Journal of Agricultural Sciences (Belgrade) https://doi.org/10.2298/JAS2102165B
Vol. 66, No. 2, 2021 UDC: 664.2.036
Pages 165-179 Original scientific paper

EFFECT OF STORAGE PERIOD ON PHYSICAL, CHEMICAL, MICROBIAL, AND SENSORY QUALITIES OF INSTANT *MASA* FLOUR PRODUCED FROM BLENDS OF RICE AND BAMBARA GROUNDNUT

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Abstract: *Masa* is a traditionally fermented meal usually made from cereals. The aim of this research was to produce an enriched meal from rice and Bambara groundnut. The colour, functional properties and microbial quality of composite blend of rice and Bambara groundnut flour, in the ratio of 100:0, 95:5, 90:10, 85:15, 80:20, were evaluated using standard methods. Sensory properties of freshly made *masa* and *masa* prepared from stored flours were also determined. The microbial load of the *masa* flour blend increased over the storage period. Water absorption capacity, swelling capacity and bulk densities increased, while the oil absorption capacity decreased with the storage period. The objective colour result showed a decrease in the lightness (L*) value. Sensory properties of *masa* were not substantially altered with Bambara groundnut inclusion, but the ratings reduced with storage. Instant *masa* may be prepared from flour stored for 4 weeks without considerable changes in quality.

Key words: *masa,* rice, Bambara groundnut, storage, microbial.

Introduction

The knowledge of consumers on the relationship between diet and health has led to a change in the dietary pattern of the African populace. According to Samuel et al. (2015), there are swift and widespread shifts in food consumption patterns towards the western diet and lifestyle. Consumption of snacks such as *masa* produced from cereals contributes significantly to the calorie intake of the populace in many parts of the world, including Africa. *Masa* is a traditional fermented product in Nigeria from millet, maize or rice flour (Badau et al., 2018). Good quality *masa* is round in shape with brown and smooth surfaces (Badau et al., 2018).

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The nutritional value of *masa* may vary with the type and variety of cereals and perhaps the processing conditions used in its preparation. For example, the protein content of rice-*masa* (7.59%) was found to be significantly lower than those of maize (9.56%) and millet (9.21%) (Ayo et al., 2008b). In general, *masa* is very low in protein but may contain up to about 7% to 11% of protein depending on the cereals used and their combinations with legumes. Nkama and Malleshi (1998) reported that the protein content of rice-*masa* increased by 54% when 20% of cowpea was added to enrich the *masa*. Other authors reported a 10% increase in protein content of maize-*masa* enriched with groundnut paste at 20% levels (Ayo et al., 2008a).

The addition of protein-rich leguminous crop such as Bambara groundnut (*Vigna subterranea*) to cereal-based snack is a promising way to enrich the snack and improve the nutritional intake of the populace. Bambara groundnut is a leguminous crop that is rich in protein (15–27%) and carbohydrate (57–67%) (Oyeyinka and Oyeyinka, 2018). It is often referred to as a complete food because of its reasonably high protein content (Adebowale et al., 2002; Arise et al., 2015; Oyeyinka et al., 2015; Sirivongpaisal, 2008) and a good balance of the essential amino acids (Yao et al., 2015). The high levels of lysine (6.5–6.8%) in Bambara groundnut and the considerable amount of methionine (1.8-2.84%), which is normally limiting in most legumes, further confirm the grain as a balanced diet (Aremu et al., 2006; Kudre et al., 2013; Ijarotimi and Esho, 2009). Bambara groundnut is a drought-tolerant crop that has potentials for cultivation during extreme conditions of drought. Bambara groundnut has similar composition to cowpea but has limited utilisation when compared to cowpea (*Vigna unguiculata*), presumably due to the very limited research to unlock the potential of the crop (Oyeyinka et al., 2015). The hard-to-cook defect (HTC) commonly associated with legumes including Bambara groundnut may also explain the limited utilisation of the crop. It has been found that HTC defect results in high energy utilisation and consequently reduces the nutritive value of the grain (Molina and Bressani, 1975; Paredes-López et al., 1991).

Previous studies on *masa* enriched with legumes such as cowpea or groundnut found significant improvement in the nutritional value of the *masa* (Ayo et al., 2008a; Nkama and Malleshi, 1998). Besides the improvement in the nutritional value of *masa*, the addition of legumes to *masa* may affect the physical, chemical, and sensory properties. The sensory properties of maize-based *masa* enriched with 20% and 25% of groundnut paste were found to be superior to those of *masa* without groundnut paste or to those with lower levels of the paste (Ayo et al., 2008a). So far, studies on *masa* have focused on nutritional properties as well as sensory properties of the snack. In this study, instant *masa* flour was produced from blends of rice and Bambara groundnut flours. The physical, chemical, sensory, and microbial qualities of the freshly produced and stored *masa* flour were investigated.

