CO-FERMENTION OF MAIZE (Zea mays L.) AND AFRICAN BREAD FRUIT SEED (Treculia africana Dec'ne) FOR THE PRODUCTION OF IMPROVED PAP (OGI)

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ABSTRACT

Cereals such as maize are generally having low essential amino acid contents which may cause protein malnutrition. The high essential amino acid in African breadfruit could make it suitable for supplementation of grains/cereals. The microbiological, sensory and nutritional evaluation of co-fermented maize (70%) /African breadfruit seed (30%) was carried out. Characterization of isolates were by macroscopic, microscopic and biochemical tests. Standard Methods according to AOAC (1990) were used for proximate compositions and pH determination. Viscosity was measured using Rotational Viscometer. The pH of the co-fermented sample decreased from 6.2±0.01 to 4.2±0.01. Microbial isolates included *Coryne bacterium* spp., *Lactobacillus* spp., *Escherichia coli, Staphylococcus aureus, Aspergillus niger* and *Saccharomyces cerevisae* in fermenting samples. *Escherichia coli* was inhibited with increase in fermentation time. Higher microbial counts occurred in maize-African breadfruit ogi (MABO) than maize ogi (MOGI) during primary and secondary fermentations. The viscosity of the co-fermented sample was 1.990±0.12 pas^{-1}. Proximate composition shows that MOGI had lower crude protein content (2.14±0.2) than MABO (9.83±0.3). In contrast, MOGI had higher crude carbohydrate (82.12±0.1 vs 72.59±0.2). Ash, moisture and lipid contents were not significantly different in both samples. Sensory evaluation revealed that MABO recorded higher scores (7±0.02 and 7±0.01) in taste and aroma as against (6±0.01 and 6±0.02) for MOGI. Although consumers accepted both samples, overall, MOGI was more acceptable. MABO flour kept well and retained their original viscosity after 27 days of storage at (30±2°C). MABO gave a dual advantage in that protein content was increased and enteropathogens were inhibited and is therefore recommended for consumption in areas where protein intake is inadequate and food safety is an issue.

Key words: Maize, African breadfruit, co-fermentation, nutrition, supplementation

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Introduction

Maize (*Zea mays*) is native to tropical America where it has been grown for over 6,000 years. It is believed to have been introduced to Africa only ten years after the discovery of America in 1492, although both the period and the route of its introduction are uncertain. It was introduced to Nigeria probably in the 16th century by the Portuguese (Osagie and Eka, 1998).In Nigeria, production of maize is common to all parts of the country, from North to South, with an estimated annual production of about 5.6 million tons (CBN, 1992). Maize is known by different vernacular names in Nigeria depending on the locality it is found such as, "Dawar Masara" or "Masara " (Hausa); " Ogbado" or "Oka" (Ibo); "Apara" (Ibira); 'Yangan" (Yoruba); "Ibokpot" (Efik). Maize is processed into different traditional foods, varying from region to region, from one ethnic group to another. Fresh unripe maize can be roasted or boiled on the cob, and it is exceedingly popular in this form. Ripe dried grains are cooked with oil and condiments added and eaten as "adalu". Maize can be prepared into "Ogi" a fermented non-alcoholic starchy food; "Kenke" a traditional meal eaten in Ghana, or as popcorn which is eaten all over West Africa (Iwuoha and Eke, 1996).Cereals generally have low essential amino acid contents which may cause protein malnutrition (Ashaye *et al.,* 2000). Maize is generally low in lysine, methonine and tryptophan, therefore its nutritional value is greatly limited. This poor nutritional quality of maize has been attributed to its high leucine content (Osagie and Eka, 1998). Direct amino acid supplementation has been shown to improve the nutritive value of corn based products (Ashaye *et al.,* 2000). A major drawback of this approach is the fact that most maize products including "ogi" are produced in homes, by traditional methods. However, home processing methods do not include direct amino acid supplementation. This is because during preparation of ogi, most of the protein and almost all the fibre content are lost during the steeping process and to wash water. (Ashaye *et al.*, 2000; Amusa *et al.*, 2005)."Ogi" has been implicated in the etiology of protein malnutrition in children, as it is used as a major weaning food for children. (Naismith, 1973; Fashakin and Ogunsola, 1982; Oyarekua, 2011).Fermentation process has also been shown to deplete protein, lipid, fibre and ash of the final product (Iwuoha and Eke, 1996). Therefore, there is a need for further supplementation in order to improve its nutritional value as food. Previous studies have shown that supplementation of "ogi" with legumes such as soya beans and cowpea resulted in products of high nutritive value (Marero *et al*., 1988; Amusa *et al.,* 2005; Oyarekua, 2011). African breadfruit (*Treculia africana*) is a tree crop. The seed is popularly called "Ukwa" in the Southern part of Nigeria but underutilized, it has high protein and oil contents (23% and 11%, respectively). The oil can be used for industrial purposes and also for human consumption due to its high food energy value. The high essential amino acid in African breadfruit could make it suitable to fortify grains/cereals (Oyeyipo, 2011). Microbial fermentation provides a way to food preservation, reduction in volume of materials to be transported, inhibition of microbial growth, improvement of appearance and taste of some foods and reduces the energy required for preparing food, ensures safer food products and enhancement of nutritive value (Oyarekua, 2011). There is little or no information on the co-fermentation of cereals and African breadfruit seeds by traditional/laboratory processing methods of fermentation. Therefore, this study was aimed at formulating a cheap processing technique (co-fermentation) that can be practiced at household level to produce nutritionally enriched foods with low-cost, biocompatible and locally available raw materials.

