AJBCPS African Journal of Biological, Chemical and Physical Sciences

Jozac Publishers

Vol 4, Issue 1, 2025

ISSN: 2790-9522 (Print) | 2790-9530 (Online)
Website: https://journals.jozacpublishers.com/ajbcps/index
https://doi.org/10.5281/zenodo.17107071

OPEN ACCESS

Assessment of the mycological, proximate and Sensory quality of masa produced from Caruso potato (*Solanum tuberosum* Linn) flour in Jos, Nigeria

Margaret Musa Atsen Danladi[1,2], Luka Sambo Danahap[2], Brains Ode Okechalu[3]
[1,2&3]Department of Plant Science and Biotechnology, University of Jos, Nigeria, margaretshambor@gmail.com[1], odebrains@yahoo.com[2], danahapluka@yahoo.com[3]
[2]Department of Microbiology, Plateau State University, Bokkos, Nigeria, margaretshambor@gmail.com

*Correspondence: margaretshambor@gmail.com

Received: April 07, 2025 | **Accepted:** June 03, 2025 | **Published:** September 12, 2025

Abstract

Masa is a snack prepared using varieties of raw material and consumed in Nigeria. The study determined the mycological, proximate and sensory quality of masa produced from Caruso potato (*Solanum tuberosum*) flour. A quantity of 200 g Caruso and 100 g of rice (CF+RF) flours (control), 500 g of pre sterilized Caruso flour (CF) (test) was fermented spontaneously and using *Saccharomyces cerevisiae* respectively, thereafter the masa batter was ready for frying. Fungal species were identified using standard microbiological methods from the control sample, the proximate composition using standard analytical methods and the sensory evaluation using trained tasters on a nine hedonic scale. Brown coloured masa was observed after frying. The fungal load ranged from $8.00 \pm 1.00 \times 10^1$ to $100.00 \pm 0.08 \times 10^3$ colony forming unit/gram. *Saccharomyces cerevisiae*, *Schizosaccharomyces pombe*, *Fusarium solani* and *Aspergillus oryzae* were identified. The proximate composition indicated that protein ranged from 2.42±0.03 to 2.47±0.02. and carbohydrate content from 61.81±0.02 to 66.33±0.01. The sensory evaluation for colour, taste, texture, aroma, overall acceptability of masa rated as 'like very much' and 'like moderately' with scores that ranged from 8.05±1.05 to 8.45±0.69, 8.35±0.81 to 8.45±0.83, 7.60±1.10 to 7.75±1.25, 8.35±0.75 to 8.45±0.76, 7.95±1.23 to 8.25±1.16 respectively. Caruso potato variety served an alternative raw material for masa production having a palatable outcome with acceptable nutrient and sensory feel.

Keywords: Fermentation, Fungal composition, Masa, Proximate, Sensory quality

1. Introduction

Roots and tubers are one of the cheap sources of dietary energy and the most popular ones are potato, sweet potato, yam, cocoyam and cassava (Van Vugt & Franke, 2018) which become deteriorated because of microbial action and poor storage facilities after harvest. Potatoes are grown worldwide but the commercialization of potato (*Solanum tuberosum* L.) depends on the varieties, crop management and location of processors, all of which influence the yield and quality of the finished products (Haverkort et al., 2023). Masa is a fermented snack prepared and consumed in many parts of West Africa, especially Nigeria (Sanni & Adesulu, 2013; Owusu-Kwarteng & Akabanda 2013) and can be processed using varieties of raw material. Because of the deterioration of crops especially potato, there is a need to process it into masa, which can mitigate the deterioration of potato.

2. Literature review

Nigeria has about 30 indigenous based fermented foods made from cereals (ogi, burukutu, masa) and tubers (garri, fufu, lafun) fruits (wine, ugba,) legumes (iru, dadawa) palm tree (palm wine) milk (manshanu, nono) (Izah et al., 2016) but information on fermented masa from potato source has limited literature, especially in Nigeria. Considering the Nigerian peculiarity with regards to consumers, economic status, food access, nutritional and health benefits, the role of traditionally fermented foods is imperative (Ndudi et al., 2024). Many agricultural crops are used in the production of fermented and non-fermented foods. Crops such as tubers, roots, fruits, pulses, pseudo cereals, animal products, cereals, vegetables, oilseeds are potential raw materials for processing for value addition and mitigation of wastage (Offiah et al., 2019).

2.1. Fermenting substrates, fermenters and fermented products

An increase in population has prompted scientist to investigate raw and sustainable materials for producing new and cheap foods (Delgado et al., 2019). Ijah et al., (2019) produced bread from wheat and potato flour. Maize and Sorghum are also a rich source of fermentable carbohydrates that could support a wide range of microorganisms such as yeasts and moulds (Umokaso et al., 2022). Many genera of microorganisms have been implicated in fermentation such as the genera *Saccharomyces*, *Aspergillus*, *Clostridiums*, among others (Deka et al., 2021; Umokaso et al., 2022). Researchers have presented their work on masa using varieties of raw material (Sanni & Adesulu, 2013; Malomo & Abiose, 2019).