Materials and Methods

Materials

Local rice, Bambara groundnut, corn starch, and polyethene bags were obtained from the Oja Oba market in Ilorin, Kwara State. Materials were transferred into the Food Processing laboratory of the Department of Home Economics and Food Science, University of Ilorin, for further processing.

The preparation of *masa* flour

Masa was prepared from rice as previously described by Ayo et al. (2008a), except that Bambara groundnut was used to enrich the *masa* instead of groundnut paste. Briefly, rice grains (500 g) were sorted to remove foreign matters, washed, and soaked in distilled water (600 ml) at 34^{o}C for 12 hrs. A quarter ($^1/_4$) of the cooked rice grains was mixed with three-quarters ($^3/_4$) of milled rice flour to form a batter. The resulting batter was inoculated with bakers' yeast (1% w/w of rice grain) and left to ferment at room temperature (25±2^{o}C) for 16 hrs, and the thick batter obtained was diluted with 10 ml of 20% sodium carbonate solution. Salt (10 g/500 g of rice), sugar (30 g/500 g of rice) and Bambara groundnut flour in varying proportions (5, 10, 15 and 20% w/w of rice grain) were added to the batter and properly mixed. Samples were dried in an oven at 60^{o}C for 5 hrs, cooled and milled into fine flour, mixed with 5% of corn starch, and packaged into a high-density polythene bag. The *masa* flours were stored for two months at room temperature (25±2^{o}C), and the colour and functional properties of the flour, as well as the sensory and microbial qualities of the masa, were assessed bi-weekly from the day of production.

The proximate composition of *masa* flour

The proximate composition (ash, fat, fibre and moisture contents) of the flour was determined using standard methods (AOAC, 2000). Protein content was measured using the Kjeldahl method (6.25 × N), while the total carbohydrate was calculated by difference.

The colour of masa flour

Tristimulus l* a* b* parameters of *masa* flour were determined after standardisation using colour Flex (A60-1014593, USA). Snapshots in triplicate were taken, and values were read directly from a digital print. The average of the readings was computed and recorded.

Functional properties of *masa* flour

Water absorption capacity was determined by the method described by Oyeyinka et al. (2015). One gram of sample was mixed with 10 ml of distilled water. The mixture was left at room temperature (25±2 ^{o}C) for 30 mins and thereafter centrifuged (model 5810R, Eppendorf International, Frankfurt, Germany) for 30 mins. Water absorption capacity was expressed as a gram of water bound per gram of flour. The same procedure was repeated for oil absorption capacity, except that the water was replaced with soybean oil.

Swelling capacity was determined as previously described with slight modifications (Oyeyinka et al., 2019). Flour blends were filled to the 10 ml mark in a 50-ml glass measuring cylinder. Distilled water was added at room temperature to give a total volume of 50 ml. The top of the cylinder was tightly covered, and the contents mixed by inverting the cylinder. The cylinder was then left to stand for additional 4 hrs, and the final volume occupied by the sample was recorded. Swelling capacity was determined by dividing the volume of the flour in water by the initial volume of the flour blends.

The microbial analysis of masa flour

Quantitative bacteriological analysis of the samples was carried out using the total plate count on nutrient agar (NA), and potato dextrose agar (PDA) was used for the fungal count. The counts were expressed as colony-forming units per millimetre (cfu/ml) (Balogun et al., 2016).

Sensory analysis

For sensory evaluation, *masa* was prepared from the instant *masa* flour, and sensory evaluation was carried out to know the most acceptable blend of rice flour and Bambara groundnut flour from the various mixing ratios. The analysis was done using a nine-point hedonic scale questionnaire. The *masa* samples were placed in front of 30 panellists to decide on the most acceptable one by assessing the samples for sourness, appearance, aroma, taste, texture, and overall acceptability. The panellists were selected among the staff and students at the University of Ilorin who are regular consumers of *masa*. Dried *masa* flour was mixed with water to form a batter. The batter was deep-fried in heated soybean oil for 4 mins on one side and turned over for additional 4 mins. Fried *masa* samples were cooled, packaged, and stored at 4^{o}C until needed for analysis for a maximum of 1 week. Freshly made samples and *masa* from stored flours were prepared and used for sensory evaluation. Panel members were provided with water to rinse their mouths after evaluating each sample to prevent carry-over effects.