MATERIALS AND METHODS

Sources of maize and african breadfruit seeds

The maize (*Zea mays*) (yellow variety) and African breadfruit seeds (*Trecuila africana*) were purchased from mile 1 market in Port Harcourt, Rivers State, Nigeria.

Preparation of nutritionally improved ogi

There are slight variations from locality in the methods adopted for "ogi" production. However, the eventual product is the same anywhere it is made in Nigeria. The traditional preparation of "ogi" is a batch process carried out on a small scale. Winnowing and hand sorting of the grains are carried out to remove damaged or bad grains. For this study, "ogi" was produced using a modified method by Akingbala *et al.* (1981) with some modifications. Two hundred grams (200g) of cleaned maize samples was soaked in a plastic bucket containing 300ml of water and another plastic bucket contained 140g of maize and 60g of African breadfruit seeds (70:30w/w), samples were steeped for 72 h at room temperature (30±2°C). The water was then decanted and the steeped grains were wet milled using a clean blender (Model KM 910D; Kenwood Electronic, Hertfordshire, UK). It was then sieved using a fine mesh sieve (300µm). The filtered slurry was then allowed to sediment and passed through further fermentation for 24h at 30±2°C. The souring supernatant was decanted, and the slurry was collected using a sterile muslin cloth and hand squeezed to remove excess water. Samples were sun-dried and milled to obtain dry "ogi" powder (Figure 1).

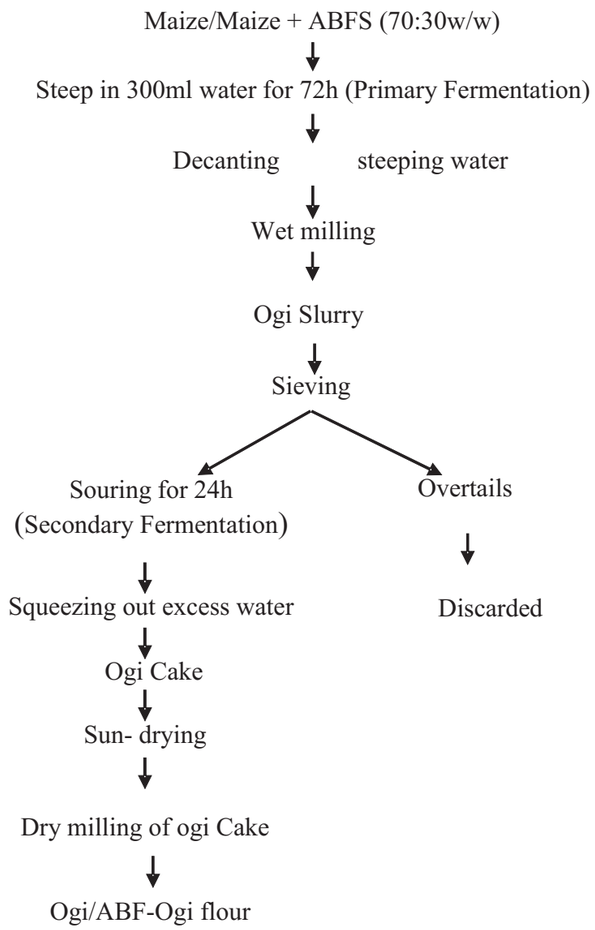

Fig. 1: Flow Diagram for the Production of "Ogi" and ABF (African bread fruit) "Ogi"