The main microorganisms used in the production of fermented foods including Nigerian fermented foods are yeasts which may be added as starter culture or the microbes may be indigenously associated with the raw material (Malomo & Popoola, 2020). Fermenting microbes associated with fermented foods may be introduced from the environment at any stage of production or from the substrate (Nwokoro & Chukwu, 2012; Akinleye et al., 2014). Anumudu et al., (2018), reported the following genera of microorganisms associated with fermented product: *Aspergillus*, *Fusarium*, *Pencillium*, *Saccharomyces* and *Candida*.

The proximate composition of processed potato products has been reported by some researchers Salvador et al., 2009; Kowalczewski et al., 2019; Yaseen et al., 2020). Ijah et al., (2014), reported the nutritional composition of bread produced with potato flour and other composite flours, though there is scarce literature on masa and other fermented foods produced from potato crop, especially in Nigeria.

Sensory evaluation is a field, which integrates methods from various scientific disciplines Meiselman (2013), which is hinged on standard protocols, used to comprehend the human stimuli in response to food and beverage products (Torrico et al., 2023). New forms of processed food products are assessed for their acceptability through sensory evaluation, which is a traditional method of assessing the quality of foods (Vivek et al., 2020). Ijah et al. (2014), reported sensory characteristics of their potato flour bread which ranged from 2.1 ± 0.06 to 2.7 ± 0.17 but was higher in their bread made from composite flours. This study aims to produce masa using potato flour, determination of fermenting fungi, proximate composition and the sensory evaluation of masa.

Table 1: Produced masa from Caruso flour (CF) test, Caruso flour (CF) +Rice flour (RF) (control) blend

Sample	Colour
Masa (CF+RF) control	Brown
Masa (CF) test	Brown

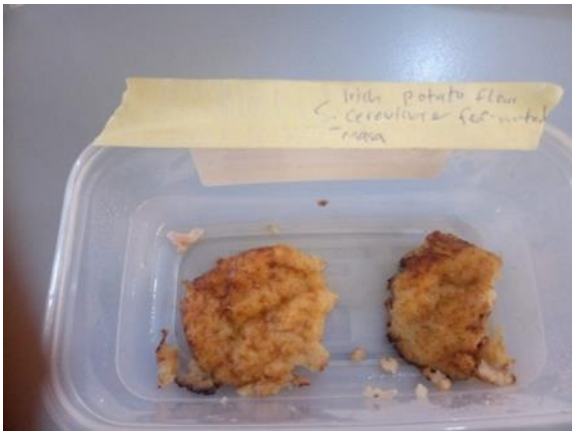

Figure 1: Masa produced using potato flour

Table 2: Mycoloical quality (total fungal counts) in masa during fermentation

Fermentation Time	Fungal Counts (dilution factor)
0	$8.00±1.00^{e}×10^{1})$
12	$11.33±1.53^{d} × (10^{1})$
24	$47.33±2.52^{c} × (10^{2})$
36	$100.00±0.08^{a} × (10^{3})$
48	$91.00±1.73^{b} × (10^{1})$
LSD	1.26
Pvalue	<0.0001
pp	

At P≤0.05, values were presented as means of triplicate readings±standard deviation (dilution factor).

Table 3: Biochemical Identification of Yeast Isolates

Glucose	Lactose	Raffinose	Sucrose	Maltose	Galatose	Suspected Organism
+	-	+	+	+	_	*Saccharomyces cerevisae*
+	-	±	+	±	-	*Schizosaccharomyces pombe*

+ Positive, - Negative, ± Variable

Table 4: Distribution of fungal species and their percentage frequencies of occurrence during fermentation of masa

Fungal Isolates	Time Fermentation (hours)						
	0	12	24	36	48	Total	%FOC
S. cerevisiae	+	+	+	+	+	5	100
S. pombe	+	+	+	+	+	5	100
Fusarium solani	+	+	-	-	-	2	40
A. oryzae	+	+	+	+	+	5	100

+= Present, - = Absent, *S* = *Saccharomyces*, *A* = *Aspergillus* F = Frequency, %FOC = Percentage frequency of occurrence

Table 5: Proximate composition (g/100g) of masa from Caruso flour (CF) test+Rice flour (RF) (control) blend