Statistical analysis

Duplicate samples were prepared, and analyses were done in triplicate. Data were analysed using the one-way analysis of variance (ANOVA), and means were compared using the Fisher's least significant difference (LSD) test ($p \leq 0.05$) using the Statistical Package for the Social Sciences (SPSS) Version 16.0 for Windows (SPSS Inc., Chicago, USA).

Results and Discussion

Effect of storage period on the colour of rice-Bambara *masa* flour

The objective colour parameters of the freshly made and stored rice-Bambara groundnut *masa* flour blends are presented in Table 1. Lightness (L) values (83.99–85.81) for the flour blends containing Bambara groundnut flour were generally lower than that of the control sample (88.11) without Bambara groundnut (Table 1). Although the L values of the enriched samples were lower than the control, the addition of Bambara groundnut up to 20% level did not significantly ($p < 0.05$) change the colour of the samples. The L value result suggests that the *masa* flour without Bambara was whiter in appearance, which could be attributed to variation in the composition of the grains. Enriched *masa* flour samples showed a significant decline in all the colour values (L, a and b) with an increase in the storage period (Table 1), which could be due to the Maillard reaction in the stored flour (Ward et al., 1998; Yeboah-Awudzi et al., 2018). This seems plausible since the presence of protein from Bambara grains and carbohydrate in the *masa* flour may facilitate the Maillard reaction. Previous studies similarly observed a decline in the colour of maize with an increase in the storage period (Paraginski et al., 2014).

Table 1. Colour of rice-Bambara groundnut *masa* flour blend stored for 0 and 8 weeks.

Sample	Week 0			Week 8		
	L	a	b	L	a	b
$R_{100}B_0$	88.11^{a}±1.37	7.21^{b}±0.05	-1.08^{bc}±1.45	77.29^{a}±2.82	1.20^{d}±0.03	-3.75^{a}±0.64
$R_{95}B_5$	85.42^{b}±1.33	7.02^{b}±0.12	-1.06^{c}±0.21	73.91^{b}±2.93	1.41^{bc}±0.05	-2.65^{b}±0.33
$R_{90}B_{10}$	85.81^{b}±1.92	7.46^{a}±0.14	0.05^{a}±0.53	75.14^{ab}±1.13	1.76^{a}±0.06	-0.17^{a}±0.45
$R_{85}B_{15}$	83.99^{b}±1.51	7.02^{b}±0.10	-0.16^{b}±0.62	77.97^{a}±2.81	1.56^{b}±0.16	0.28^{a}±0.70
$R_{80}B_{20}$	85.24^{b}±0.94	7.51^{a}±0.15	1.59^{a}±0.06	74.92^{ab}±0.59	1.46^{bc}±0.11	-0.42^{a}±0.30

Values are means ±SD (N=3). Means with different superscript letters are significantly different across columns ($p < .05$). $R_{100}B_0$: 100% of rice and 0% of Bambara; $R_{95}B_5$: 95% of rice and 5% of Bambara; $R_{90}B_{10}$: 90% of rice and 10% of Bambara; $R_{85}B_{15}$: 85% of rice and 15% of Bambara; $R_{80}B_{20}$: 80% of rice and 20% of Bambara.

Effect of storage period on proximate composition of rice-Bambara *masa* flour

The proximate composition of freshly prepared and stored *masa* flour from blends of rice and Bambara flour is shown in Table 2. Carbohydrate was the major nutrient in the freshly prepared *masa* flour (75.43–82.57%) and stored flour samples (74.13–81.19%). Other nutrients such as ash (0.50–0.87%), fat (0.41–0.95%), fibre (4.28–6.03%) and protein (6.80–9.74%) were generally low (Table 2). Bambara groundnut flour addition to rice flour increased the ash, fibre, fat, and protein contents in the composite flour but decreased the carbohydrate content. The protein content of the composite flour increased by approximately 15%, 21%, 33% and 42% when adding 5%, 10%, 15% and 20% of Bambara groundnut flour, respectively. The increase in protein is expected since legumes, including Bambara groundnut, are known to be good sources of protein (Oyeyinka and Oyeyinka, 2018). This increase in protein represents a good strategy to improve the nutritional intake of *masa*-loving individuals and could further help reduce protein-energy malnutrition prevalent in Africa, including Nigeria.

Table 2. Proximate composition of rice-Bambara groundnut *masa* flour blend stored for 0 and 8 weeks.