Microbial Evaluation of Steep Liquor
Steep liquor (10ml portions) was aseptically collected every 24 h over the 72 h of primary fermentation and the 48 h of secondary fermentation and serially diluted with sterile distilled water (Oyarekua, 2011).

Total Plate Count
Aerobic plate counts were evaluated on plate count agar (PCA, Oxoid CM 325) using the pour plate method. Plates (in duplicate) were incubated at 37°C for 24hours and developed colonies (30-300) were counted (Onasoga *et al.,* 2014).

Lactic Acid Bacteria Count
These were done on de Man Rogosa Sharpe (MRS agar, Oxoid CM 361)) agar. Plates were incubated in a candle jar for 48 h at 30°C. The colonies which appeared after incubation were counted as colony forming unit per ml (cfu/ml).

Coliform Counts
These were done on MacConkey agar and incubated for 24 h at 37°C. Confirmation of coliform was done on eosin methylene blue agar and incubation at 37°C for 24 h. The growth of green metallic sheen colonies confirmed Coliforms.

Staphylococcal Count
Staphylococcal count was done using Mannitol salt agar, followed by incubation at 37°C for 24 h.

Yeast and Mould Count
Enumeration of yeasts and molds were done on Sabouraud Dextrose Agar (SDA) substituted with chloramphenicol. A 0.1 ml of each sample was dropped in sterile agar plates and evenly spread using a glass spreader. The inoculated plates were incubated at room temperature (28 ± 2°C) for 5 days. The isolates were identified using conventional microbiology methods, i.e. morphology.

Identification and Characterization of Isolates
All the isolated organisms were identified using conventional microbiological methods. For bacteria, the standard tests used for characterization of the isolates were microscopic examination, biochemical tests and sugar fermentation. Identification was also based on comparison of characteristics of the isolates with those in Bergey's Manual of Determinative Bacteriology, 8th edition, 1974. Fungi were identified using their morphology.

Physico-chemical analyses of maize ogi and maize-African breadfruit ogi

Determination of pH
The pH of the fermenting samples was determined according to the method of AOAC (1990). Ten gram of sample was mixed in 100 ml of CO_2 - free distilled water. The mixture was allowed to stand for 15 min shaken at 5 min interval and filtered with Whatman No. 14 filter paper. The pH of the filtrate was measured in duplicate using a pH meter (Model HM-305, Tokyo, Japan).

Determination of total titratable acidity (TTA)
Ten millilitre aliquots of the samples were pipetted and titrated against 0.1 M NaOH solution to phenolphthalein end point and the acidity was calculated as g lactic acid /100%(AOAC, 1990).

Determination of viscosity
Viscosity procedure: Simple empirical measurement for consistency of each gruel was determined using Botswick Consistometer. (Laomat CEDEX). Four to 18% (on dry matter basis weight *'ogi'* gruel cake: water) were mixed and stirred constantly on hot plate at 80°C. At the first appearance of first bubble, cooking was timed to 5 minutes after which it was cooled to 45°C.The first compartment was filled with 100ml of each sample (maize ogi and maize-aAfrica breadfruit ogi). At time =0, the trigger was pressed to release the gate of the first compartment to allow gruel flow by gravity to the second compartment. The distance the gruel covered in 30seconds was measured in millimeters as the Bostwick Consistency reading (i.e flow in mm/30seconds). Dry matter of gruel was determined according to AOAC (1990).
Viscosity measurement was determined using Haake VT500 viscometer with coaxial gruel spindle. The computerized viscometer was operated to record the viscosity of gruel for 10minutes shear rate SV-Din spindle at 83.21 sec^{-1} (64.5rpm), gruel temperature =45°C. Readings were taken in Pascal per seconds (Pas^{-1}) after 10 minutes of spindle rotation when they became stable. The dry matter values were compared with consistency and viscosity measurements (Oyarekua, 2011; Onasoga *et al.,* 2014).