	Moisture	Crude Prot	Crude fibe	Lipid	Ash	Carbohydr	Calcium	Phosphorus	Energy kcal
Masa test	49.76±0.02a	2.42±0.03a	3.94±0.04a	4.23±0.15b	0.95±0.01a	61.81±0.02a	0.93±0.02a	0.04±0.00a	295
Masa con	45.86±0.01a	2.47±0.02a	1.53±0.03b	7.14±0.02a	1.05±0.02a	66.33±0.06b	1.03±0.01a	0.05±0.01a	339
LSD	0.08								
Pvalue									
<0.0001									

Table 6: Titratable acidity (TTA) and pH of masa

Time(hours)	TTA	pH	TTA	pH
	Masa test	Masa test	Masa control	Masa control
0	0.12±0.01^{a}	6.4±0.00^{a}	0.08±0.01^{a}	6.27±0.06^{b}
12	0.13±0.01^{a}	5.23±0.16^{b}	0.09±0.00^{a}	5.60±0.10^{b}
24	0.15±0.01^{a}	5.47±0.06^{a}	0.14±0.01^{a}	5.43±0.06^{c}
36	0.21±0.00^{a}	4.30±0.10^{b}	0.25±0.01^{a}	3.93±0.06^{a}

48	0.26±0.05[a]	3.77±0.06[a]	0.28±0.01[a]	3.83±0.06[a]
LSD	0.08			
P-value <0.0001				

At p≤0.05, values are means of triplicate readings±standard deviation. Means with the same superscripts are not significantly different and values with different superscript are statistically different as represented along the column.

3. Research methodology

3.1. Production of "Masa" a Nigerian Fermented Meal using Potato (*Solanum tuberosum* L.), and Rice (*Oryzea sativa*) Flour Blends

The preparation of masa was done as presented in the flow chat (Figure 2) using methods of Samuel et al., (2015) by measuring 100 g of rice and 200 g (Caruso) flours (Control), 500 g of pre sterilized potato (Caruso) flour which was pre-sterilized using a hot air oven set at a temperature of 120 °C at time, 45 minutes, thereafter soaked in clean portable water and left to ferment separately and naturally in a closed container for 24 hours using the methods of (Nakamura et al., 2008; Samuel et al., 2015). A starter culture of *Saccharomyces cerevisiae*, was used for the test sample while the control sample was allowed to ferment spontaneously. The masa batters were ready for frying.

Raw material

↓

Flour + warm water

↓

Mixing

↓

Neutralization (Trona, sugar and salt added)

↓

Mixing

↓

Frying in hot oil

↓

Resultant masa (both control and test masa samples)

Figure 2: Flow Chat for the Production of Masa

Source: Samuel et al., (2015)

3.2. Mycological (Fungal load and Fungal species) Quality of masa

For the isolation of fungi during fermentation of masa, one gram (1 g) of the sample that was allowed to ferment spontaneously, was uniformly prepared and placed in 9 ml of sterile peptone water, serial dilutions were made from10^1 to 10^5 dilutions and approximately 0.1 ml of aliquots from 10^1 dilutions of the masa sample was plated on Potato Dextrose Agar PDA (Oxoid) for all fungi species amended with streptomycin sulphate 50 µg ml-1 at time 0, 6, 12, 24, 36 and 48-hours interval. All the plates for fungal isolation were incubated in triplicates at 25 °C for 3 to 5 days. Discrete colonies after incubation were subcultured on PDA. The yeast isolates were identified by carbohydrate utilization test while filamentous fungi were identified microscopically using standard taxonomic keys and atlas as adopted by researchers (Oyedeji et al., 2013; Oranusi et al., 2013; Dashen et al., 2017).

3.3. Determination of the proximate composition of physico-chemical composition of masa produced from caruso potato variety

The moisture, protein, crude fibre, fat/lipid and ash were determined by oven drying, Kjeldahl's, gravimetric, Soxhlet and dry ashing methods respectively, as described by AOAC (2000) while the carbohydrate was determined by difference which equals 100-(moisture+protein+fiber+fat+ash) Akintomide and Antai (2012), calcium (titrimetry)¸ Phosphorus (Colorimetry) for tubers and processed products. The energy content of the samples was estimated by multiplying the values of the carbohydrates, protein, and fat content by 4 kcal, 4 kcal, and 9 kcal, respectively as adopted by (Twinomuhwezi et al., 2020). The titratable acidity by titrimetry (AOAC, 2000) and determined (Nafar et al., 2013) with slight mordification using the formula, TTA=volume of NaOH×Normality of NaOH×0.64/weight of sample. A quantity of 0.25 g sample was mixed with 25 ml of water and vortexed for 3 min. Ten milliliter of the supernatant was used to measure the pH with the aid of a digital pH meter (Metrohm 780, Switzerland) (Sanni & Adesulu, 2013).