Parameters	Week 0					
	$R_{100}B_0$	$R_{95}B_5$	$R_{90}B_{10}$	$R_{85}B_{15}$	$R_{80}B_{20}$	$R_{100}B_0$
Moisture	$5.38^b±0.36$	$6.66^a±0.00$	$6.72^a±0.02$	$6.96^a±0.01$	$7.06^a±0.04$	$5.38^b±0.36$
Fat	$0.41^d±0.00$	$0.55^c±0.01$	$0.62^c±0.01$	$0.87^b±0.00$	$0.95^a±0.07$	$0.41^d±0.00$
Ash	$0.50^c±0.01$	$0.61^b±0.00$	$0.66^b±0.02$	$0.68^a±0.00$	$0.74^a±0.04$	$0.50^c±0.01$
Protein	$6.84^e±0.03$	$7.84^d±0.02$	$8.26^c±0.01$	$9.07^b±0.28$	$9.74^a±0.01$	$6.84^e±0.03$
Fibre	$4.28^a±0.02$	$4.44^b±0.06$	$4.62^c±0.04$	$5.25^d±0.05$	$6.03^e±0.02$	$4.28^a±0.02$
CHO	$82.57^e±0.37$	$79.88^d±0.02$	$79.12^c±0.04$	$77.36^b±0.09$	$75.43^a±0.02$	$82.57^e±0.37$
Parameters	Week 8					
	$R_{100}B_0$	$R_{95}B_5$	$R_{90}B_{10}$	$R_{85}B_{15}$	$R_{80}B_{20}$	$R_{100}B_0$
Moisture	$6.50^b±0.02$	$8.47^a±0.07$	$8.54^a±1.10$	$8.84^a±0.43$	$8.37^a±0.24$	$6.50^b±0.02$
Fat	$0.45^c±0.02$	$0.56^c±0.00$	$0.71^b±0.02$	$0.90^a±0.01$	$0.94^a±0.05$	$0.45^c±0.02$
Ash	$0.56^d±0.00$	$0.66^c±0.01$	$0.81^b±0.01$	$0.84^{ab}±0.01$	$0.87^a±0.02$	$0.56^d±0.00$
Protein	$6.80^e±0.00$	$7.86^d±0.00$	$8.27^c±0.02$	$9.06^b±0.01$	$9.74^a±0.01$	$6.80^e±0.00$
Fibre	$4.36^d±0.00$	$4.46^d±0.01$	$4.62^c±0.03$	$5.17^b±0.08$	$5.98^a±0.04$	$4.36^d±0.00$
CHO	$81.19^a±0.04$	$77.97^b±0.06$	$77.04^b±1.11$	$75.12^c±0.50$	$74.13^c±0.28$	$81.19^a±0.04$

Values are means ±SD (N=3). Means with different superscript letters are significantly different across columns ($p < .05$). $R_{100}B_0$: 100% of rice and 0% of Bambara; $R_{95}B_5$: 95% of rice and 5% of Bambara; $R_{90}B_{10}$: 90% of rice and 10% of Bambara; $R_{85}B_{15}$: 85% of rice and 15% of Bambara; $R_{80}B_{20}$: 80% of rice and 20% of Bambara; CHO: Carbohydrate.

The storage of the flour in a high-density polythene bag at room temperature (25±2°C) for a period of 8 weeks did not substantially alter the composition of the flours, except for the moisture values (Table 2). The moisture content of the flours increased significantly ($p < .05$), suggesting that the polythene bags were not impermeable to water vapour. Similar results were reported for Bambara and cowpea snacks for a period of 4 weeks (Oyeyinka et al., 2018). The ash, fibre, fat and protein contents were almost constant, while the carbohydrate content of the flours reduced with an increase in the storage period. The proximate results were within the range reported for rice-Bambara nut flour extruded flakes (Adebowale et al., 2016).

Effect of storage period on selected functional properties of rice-Bambara *masa* flour

The water absorption capacity (WAC) of the flour blend increased with increasing levels of Bambara groundnut (Figure 1). This could be due to higher polar amino acid residues of proteins in the Bambara flour which presumably have more affinity for water molecules (Yusuf et al., 2008).

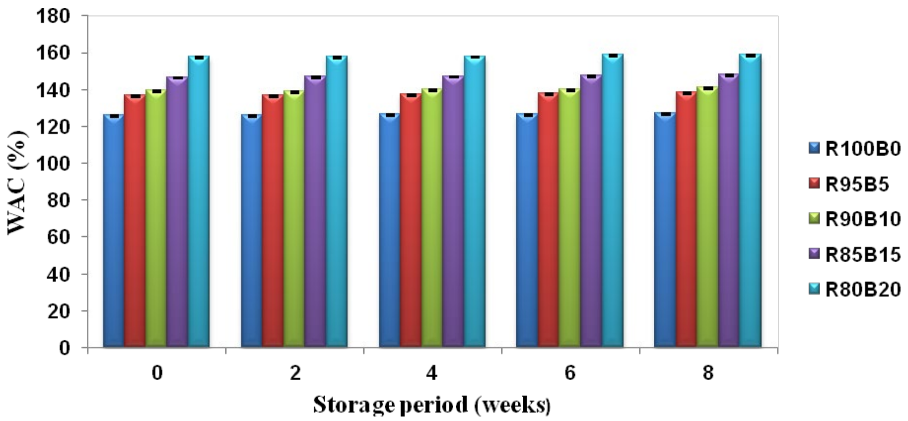

Figure 1. Effect of storage period on the water absorption capacity of *masa* flour blends.