Proximate analyses
The carbohydrate, moisture content, lipid and percentage ash compositions of maize ogi and maize-African breadfruit ogi were analyzed using standard methods (Osborne and Voogt, 1978; AOAC, 1990). Crude protein was determined using kjeldahl method, where nitrogen percentage was multiplied by a factor of 6.25 to obtain crude protein (AOAC, 1990).

Sensory evaluation of maize ogi and maize-African breadfruit ogi
Ten-man panels (habitual consumer of "ogi") were used for this study. The products (maize ogi and maize-African breadfruit ogi) were reconstituted into meal and evaluated organoleptically. The porridge sample were assessed for colour, taste, odour, consistency and overall acceptability using a

nine (9) point hedonic scale on basis of their acceptability with 1= disliked extremely 9= like extremely (Modu and Milala, 2004; Onasoga *et al.,* 2014).

Statistical analysis

Data obtained were subjected to mean and standard deviations using Statistical Package for Social Sciences (SPSS) version 16.0. Significant means (p <0.5) were separated using Duncan multiple range test.

RESULTS

pH and titratable acidity (TTA) during steeping

There was a gradual decrease in the pH values of MOGI from 6.3±0.03 to 6.0±0.03 at 0 and 24 h of steeping, at 72 h the pH decreased to 4.9±0.04. The pH of MABO also showed similar pattern of decrease, from 6.2±0.01 to 6.0±0.01 at 0 and 24 h, and 4.7±0.01 at 72 h. Titratable acidity (TTA) increased as pH decreased, for MOGI (0.07±005 to 0.25±0.02) and MABO (0.07±005 to 0.14±0.02). MABO recorded higher viscosity value (1.990±0.16) than MOGI (1.890±0.12) (Table 1).

Table 1: pH,Titratable acidity and Viscosity values of MOGI and MABO

Sample codes	Parameter	Fermentation time (Hour) 0	24	48	72	V (pas^{-1})
MOGI	pH	6.3±0.03	6.0±0.03	5.1±0.01	4.9±0.04	1.890±0.12
TTA	TTA	0.07±0.05	0.14±0.03	0.72±0.04	0.25±0.02	
MABO	pH	6.2±0.01	6.0±0.01	5.0±0.02	4.7±0.01	1.990±0.16
TTA	TTA	0.07±0.05	0.09±0.02	0.18±0.03	0.14±0.02	

Key: Values are mean ± standard deviation of two replicates (n=2). MOGI = Maize Ogi; MABO =Maize-African Breadfruit Ogi; V= Viscosity, pas^{-1}= Pascal per second.

Microbial quality of Maize ogi and Maize-African Breadfruit ogi

Tables 2-5 show the occurrence of microbial isolates (bacteria and fungi) from fermenting samples during primary and secondary fermentations of MOGI and MABO. Lactobacillus species were the major isolates in both samples, occurring throughout the fermentation time (0 to 72 h for primary fermentation, and 0-24 h for secondary fermentation). *Escherichia coli* was isolated at time 0 and 24 h during the primary fermentations of MOGI and MABO, however, it was not isolated after 24 h of primary fermentations (tables 2 and 3). Similarly, *Clostridium bifermentans* was isolated at the initial stage (0 h) of primary fermentation of MABO but was isolated with further fermentation (table 3). Also, *Staphylococcus aureus* was isolated during initial stages (0-24 h) of primary and secondary fermentations (except at the secondary fermentation stage of MABO), but its growth was inhibited as fermentation progressed (tables 2, 3 and 4). Saccharomyces cerevisiae was consistently isolated in both samples during the primary and secondary fermentation stages, however, Aspergillus niger occurred at the initial stages (0 h) in both samples during the primary fermentations but with further fermentation its growth was not observed. Tables 6 and 7 shows the microbial counts (bacterial and fungal, respectively) during the primary and secondary fermentations of MOGI and MABO. MOGI recorded lower bacterial and fungal counts (1.8x109and 1.4x101) compared to MABO (1.9x109 and 1.2x102) during the primary fermentation. Similar trend was observed during the secondary fermentation, with MABO recording higher microbial counts (3.8x106 and 3.4x102) compared with (3.5x106 and 3.0x102) for MOGI.