3.4. Determination of the Sensory characteristics of Masa

Prepared ready to eat masa was subjected to sensory evaluation by the panel of tasters using a nine-point hedonic scale with the ratings: 9=Like extremely, 8=Like very much, 7=Like moderately, 6=like slightly, 5=neither like or dislike, 4=dislike slightly, 3=dislike moderately, 2=dislike very much and 1=dislike extremely. The yardstick for rating were colour, taste, texture, aroma and overall acceptability. Evaluation was done using a 20-member trained panelist as described by O'Mahony & Wichchukit, 2015).

4. Data analysis

The experiments were conducted in triplicates and the mean data ± Standard deviation was reported. A Two-way Analysis of Variance (ANOVA) was adopted to analyse some data. The graph pad prism version 8.2 package was used. The level of significance was accepted at $p<0.05$.

5. Results and discussions

Masa was produced from Caruso Flour, which resulted in a brown-coloured surface masa after frying as represented in Table 1. The resultant brown colour of the Caruso (CF) test and Caruso flour and rice flour (CF+RF) control masa did not vary, even though they were produced from a new type of raw material. This may be because the raw material used in masa production does not affect the outcome of the final product. Both masa formulation samples were produced through the process of fermentation which is closely related with reports of other researchers whose works dwelled on fermentation of cereal (Odunfa & Adeyele, 1985; Sanni & Adesulu, 2013; Samuel et al., 2015) to produce fermented food products made from sorghum, maize, rice, enriched with soybean and crayfish respectively. There is little or no literature on the production of masa using potato flour, especially from Caruso variety.

There was significant difference at $p<0.05$ in the fungal counts of masa as represented in Table 2. During fermentation of masa, the total fungal counts ranged from $8.00\pm1.00 \times 10^{1}$ to $100.00\pm0.08 \times 10^{3}$ cfu/g from 0 hour to 48 hours. The limit of the fungal count in cfu/g was within the limit 10^{1} at 0 hour. The limit of the fungal count in cfu/g was within the limit 10^{1} at 12 hours. The limit of the fungal count in cfu/g was within the limit 10^{2} at 24 hours. The limit of the fungal count in cfu/g was within the limit 10^{3} at 36 hours. The limit of the fungal count in cfu/g was within the limit 10^{1} at 48 hours. The highest count was at the 36th hour. This may be as a result of the peak of microbial activity. The values were within the permissible limit prescribed by Stanadard Organization of Nigeria ($>10^{4}$ to $< 10^{6}$) Balogun et al. (2021) which agree with results in the present study. The fungal load showed that there was increase in the fungal counts as compared to what was obtained at the beginning of fermentation. Adegbehingbe (2014) reported an increase in his microbial count which ranged from 4.5log cfu/ml to 5.7 log cfu/ml for fungi. This report agrees with the present study.

Pure colonies of yeast had certain biochemical characteristics which were colour changes in the sugars used for the carbohydrate fermentation tests which was the basis for their identification as represented in Table 3. The microbes *Saccharomyces cerevisiae*, *Schizosaccharomyces pombe, Fusarium solani and Aspergillus oryzae* were isolated from the beginning to the end of fermentation with varying distribution across the time of fermentation Table 4. The microorganisms isolated in the present study varied. The microorganisms associated with the present study are known fermenters and were isolated at some stages during the fermentation process. These fungal isolates may have been accompanied in the raw material or their spores may have settled in from the indoor environment. This report is in agreement with the findings of Sanni and Adesulu, (2013) and Adegbehingbe (2014), who isolated *Aspergillus sp*, *Fusarium* sp and *Saccharomyces cerevisiae*. The fungal specie that dominated the fermentation of masa was from the genera *Saccharomyces cerevisiae*. This is in agreement with reports of Malomo and Popoola, (2020), who also reported same dominating organisms in Burukutu. Efiuvwevwere and Ezeama, (1996), also reported *Saccharomyces cerevisiae* in masa. Fermented foods are consumed worldwide (Tamang et al., 2020).

The proximate composition indicated that values with the same superscript had no statistical difference while values with different superscript are statistically significant at $p\leq0.05$ as represented along the column Table 5. The moisture content of masa ranged from 45.86±0.01 to 49.76±0.02. It was highest in masa prepared with Caruso flour CF alone while CF and rice flour RF blend had the least moisture content. The crude protein for both the test and control masa samples ranged from 2.42±0.03 to 2.47±0.02. The values for the crude fibre ranged from 1.53±0.03 to 3.94±0.04. The lipid content for both samples ranged from 4.23 ± 0.15^{b} to 7.14 ± 0.02^{a}. The ash content for both samples ranged from 0.95±0.01 to 1.05±0.02. The carbohydrate content ranged from 61.81±0.02 to 66.33±0.06. The calcium content for both samples had values ranging from 0.93±0.02 to 1.03±0.01. The phosphorus content for both masa samples ranged from 0.04±0.00 to 0.05±0.01. The energy content ranged from 295 to 339 across the masa samples. Samuel et al. (2015), reported the value of their protein content to be 4.23 which is higher than the one in this current study and not in tandem with this study. Ijah et al. (2014) reported the protein content of bread produced using solely potato flour to be 7.00 not in consonance with this research.