Error bars indicate standard deviation. $R_{100}B_0$: 100% of rice and 0% of Bambara; $R_{95}B_5$: 95% of rice and 5% of Bambara; $R_{90}B_{10}$: 90% of rice and 10% of Bambara; $R_{85}B_{15}$: 85% of rice and 15% of Bambara; $R_{80}B_{20}$: 80% of rice and 20% of Bambara; WAC: Water absorption capacity.

According to Lawal and Adebowale (2004), the major chemical compositions that enhance the WAC of flours are proteins and carbohydrates since these constituents contain hydrophobic part such as polar or charged side chains. Thus, the increased WAC of the blends may also be associated with an increase in the starch content of the flour. This seems plausible since previous studies reported Bambara groundnut to be a good starch source, contributing to increased swelling (Oyeyinka et al., 2015; Oyeyinka et al., 2017). Although the WAC increased slightly with an increase in the storage period, the increase was not significant ($p \geq 0.05$). The WAC of the samples ranged between 126.08 and 157.74 % (Figure 1), which is similar to the values previously reported for Bambara groundnut during short time storage (Goudoum et al., 2016).

The oil absorption capacity (OAC) of the flour blends (Figure 2) was generally lower than their WAC (Figure 1). The storage period similarly did not significantly ($p < 0.05$) alter the OAC of the flour blends, though there was a slight increase (Figure 2). In general, the OAC decreased with an increase in the percentage of Bambara groundnut flour, suggesting that Bambara groundnut has fewer hydrophobic proteins compared with rice. Although rice is a cereal, its protein has been reported to have surface hydrophobicity, which may increase with heat denaturation (Ju et al., 2001). In addition, earlier studies have indicated hydrophobic proteins have better oil binding properties (Lawal and Adebowale, 2004).

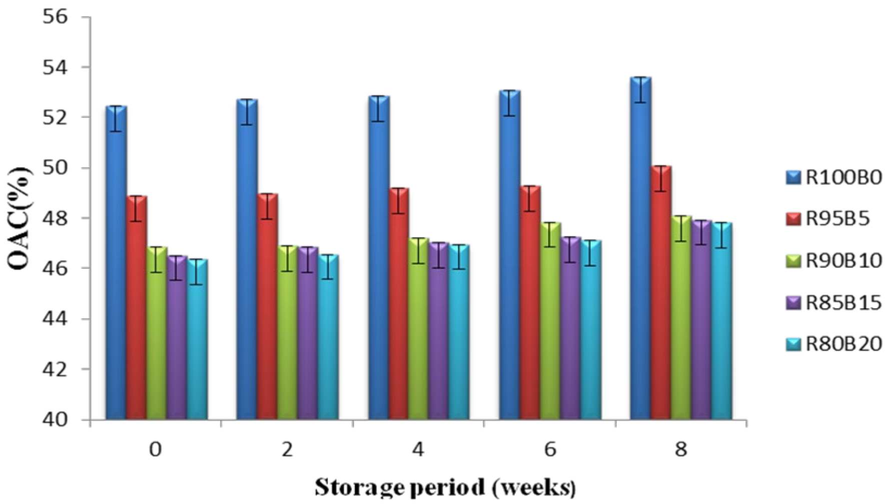

Figure 2. Effect of storage period on the oil absorption capacity of *masa* flour blends.

$R_{100}B_0$: 100% of rice and 0% of Bambara; $R_{95}B_5$: 95% of rice and 5% of Bambara; $R_{90}B_{10}$: 90% of rice and 10% of Bambara; $R_{85}B_{15}$: 85% of rice and 15% of Bambara; $R_{80}B_{20}$: 80% of rice and 20% of Bambara; OAC: Oil absorption capacity. Error bars indicate standard deviation.