Table 2: Occurrence of Microorganisms during primary fermentation of Maize "ogi"

Microbial isolates	Fermentation time (hours) 0	24	48	72
Clostridium bifermentans	-	-	-	-
*Corynebacterium*spp.	+	+	+	+
Lactobacillus fermentum	+	+	+	+
Lactobacillus plantarum	+	+	+	+
Escherichia coli	+	+	-	-
Staphylococcus aureus	+	-	-	-
Aspergillusniger	+	-	-	-
Mucormucedo	-	-	-	-
*Penicillium*spp.	-	-	-	-
Rhizopusstolonifer	-	-	-	-
Saccharomyces cerevisiae	+	+	+	+

Key: + = Isolated, - = Not isolated

Table 3: Occurrence of Microorganisms during primary fermentation of Maize-African bread fruit "ogi"

Microbial Isolates	Fermentation Time (hour) 0	24	48	72
Clostridium bifermentans	+	-	-	-
*Corynebacterium*spp.	+	+	-	-
Lactobacillus fermentum	+	+	+	+
Lactobacillus plantarum	+	+	+	+
Escherichia coli	+	+	-	-
Staphylococcus aureus	+	+	-	-
Aspergillusniger	+	-	-	-
Mucormucedo	-	-	-	-
*Penicillium*spp.	+	-	-	-
Rhizopusstolonifer	-	-	-	-
Saccharomyces cerevisiae	+	+	+	+

Key; + = Isolated, - = Not isolated

Table 4: Occurrence of Microorganisms during secondary fermentation of Maize ogi

Fermentation time (hours) Microbial Isolates	0	24	48
Clostridium bifermentans	-	-	-
*Corynebacterium*spp.	-	-	-
Lactobacillus fermentum	+	+	+
Lactobacillus plantarum	+	+	+
Escherichia coli	-	-	-
Staphylococcus aureus	+	-	-
Aspergillusniger	-	-	-
Mucormucedo	-	-	-
*Penicillium*spp.	-	-	-
Rhizopusstolonifer	-	-	-
Saccharomyces cerevisiae	+	+	+

Key: + = Isolated, - = Not isolated

Table 5: Occurrence of Microorganisms during secondary fermentation of Maize-African Bread fruit ogi

Fermentation time (hours) Microbial Isolates	0	24	48
Clostridium bifermentans	-	-	-
*Corynebacterium*spp.	-	-	-
Lactobacillus fermentum	+	+	+
Lactobacillus plantarum	+	+	+
Escherichia coli	-	-	-
Staphylococcus aureus	-	-	-
Aspergillusniger	-	-	-
Mucormucedo	-	-	-
*Penicillium*spp.	-	-	-
Rhizopusstolonifer	-	-	-
Saccharomyces cerevisiae	+	+	+

Key: + = Isolated; - = Not isolated

Table 6: Total Bacterial and Fungal counts (log cfu/ml) during primary fermentation

Bacteria			Fungi	
Time (hours)	MOGI	MABO	MOGI	MABO
0	$3.0x10^9$	$3.4x10^9$	$1.0x10^2$	$1.5x10^2$
24	$4.1x10^9$	$4.3x10^9$	$2.5x10^1$	$2.9x10^1$
48	$2.6x10^9$	$2.8x10^9$	$1.5x10^1$	$1.7x10^1$
72	$1.8x10^9$	$1.9x10^9$	$1.4x10^1$	$1.2x10^2$

Key: MOGI = Maize ogi; MABO = maize-African breadfruit ogi; cfu = Colony forming unit

Table 7: Total Bacterial and Fungal counts (log cfu/ml) during secondary fermentation

Bacteria			Fungi	
Time (hours)	MOGI	MABO	MOGI	MABO
0	$1.2x10^6$	$1.7x10^6$	$0.4x10^2$	$0.6x10^2$
24	$2.6x10^6$	$2.8x10^6$	$2.1x10^2$	$2.5x10^2$
48	$3.5x10^6$	$3.8x10^6$	$3.0x10^2$	$3.4x10^2$

Key: MOGI = Maize ogi; MABO = African breadfruit ogi; cfu=Colony forming unit

Proximate composition

Table 8 shows the proximate composition of MOGI and MABO. MOGI had lower protein (2.14±0.2) compared to MABO (9.83±0.3). In contrast, MOGI recorded higher carbohydrate (82.12±0.1) than MABO (72.59±0.2). The moisture and ash contents (10.22±0.3 and 2.09±0.03) of MOGI were lower than MABO (10.49±0.2 and 2.78±0.01). MABO recorded higher lipid (6.31±0.2) content as against 5.43±0.3, for MOGI.