The crude fibre contents at $p \leq 0.05$ were not significantly different. The difference in the crude fibre could imply the variation in the chemical composition of the cereal and tuber flours used in the fermentation of instant masa meal. There is paucity of literature on the masa formulations used for this present work. Samuel et al. (2015), reported varying crude fibre for the flour blends they used with values ranging from 0.34±0.01 to 1.08±0.02. Akande et al. (2018), reported their crude fibre range from 1.05±0.05 to 1.56±0.01. Their values are closely related with reports of the present study. There was significant difference ($p \leq 0.05$) in the lipid contents. Values for the lipid content may be associated with the processing technique employed during production.

The ash contents of masa for the present study showed that there was no significant difference ($p \leq 0.05$). Reports by Samuel et al., (2015) indicates values of 0.20±0.01 to 1.15±0.01 which agrees with the present work. The carbohydrate contents in the present study were significantly different ($p \leq 0.05$). The value of the carbohydrates depends on the variety of the potato. Akande et al. (2018), reported their carbohydrate content as 50.48±0.01 to 56.72±0.05 which are close values with those carbohydrate contents in this study and agrees with this work.

The calcium and phosphorus contents in the samples were not statistically significant at ($p \leq 0.05$). Values obtained are quite minimal and this may be associated with the variety of the potato used in the study. Akande et al. (2018), also reported 0.10±0.00 to 0.18±0.00 phosphorus. The low minerals may be associated with extent of cultural practices employed during planting and nurturing of the crop. Nkama and Malleshi (1998) observed a higher calcium content than that of the present study in the ingredients used to formulate their masa which ranged from 0.024 to 0.258.5. Their low calcium level indicates that it does not support the present study. The energy value was higher in the control masa sample which may have been as a result of high carbohydrate content in the sample. The present energy values will provide some required energy for human activities. The energy content in any food is required for all human activities which is mainly gotten from carbohydrates, fats and in some instances protein and which can be used to combat protein energy deficiency (Twinomuhwezi et al., 2020).

The titratable acidity recorded was not statistically different but the values ranged from 0.12±0.01 to 0.26±0.05 from 0 hour to 48 hours in the test masa sample and 0.08±0.01 to 0.28±0.01 at the beginning of the fermentation to 48 hours at the end of fermentation respectively for the control masa sample. The pH was statistically different at $p<0.05$ which ranged from 3.77±0.06 to 6.4±0.00 at 0 to 48 hours and 3.83±0.06 to 6.27±0.06 at 0 hour to 48 hours for the test (CF masa) and control (CF and RF masa) samples respectively Table 6. However, lower TTA for the test and control samples may have been as a result of inadequate fermentation metabolites produced by the microorganisms and the use of potato flour which is not so rich in sugar but as TTA increases, there was a gradual fall in pH Odunfa and Adeyele, (1985), but the values of TTA increased as the time of fermentation increased in this present research work. Abdulkadir et al. (2023), reported values of TTA of their masa which ranged from 0.05 to 0.17, their values showed increase in values of titratable acidity with increased time of fermentation which supports this present study.

The drop in pH may be as a result of metabolites produced by fungal species associated with the fermentation process which improve the nutritional, shelf life and organoleptic characteristics of fermented food (Martelli et al., 2020). Sankhla et al. (2012), reported a drop in pH as fermentation progresses. Abdulkadir et al. (2023), reported the pH range of 3.76 to 5.57 while Dashen et al. (2017), reported their pH which ranged from 3.7 to 5.7. Their values are in tandem with those obtained in this present study which supports the present study.

The result for the sensory evaluation of masa was generally liked as represented in Table 7. The sensory evaluation of masa rated the colour of masa made from potato variety Caruso as "like very much "for both the CF and CF+RF masa with the scores that ranged from 8.05±1.05 to 8.45±0.69 respectively. The taste for both the control and the test masa product rated like very much with scores ranging from 8.35±0.81 to 8.45±0.83. The texture of masa rated like moderately with scores ranging from 7.60±1.10 to 7.75±1.25. The aroma of the control and test masa rated like very much with scores that ranged from 8.35±0.75 to 8.45±0.76. The overall acceptability rated like moderately and like very much with the score that ranged from 7.95±1.23 to 8.25±1.16 for the masa samples.