The swelling capacity of the flour blends increased with increasing levels of Bambara groundnut flour (Figure 3). However, the swelling index showed an insignificant ($p > 0.05$) increase with an increase in the storage period. The swelling index represents the ability of the flour samples to imbibe water and swell at room temperature. The extent of swelling is determined by the amount of water that starch and protein can absorb before the chains become separated completely

(Chrastil, 1990). Starch is chiefly responsible for swelling, and the degree of swelling depends on the ratio of amylose to amylopectin and the chain length distribution of the amylopectin chain length. Functional properties of cereal and legume flours are important parameters to be considered in developing food products because they contribute to the texture, mouth feel as well as consistency of the product (Bhat and Nabilah, 2014).

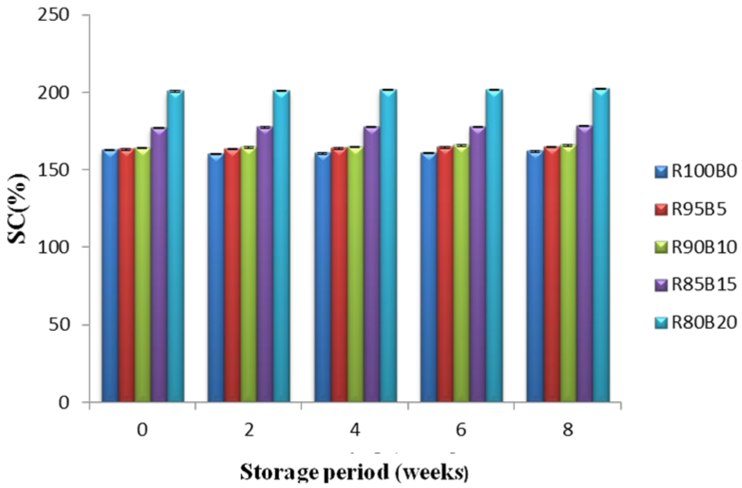

Figure 3. Effect of storage period on the swelling capacity of *masa* flour blends.

$R_{100}B_0$: 100% of rice and 0% of Bambara; $R_{95}B_5$: 95% of rice and 5% of Bambara; $R_{90}B_{10}$: 90% of rice and 10% of Bambara; $R_{85}B_{15}$: 85% of rice and 15% of Bambara; $R_{80}B_{20}$: 80% of rice and 20% of Bambara; SC: Swelling capacity; Error bars indicate standard deviation.

Effect of storage period on the microbial load of rice-Bambara *masa* flour

The total bacterial count (TBC) and total fungal count (TFC) as measured in cfu/g in rice-Bambara *masa* flour samples during storage at room temperature for a period of 8 weeks are presented in Figures 4 and 5, respectively. In general, there was an increase in both TBC and TFC of the flour blends with an increase in the storage period (Figures 4 and 5). Furthermore, the TBC and TFC similarly increased with an increase in the levels of Bambara groundnut. Bambara groundnut is a good source of protein and other nutrients that are needed by microbes for growth. Balogun et al. (2016) also reported an increase in microbial growth with an increase in the storage period of gruel made from fermented maize and soybean. Bacteria seem to grow faster in the flour blends than the fungi. For example, the TBC ranged between 2.1 and 9.05 cfu/g $\times 10^4$, while the TFC ranged between 0 and 3.8 cfu/g $\times 10^4$. These values fall within the range of the maximum permissible level ($>10^4$ to $<10^6$cfu/g) of the total aerobic colony.

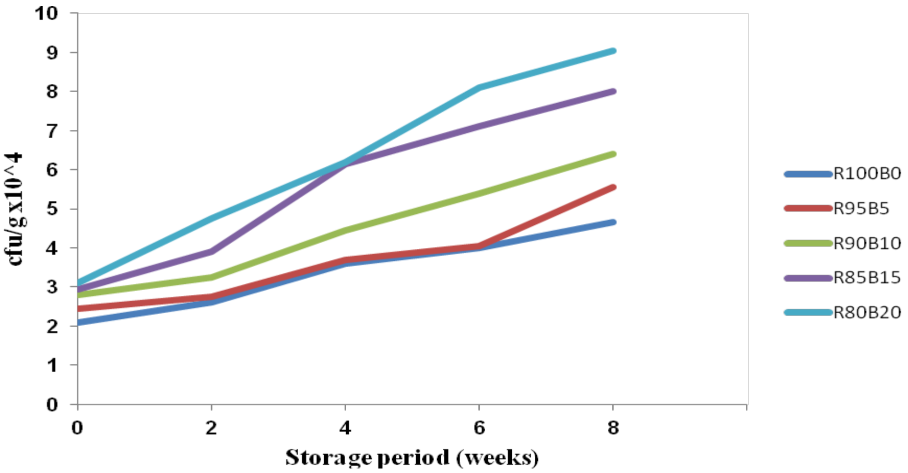

Figure 4. Effect of storage period on the swelling capacity of *masa* flour blends.

