour

2.6.1. Swelling Capacity

Swelling capacity was measured following a modified version of the method by Malomo et al. [18].

2.6.2. Water Absorption Capacity (WAC)

Water absorption capacity was determined in line with the procedure described by Oyeyinka et al. [27].

2.6.3. Bulk Density

Bulk density was determined using the technique outlined in Arisa et al. [10].

2.6.4. Dispersibility

Dispersibility (D) was measured by the method of Mora-Escobedo et al. [19].

2.7. Colour Measurement

Colour was assessed with a Hunter Lab Colorimeter (Hunter Associates Laboratory, Reston, VA, USA) following Gopika and Sandeeppal [16]. The instrument was calibrated using standard black and white tiles. Values of L*, a*, and b* were recorded, where L* indicates lightness (100 = white, 0 = black), a* denotes redness (positive) or greenness (negative), and b* indicates yellowness (positive) or blueness (negative).

2.8. Sensory Evaluation

Sensory testing followed Akinjayeju [5]. Thirty panelists comprising students and staff from the Food Technology Department of Yaba College of Technology familiar with fufu evaluated coded samples for color, taste, flavor, texture (smoothness), and overall acceptability using a 9-point hedonic scale (1 = dislike extremely, 5 = neither like nor dislike, 9 = like extremely). Water and tissue were provided for palate cleansing. Panelists washed their hands before testing and used cucumber slices and water to rinse their mouths before and after tasting each sample.

2.9. Statistical Analysis

SPSS Software (version 15.00) was used to analyze data obtained. All data was subjected to analysis of variance (ANOVA).

3. Results and Discussion

The functional characteristics of the cassava fufu flour samples are detailed in Table 2. These properties such as water absorption capacity (WAC), swelling power, dispersibility, and bulk density are vital in determining their potential applications in food processing and formulation [6] [21].

Water Absorption Capacity (WAC) is a critical parameter for assessing the flour's ability to interact with water, particularly in dough-based products [14]. Across the samples, WAC values ranged from 2.45 g/g to 3.00 g/g. Sample SDM recorded the highest water absorption (3.00 g/g), suggesting better hydration potential, while the control sample had the lowest. These findings are consistent with previous work by Obasi et al. [20], who reported WAC values between 1.61 and 4.01 g/g for cassava mosaic disease-resistant varieties.

Swelling capacity varied from 3.66 g/g to 4.48 g/g, with the highest value also recorded for sample SDM. Conversely, sample FES had the lowest swelling index. As observed by Shittu et al. [29], swelling behavior significantly influences the pasting characteristics of starch-based flours, higher swelling often leads to higher viscosity, whereas increased solubility can indicate breakdown or dextrinization.

Dispersibility, which indicates the ability of the flour to rehydrate and dissolve in water without forming lumps, ranged from 67.00% to 79.00%. SDM once again showed the highest dispersibility, indicating a higher likelihood of smooth reconstitution in boiling water [23].

Bulk density, which affects packaging and storage requirements, ranged between 0.54 g/ml and 0.62 g/ml. Sample SDM had the highest density, suggesting better packing and shelf-life potential, while POY had the lowest. These values were slightly lower than those reported by Etudaiye et al. [14] (0.61-0.77 g/ml). Bulk density is also influenced by particle size and starch structure [25], with looser starch structures generally resulting in lower values [7]. Lower bulk density, as seen in FES, would require lighter packaging materials [3, 4].

Table 2. *Functional Properties of the Fufu Flour Produced from Fermented Cassava Using Isolated Yeast from Palm Wine.*

Sample	Water Absorption Capacity (g/g)	Swelling Power (g/g)	Dispersibility (%)	Bulk Density (g/ml)
FDF	2.45 ±0.01[a]	4.34 ±0.00[b]	68.00 ±0.00	0.55 ±0.00
POY	2.51 ±0.07[a]	4.42 ±0.02[c]	69.00 ±0.00	0.54 ±0.00
FES	2.77 ±0.09[b]	4.48 ±0.00[d]	67.00 ±0.00	0.58 ±0.00
SDM	3.01 ±0.01[c]	3.66 ±0.01[a]	78.00 ±0.00	0.62 ±0.00

NB: Data are mean values of duplicate determination ±standard deviation. Mean values with the same letter within the same column are not significantly difference ($p > 0.05$)

FDF: Fufu fermented for 2 days; POY: Fufu fermented for 3 days; FES: Fufu fermented for 5 days; SDM: Fufu fermented for 5 days

3.1. Colour Properties

Colour is an essential quality indicator, influencing consumer acceptance. Using a Hunter Lab Colorimeter, the lightness (L*), redness/greenness (a*), and yellowness/blueness (b*) values of the fufu flour samples were determined (Table 3).

Lightness (L*) values ranged from 68.71 to 69.95, with sample POY being the lightest and FES the darkest. The a*-values, indicating red-green balance, ranged from -0.99 to -0.88. FES had the highest a*-value, suggesting a slight reddish tone, while POY had the lowest. The b*-values ranged between 6.66 and 7.15, with SDM exhibiting the most yellow hue. These values are somewhat lower than those reported by Awolu et al. [9], suggesting slight variations due to processing or cassava variety differences.