The scores for the colour were all within the like very much for both the masa (test) and masa (control). This may be because the colour looked like the normal conventional masa made with the popular cereals. Abdulkadir et al. (2023), reported their colour of masa ranging from 5.90±0.99 to 7.80±0.92. Their values are not in tandem with the outcome reported in this study and does not agree with values obtained in this study. The taste parameter recorded all fell within the like very much. This may be because the taste was palatable for the both test and the control masa samples since they were both products of fermentation. Abdulkadir et al. (2023), reported their values for taste in their masa which ranged from 5.70±1.4 to 7.20±1.03 which were lower than the values obtained in this study, though their higher value fell within the like scores. Their values are not in agreement with the values obtained in this present study.

The texture scores were all within the like score. This may have been because the feel especially the mouth-feel and the feel by handling. Abdulkadir et al. (2023), reported their texture of masa which ranged from 6.00±1.25 to 6.10±0.9 which are much lower than values obtained in this present study and does not agree with values obtained in this present study. This indicates that Caruso flour can actually be an alternative to cereal for the production of masa because it can compete favourably with the conventional masa produced with rice, maize and other cereal.

The scores for the aroma were high for both test and control masa samples in this study. This may be because fermented food products have an inviting aroma to the consumer, hence, the outcome for the masa in this present study. Amove and Ogori (2022) reported the values of their masa aroma which ranged from 6.73 to 7.00 which are lower than the findings in this present study. Their findings are not consonance with those obtained in this present study.

The overall acceptability showed that the overall acceptability was highest in the test masa. This is because the other parameters were scored high by the consumers and the new product was accepted by the consumers. The sensory evaluation showed that the colour, taste, texture, aroma and overall acceptability for both the test and the control masa sample were liked by the panel of untrained tasters. Samuel et al. (2015), reported that their masa made with rice had the highest acceptability which is closely related with the present study. Abiose and Malomo (2020), reported their overall acceptability ranging from 3.80±0.14 to 6.00±0.21 in their masa made from maize, soybean and acha composite. Their values are low for the overall acceptability and not in tandem with the values obtained in this Present study. Different grains have been used for the production of masa with resultant qualities such as good thickness, good weight, acceptable sensory qualities and some degree of sourness (Akande et al., 2018). The masa produced in this present study agrees with reports presented by Akande et al. (Akande et al., 2018).

6. Conclusion

Masa which is staple especially in Nigeria can be made from potato being the raw material aside the conventional cereal-based masa. Floor made from Caruso variety of potato can be used to make masa. The fermentation process did not affect the quality of masa. The mycological quality revealed that fungal species were responsible for fermentation, giving rise to the fermented masa batter. The proximate composition of masa made from Caruso potato variety competed favourably with those produced from cereals and other raw materials. The new food product from potato had a good sensory quality and consumers which indicates acceptability.

The study indicate that consumers can adopt new raw material for masa production such as tubers which is commonly enjoyed in many African countries, especially Nigeria. Other potato varieties, other agricultural raw materials or a combination of other agricultural raw materials could be explored in making masa.

ORCID

Margaret Musa Atsen Danladi https://orcid.org/0000-0003-1623-7160
Luka Sambo Danahap https://orcid.org/0009-0008-2646-5056
Ode Brains Okechalu https://orcid.org/0009-0002-8437-217X

References

1. Abdulkadir, F., Kolo, S. I., Maude, M. M., & Mohammed, I. K. (2023). Effects of different fermenting agents on proximate composition and sensory evaluation of masa—a fermented puff fried batter. *Journal of Applied Sciences and Environmental Management*, 27(7), 1399–1402.
2. Abdullah, N., Nawawi, A., & Othman, I. (2000). Fungal spoilage of starch-based foods in relation to its water activity (aw). *Journal of Stored Products Research, 36*(1), 47–54.
3. Abiose, S., & Malomo, A. (2020). The effect of the substitution of acha (Digitaria exilis) and soybean on the chemical composition and sensory properties of maize masa. *Croatian Journal of Food Science and Technology, 12*(1), 101–109.
4. Adegbehingbe, K. T. (2014). Production of masa using maize-sorghum blends. *International Journal of Science and Research, 3*(8), 484–489.
5. Akinleye, O. M., Fajolu, I. O., Fasure, A. K., Osanyinpeju, O. S., Aboderin, A. O., & Salami, O. O. (2014). Evaluation of microorganisms at different stages of production of Ogi in Alimosho Community, Area Southwest, Lagos, Nigeria. *American Journal of Research Communication, 2*(10), 215–230.
6. Akande, O. A., Jolayemi, O. S., Familusi, A., & Idowu, B. (2018). Nutritional, antioxidant, and sensory properties of rice-based masa enriched with grain amaranth and carrot powder. *Annals of Food Science and Technology, 19*(4), 645–656.
7. Akintomide, M. J., & Antai, S. P. (2012). Protein enrichment of Irish potato (Solanum tuberosum L.) peels through solid substrate fermentation by *Saccharomyces cerevisiae* and *Aspergillus niger*. *Journal of Environmental Science, 1*, 15–19.