$R_{100}B_0$: 100% of rice and 0% of Bambara; $R_{95}B_5$: 95% of rice and 5% of Bambara; $R_{90}B_{10}$: 90% of rice and 10% of Bambara; $R_{85}B_{15}$: 85% of rice and 15% of Bambara; $R_{80}B_{20}$: 80% of rice and 20% of Bambara; SC: Swelling capacity; Error bars indicate standard deviation.

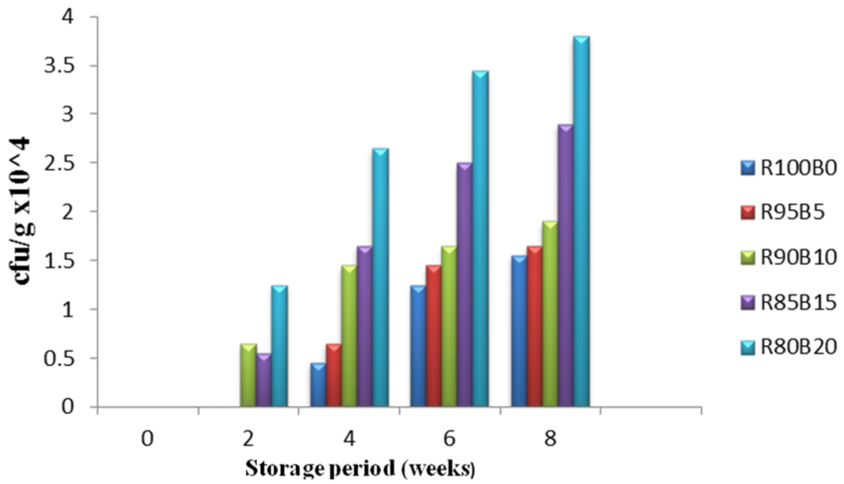

Figure 5. Effect of storage period on the total fungal count of *masa* flour blends.

$R_{100}B_0$: 100% of rice and 0% of Bambara; $R_{95}B_5$: 95% of rice and 5% of Bambara; $R_{90}B_{10}$: 90% of rice and 10% of Bambara; $R_{85}B_{15}$: 85% of rice and 15% of Bambara; $R_{80}B_{20}$: 80% of rice and 20% of Bambara.

Effect of storage period on the sensory properties of rice-Bambara *masa*

Masa samples were prepared from the flour blends, and the sensory quality was assessed using panel members as described above. Mean sensory scores showed that there were no significant differences ($p<0.05$) in sourness, appearance, aroma, and texture, but in taste and overall acceptability among the samples (Table 3). *Masa* flour with 100% of rice had the highest rating for appearance, aroma, taste, texture, and overall acceptability. Panel members consisted of regular consumers of *masa*. Thus, the higher rating recorded for *masa* prepared from 100% of rice flour could be due to the familiarity of the panel members with *masa*. The storage period significantly ($p<0.05$) affected the sensory properties of *masa* (Table 3). The ratings recorded for all the sensory properties reduced significantly with an increase in the storage period. *Masa* prepared from 80% of rice and 20% of Bambara groundnut flour had the highest rating in overall acceptability after the storage period of 8 weeks.

Table 3. Mean sensory scores of rice-Bambara groundnut *masa* flour blend stored for 0 and 8 weeks.

Parameters	Week 0				
	$R_{100}B_0$	$R_{95}B_5$	$R_{90}B_{10}$	$R_{85}B_{15}$	$R_{80}B_{20}$
Sourness	$6.6^a±1.6$	$6.1^a±1.4$	$6.7^a±1.8$	$6.0^a±1.6$	$6.4^a±1.7$
Appearance	$7.2^a±1.6$	$6.7^a±1.4$	$6.7^a±1.8$	$6.7^a±1.9$	$6.9^a±1.4$
Aroma	$6.9^a±1.4$	$6.0^a±1.2$	$6.5^a±1.4$	$6.9^a±1.3$	$6.5^a±1.7$
Taste	$7.3^a±0.9$	$6.0^b±1.7$	$6.0^b±1.6$	$6.6^a±1.5$	$6.1^b±1.7$
Texture	$6.6^a±1.9$	$6.2^a±1.7$	$6.1^a±1.9$	$6.1^a±1.7$	$6.0^a±1.9$
Overall acceptability	$7.4^a±1.4$	$7.0^{ab}±1.2$	$6.9^{ab}±1.5$	$6.7^{ab}±1.5$	$6.3^b±1.5$
Parameters	Week 8				
	$R_{100}B_0$	$R_{95}B_5$	$R_{90}B_{10}$	$R_{85}B_{15}$	$R_{80}B_{20}$
Sourness	$5.2^b±1.0$	$5.1^b±1.1$	$5.9^a±1.1$	$5.8^{ab}±0.9$	$5.5^{ab}±1.0$
Appearance	$5.1^b±0.9$	$5.2^b±1.6$	$5.3^b±0.9$	$5.6^{ab}±1.2$	$6.1^a±1.2$
Aroma	$4.9^b±1.5$	$5.6^{ab}±1.4$	$5.5^{ab}±1.4$	$5.8^{ab}±1.2$	$6.4^{ab}±1.1$
Taste	$5.2^a±1.3$	$5.5^a±1.9$	$5.3^a±1.3$	$8.6^a±1.4$	$5.6^a±1.5$
Texture	$5.5^a±1.5$	$5.5^a±1.3$	$5.6^a±1.9$	$5.4^a±1.1$	$5.9^a±1.4$
Overall acceptability	$5.3^{ab}±1.8$	$5.3^{ab}±1.5$	$4.9^b±1.6$	$5.5^{ab}±0.9$	$6.2^a±1.5$