Table 3. *Colour Properties of the Fufu Flour Produced from Fermented Cassava Using Isolated Yeast from Palm Wine.*

Sample	Lightness (L*)	Redness (a*)	Yellowness (b*)
FDF	68.90 ±0.43[a]	-0.89 ±0.01[c]	5.75 ±0.02[a]
POY	69.95 ±0.12[b]	-0.88 ±0.00[d]	6.66 ±0.01[b]
FES	68.71 ±0.11[a]	-0.99 ±0.00[a]	7.04 ±0.01[c]
SDM	68.74 ±0.44[a]	-0.92 ±0.01[b]	7.15 ±0.04[d]

NB: Data are mean values of duplicate determination ± standard deviation. Mean values with the same letter within the same column are not significantly difference ($p > 0.05$)

FDF: Fufu fermented for 2 days; POY: Fufu fermented for 3 days; FES: Fufu fermented for 5 days; SDM: Fufu fermented for 5 days

3.2. Sensory Evaluation

Sensory testing offers valuable insight into the overall acceptability of food products by assessing individual preferences. Table 4 presents the sensory scores for taste, flavor, color, texture, and overall acceptability.

Taste scores ranged from 7.23 to 7.90. The control sample (FDF) received the highest rating, while POY scored the lowest. There was a statistically significant difference ($p > 0.05$) between these two samples. The trend indicated that longer fermentation durations may negatively affect taste a result more favorable than those reported by Felix and Sanful [15], who observed lower scores (4.55-5.15).

Flavor ratings followed a similar trend: FDF (8.03) had the highest rating, while POY had the lowest (7.26). FES and POY did not differ significantly ($p > 0.05$). This suggests that extended fermentation may enhance flavor development.

Color was well rated across all samples, ranging from 7.16

to 7.46, with the control again scoring highest. No statistically significant difference was observed. These values exceed those recorded by Obasi et al. [20] (6.28-6.40), indicating that all samples were visually appealing. Interestingly, fufu samples with shorter fermentation periods were slightly more favored in terms of visual appeal.

Texture scores ranged from 6.90 to 7.76. Again, FDF (control) was the most preferred for its smoothness, while FES scored the lowest. POY and SDM had no significant differences in texture perception ($p > 0.05$). The scores obtained here surpass those by Felix and Sanful [15], who reported texture scores between 5.05 and 5.55.

Overall acceptability, a summary measure of all sensory attributes, ranged from 7.40 (FES) to 8.13 (FDF). Although FES was the least preferred, the difference was not statistically significant when compared to SDM and POY. Acceptability tended to improve with shorter fermentation durations, in contrast to findings by Obasi et al. [20], who reported slightly lower acceptance (6.85-7.76).

Table 4. *Sensory Properties of the Fufu Flour Produced from Fermented Cassava Using Isolated Yeast from Palm Wine.*

Sample	Taste	Flavour	Colour	Texture	Overall Acceptability
FDF	7.90 ± 1.06^{b}	8.03 ± 0.96^{b}	7.46 ± 1.43^{a}	7.76 ± 1.25^{b}	8.13 ± 0.93^{b}
POY	7.23 ± 1.27^{a}	7.26 ± 1.48^{a}	7.43 ± 1.25^{a}	7.43 ± 1.30^{ab}	7.80 ± 0.92^{ab}
FES	7.33 ± 1.18^{ab}	7.36 ± 1.24^{a}	7.26 ± 1.14^{a}	6.90 ± 1.24^{a}	7.40 ± 1.16^{a}
SDM	7.46 ± 1.13^{ab}	7.90 ± 1.06^{ab}	7.16 ± 1.34^{a}	7.46 ± 1.35^{ab}	7.63 ± 0.96^{ab}

NB: Data are mean values of duplicate determination ± standard deviation. Mean values with the same letter within the same column are not significantly difference ($p > 0.05$)

FDF: Fufu fermented for 2 days; POY: Fufu fermented for 3 days; FES: Fufu fermented for 5 days; SDM: Fufu fermented for 5 days

4. Conclusion and Recommendations

This research highlights the effective use of *Saccharomyces cerevisiae* isolated from palm wine as a starter culture in cassava fermentation for fufu flour production. The approach not only improved certain functional properties (such as water absorption, swelling, and dispersibility) but also maintained acceptable sensory characteristics, especially when fermentation time was optimized.

The transformation of fufu into a dried, flour-based form has the potential to reduce variability commonly associated with traditional processing methods. This standardized approach can enhance shelf-life, reduce post-harvest losses, and improve consumer confidence.

However, the processing of fufu flour on a larger scale remains underutilized. There is a pressing need to address inconsistencies in traditional fermentation and raise awareness around cyanogenic glucosides in cassava. Proper public education regarding detoxification processes is essential to minimize health risks.

Commercial-scale production of fufu flour using palm wine yeast offers a promising solution to food security issues, particularly in reducing malnutrition and improving the accessibility of safe, shelf-stable cassava-based foods. Further research could explore fermentation optimization, nutrient enhancement, and consumer behavior to better align product development with nutritional and market demands.

Abbreviations

ANOVA	Analysis of Variance
D	Dispersibility
FDF	Fufu fermented for 2 days
FES	Fufu fermented for 5 days
L*, a*, b*	Hunter Lab colour parameters for Lightness (L*), Redness/Greenness (a*), and Yellowness/Blueness (b*)
PDA	Potato Dextrose Agar
POY	Fufu fermented for 3 days
SDM	Fufu fermented for 5 days
SPSS	Statistical Package for the Social Sciences
WAC	Water Absorption Capacity

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Author Contributions

Abiodun O Adebayo-Oyetoro: Conceptualization, Data curation, Formal analysis, Funding acquisition, Methodology, Project administration, Resources, Supervision, Visualization, Writing - original draft, Writing - review & editing

Suliat O Abdulrauf: Conceptualization, Data curation, Formal analysis, Funding acquisition, Methodology, Resources, Writing - original draft

Oluwafemi M Alade: Conceptualization, Data curation, Formal analysis, Funding acquisition, Methodology, Resources, Writing - original draft

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Conflicts of Interest

The authors declare no conflicts of interest.

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