8. Amove, J., & Ogori, A. F. (2022). Chemical and consumer acceptance of soymilk enriched rice based masa. *J Food Sci Nutr, 8*(144), 2.

9. Anumudu, C. K., Omeje, F. I., & Obinwa, G. N. (2018). Microbial succession pattern in Ogi fermentation. *International Journal of Advanced Research in Biological Sciences, 5*(7), 247–251.

10. AOAC. (2000). Methods of association of official and analytic chemists (17th ed.). Association of Official Analytical Chemists.

11. Balogun, M. A., Oyeyinka, S. A., Kolawole, F. L., Dauda, A. O., & Abdulmalik, A. J. (2021). Effect of storage period on physical, chemical, microbial, and sensory qualities of instant masa flour produced from blends of rice and Bambara groundnut. *Journal of Agricultural Sciences (Belgrade), 66*(2), 165–179.

12. Dashen, M. M., Edia-Asuke, U. A., Amapu, T. Y., Jidangkat, M. G., & Hassan, B. B. (2017). Effect of fermented rice dough on the organoleptic quality and shelflife of rice 'Masa'. *UMYU Journal of Microbiology Research (UJMR), 2*(1), 178–185.

13. Deka, P., Mehetre, G. T., Lalnunmawii, E., Upadhyaya, K., Singh, G., Hashem, A., Al-Arjani, A. B. F., Fathi Abd_Allah, E., & Singh, B. P. (2021). Metagenomic analysis of bacterial diversity in traditional fermented foods reveals food-specific dominance of specific bacterial taxa. *Fermentation, 7*(3), 167.

14. Delgado, S., Guadamuro, L., Flórez, A. B., Vázquez, L., & Mayo, B. (2019). Fermentation of commercial soy beverages with lactobacilli and bifidobacteria strains featuring high β-glucosidase activity. *Innovative Food Science & Emerging Technologies, 51*, 148–155.

15. Efiuvwevwere, B. J., & Ezeama, C. F. (1996). Influence of fermentation time and an 'indigenous tenderiser' (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), 442–448.

16. Haverkort, A. J., Linnemann, A. R., Struik, P. C., & Wiskerke, J. S. C. (2023). On processing potato 3: Survey of performances, productivity and losses in the supply chain. *Potato Research, 66*(2), 385–427.

17. Izah, S. C., Kigigha, L. T., & Okowa, I. P. (2016). Microbial quality assessment of fermented maize Ogi (a cereal product) and options for overcoming constraints in production. *Biotechnological Research, 2*(2), 81–93.

18. Ijah, U. J. J., Auta, H. S., & Aduloju, M. O. (2014). Microbiological, nutritional and sensory quality of bread produced from wheat and potato flour blends. *International Journal of Food Science*, 1–6.

19. Kowalczewski, P. Ł., Olejnik, A., Białas, W., Rybicka, I., Zielińska-Dawidziak, M., Siger, A., Kubiak, P., & Lewandowicz, G. (2019). The nutritional value and biological activity of concentrated protein fraction of potato juice. *Nutrients, 11*(7), 1523.

20. Malomo, A. A., & Abiose, S. H. (2019). Protein quality and functional properties of masa produced from maize, acha and soybean. *Food Research, 3*(5), 556–563.

21. Malomo, A. A., & Popoola, O. (2020). Comparative studies on the microbiological and sensory property of burukutu produced from red and white variety of sorghum with or without pasteurization and preservatives. *Annals of Food Science and Technology, 21*(2), 338–346.

22. Martelli, F., Cirlini, M., Lazzi, C., Neviani, E., & Bernini, V. (2020). Solid-state fermentation of *Arthrospira platensis* to implement new food products: Evaluation of stabilization treatments and bacterial growth on the volatile fraction. *Foods, 10*(1), 67.

23. Meiselman, H. L. (2013). The future in sensory/consumer research: Evolving to a better science. *Food Quality and Preference, 27*(2), 208–214.

24. Nafar, M., Emam-Djomeh, Z., Yousefi, S., & Hashemi Ravan, M. (2013). An optimization study on the ultrasonic treatments for *Saccharomyces cerevisiae* inactivation in red grape juice with maintaining critical quality attributes. *Journal of Food Quality, 36*(4), 269–281.

25. Nakamura, C., Koshikawa, Y., & Seguchi, M. (2008). Increased volume of Kasutera cake (Japanese sponge cake) by dry heating of wheat flour. *Food Science and Technology Research, 14*(5), 431.