Values are means ± SD (N=30). Means with different superscript letters are significantly different across the row ($p < .05$). * Multiple comparison tests were done for week 0 and week 8 separately. $R_{100}B_0$: 100% of rice and 0% of Bambara; $R_{95}B_5$: 95% of rice and 5% of Bambara; $R_{90}B_{10}$: 90% of rice and 10% of Bambara; $R_{85}B_{15}$: 85% of rice and 15% of Bambara; $R_{80}B_{20}$: 80% of rice and 20% of Bambara.

Conclusion

The objective of the study was to determine the physical, chemical, sensory, and microbial qualities of freshly produced and stored *masa* flour from rice and Bambara groundnut flour blends. Bambara groundnut flour addition did not significantly alter the colour of *masa* samples prepared from rice but did change the proximate composition. However, a slight colour change was observed after storage for 8 weeks. There was an improvement in the nutritional value of the masa flour due to the Bambara groundnut addition. Flour functionality improved with the Bambara groundnut addition and did not change significantly with an increase in the storage period. However, the total bacterial and fungal count increased with an increase in the storage period. Although the microbial load was within the range accepted for ready-to-eat foods, better packaging may be required to reduce the proliferation of microorganisms during storage to extend the shelf-life of the *masa* flour. Sensory properties of *masa* were not substantially altered with Bambara groundnut inclusion, but the ratings reduced with an increase in the storage period. This study showed that enriched *masa* flour can be stored for at most 4 weeks before significant changes can be observed in the sensory properties. Conclusively, instant *masa* flour from the rice-Bambara groundnut blend had improved nutritional qualities, with extended shelf life and convenience in terms of handling and less preparation time.

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Received: May 18, 2019
Accepted: May 19, 2021

UTICAJ SKLADIŠTENJA NA FIZIČKE, HEMIJSKE, MIKROBIOLOŠKE I SENZORNE KVALITETE INSTANT BRAŠNA *MASA* DOBIJENOG OD MEŠAVINA PIRINČA I BAMBARA GRAŠKA

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R e z i m e

Masa je tradicionalno fermentisani obrok koji se obično pravi od žita. Cilj ovog istraživanja bio je da se proizvede obogaćeni obrok od pirinča i Bambara graška. Boja, funkcionalna svojstva i mikrobiološki kvaliteti kompozitne mešavine brašna od pirinča i Bambara graška u odnosu 100:0, 95:5, 90:10, 85:15, 80:20, procenjeni su korišćenjem standardnih metoda. Takođe su utvrđena senzorna svojstva sveže pripremljene *mase* i *mase* pripremljene od uskladištenih vrsta brašna. Mikrobno opterećenje mešavine brašna *masa* povećavalo se tokom perioda skladištenja. Sposobnost apsorbovanja vode, sposobnost bubrenja i zapreminske mase povećali su se, dok se sposobnost apsorbovanja ulja smanjivala sa povećanjem perioda skladištenja. Rezultat merenja boje pokazao je smanjenje vrednosti svetline (L*). Senzorna svojstva *mase* nisu bila suštinski izmenjena uključivanjem Bambara graška, ali su ocene smanjene produžavanjem skladištenja. Instant *masa* se može pripremiti od brašna skladištenog tokom 4 nedelje, a da pri tom ne dođe do značajnih promena u kvalitetu.

Ključne reči: *masa,* pirinač, Bambara grašak, skladištenje, mikrobni.

Primljeno: 18. maja 2019.
Odobreno: 19. maja 2021.

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