26. Ndudi, W., Edo, G. I., Samuel, P. O., Jikah, A. N., Opiti, R. A., Ainyanbhor, I. E., Essaghah, A. E. A., Ekokotu, H. A., Oghroro, E. A. E., & Agbo, J. J. (2024). Traditional fermented foods of Nigeria: Microbiological safety and health benefits. *Journal of Food Measurement and Characterization*, 1–26.

27. Nkama, I., & Malleshi, N. G. (1998). Production and nutritional quality of traditional Nigerian masa from mixtures of rice, pearl millet, cowpea, and groundnut. *Food and Nutrition Bulletin, 19*(4), 366–373.

28. Nwokoro, O., & Chukwu, B. C. (2012). Studies on Akamu, a traditional fermented maize food. *Revista chilena de nutrición, 39*(4), 180–184.

29. Odunfa, S. A., & Adeyele, S. (1985). Microbiological changes during the traditional production of ogi-baba, a West African fermented sorghum gruel. *Journal of Cereal Science, 3*(2), 173–180.

30. Offiah, V., Kontogiorgos, V., & Falade, K. O. (2019). Extrusion processing of raw food materials and by-products: A review. *Critical Reviews in Food Science and Nutrition, 59*(18), 2979–2998.

31. O'Mahony, M., & Wichchukit, S. (2015). The 9-point hedonic scale and hedonic ranking in food science: Some reappraisals and alternatives. *Journal of the Science of Food and Agriculture, 95*(11), 2167–2178.

32. Owusu-Kwarteng, J., & Akabanda, F. (2013). Applicability of nixtamalization in the processing of millet-based maasa, a fermented food in Ghana. *Journal of Food Research, 2*(1), 59.

33. Oyedeji, O., Ogunbanwo, S. T., & Onilude, A. A. (2013). Predominant lactic acid bacteria involved in the traditional fermentation of fufu and ogi, two Nigerian fermented food products. *Food and Nutrition Sciences, 4*(11), 40.

34. Oranusi, S. U., Oguoma, O. I., & Agusi, E. (2013). Microbiological quality assessment of foods sold in student's cafeterias. *Global Research Journal of Microbiology, 3*(1), 1–7.

35. Samuel, F. O., Ishola, O. R., & Otegbayo, B. O. (2015). Nutritional and sensory evaluation of rice-based masa enriched with soybean and crayfish. *Food and Nutrition Sciences, 6*(2), 234–241.

36. Sanni, A. I., & Adesulu, A. T. (2013). Microbiological and physico-chemical changes during fermentation of maize for masa production. *African Journal of Microbiology Research, 7*(34), 4355–4362.

37. Salvador, A., Varela, P., Sanz, T., & Fiszman, S. M. (2009). Understanding potato chips crispy texture by simultaneous fracture and acoustic measurements, and sensory analysis. *LWT - Food Science and Technology, 42*(3), 763–767.

38. Sankhla, S., Chaturvedi, A., Kuna, A., & Dhanlakshmi, K. (2012). Preservation of sugarcane juice using hurdle technology. *Sugar Tech, 14*(1), 26–39.

39. Tamang, J. P., Cotter, P. D., Endo, A., Han, N. S., Kort, R., Liu, S. Q., Mayo, B., Westerik, N., & Hutkins, R. (2020). Fermented foods in a global age: East meets West. *Comprehensive Reviews in Food Science and Food Safety, 19*(1), 184–217.

40. Torrico, D. D., Mehta, A., & Borssato, A. B. (2023). New methods to assess sensory responses: A brief review of innovative techniques in sensory evaluation. *Current Opinion in Food Science, 49*, 100978.

41. Twinomuhwezi, H., Awuchi, C. G., & Rachael, M. (2020). Comparative study of the proximate composition and functional properties of composite flours of amaranth, rice, millet, and soybean.

42. Umokaso, M. M., Efiuvwevwere, B. J., & Ire, F. S. (2022). Microbiological dynamics involved in cereal-porridge production using maize and sorghum. *GSC Biological and Pharmaceutical Sciences, 18*(1), 014–026.

43. Van Vugt, D., & Franke, A. C. (2018). Exploring the yield gap of orange-fleshed sweet potato varieties on small holder farmers' fields in Malawi. *Field Crops Research, 221*, 245–256.

44. Vivek, K., Subbarao, K. V., Routray, W., Kamini, N. R., & Dash, K. K. (2020). Application of fuzzy logic in sensory evaluation of food products: A comprehensive study. *Food and Bioprocess Technology, 13*, 1–29.

45. Yaseen, S. S., Khalf, A. A., & Al-Hadidy, Y. I. (2020, November). A study of chemical composition and determination of acrylamide in fried potato chips. In *IOP Conference Series: Materials Science and Engineering* (Vol. 928, No. 5, p. 052002). IOP Publishing.