Table 8: Proximate composition of MOGI and MABO

Samples code	Moisture	Ash	Protein	Lipid	Carbohydrate
MOGI	10.22±0.3	2.09±0.03	2.14±0.2	5.43±0.3	82.12±0.1
MABO	10.49±0.2	2.78±0.01	9.83±0.3	6.31±0.2	72.59±0.2

Key: Values are mean±standard deviation of 2 replicates (n=2), MOGI = Maize Ogi; MABO=Maize-African Breadfruit Ogi.

Sensory evaluation

Maize ogi had higher scores in visual appearance, consistency and overall acceptability (8±0.3, 8±0.01 and 7±0.02) compared with (7±0.1, 7±0.03 and 6±0.02) for MABO, whereas, MABO recorded higher scores in taste and aroma (7±0.02 and 7±0.01) as against (6±0.01 and 6±0.02), for MOGI, respectively (Table 9).

Table 9: Sensory evaluation of MOGI and MABO

Sample	Visual appearance	Taste	Aroma	Consistency	Overall acceptability
MOGI	8±0.03	6±0.01	6±0.02	8±0.01	7±0.02
MABO	7±0.01	7±0.02	7±0.01	7±0.03	6±0.02

Key: Values are mean±standard deviation of 10 scores from 10 member panel. MOGI = Maize Ogi; MABO=Maize-African Breadfruit Ogi.

DISCUSSION

Microorganism (bacteria, yeasts and moulds) may not appear to play any significant role in fermentation processes; however microbial interactions of mixed-bacterial, fungal-yeasts and yeasts-bacterial combinations in indigenous fermentation may play an important role in the nutritional, safety and sensory characteristics of the end product. The development of lactic acid bacteria is also stimulated by the presence of yeasts which provide soluble nitrogen compounds and factors like B- vitamin (Amusa *et al.,* 2005; Oyerekua, 2011). The significant decrease in pH of fermented samples could be due to the degradation of starch in the substrates by microorganisms (bacteria and fungi) with the production of various organic acids, consequently lowering the pH of the substrates. The comparative lower pH of the co-fermented mixture may be attributed to the availability of more nutrients from the African breadfruit seed that can enhance microbial metabolic activities (Oyerekua, 2011). In contrast, titratable acidity showed a gradual increase. The increase in titratable acidity values may be due to the activities of acid producing microorganisms such as *Lactobacillus* spp. (Akinrele, 1970; Banigo and Muller, 1972; Oyerekua, 2011; Onasoga, 2014). As the microbial flora multiply, the lowering of pH and increase in titratable acidity in the general fermentation environment create conditions favorable for some organisms such as lactic acid bacteria and yeasts which can tolerate the acidic environment while inhibiting the growth of others such as the enteric organisms, which is desirable in fermented food products especially in the extension of shelf-life of the product, probiotics and impartation of characteristic aroma to the food product(Oyeyipo, 2011; Onasoga *et al.,* 2014).

Co-fermentation did not significantly affect the viscosity of maize-African breadfruit ogi in this study. The higher value of lipid in co-fermented sample (MABO) compared to their non-supplemented analogue (MOGI) might be responsible for higher viscosity values of co-fermented mixtures because lipids do not absorb water in gruel preparations (Oyeyipo, 2011; Oyerekua, 2011). Viscosity reduction is due mainly to amylolytic activity. This is corroborated by the report of Oyarekua (2011) that co-fermentation did not reduce the viscosity of 60% cereal and 40% legumes.

The supplementation of maize ogi with African bread fruit did not result in a significant difference in microbial types. Perhaps due to the facts that the bacteria, yeasts and moulds in this study are known contaminants in cereals(Oyerekua, 2011) and the dehulling process of the African breadfruit prior to co-fermentation with maize, which might have drastically reduced its microbial burden (Onasoga, 2011; Oyeyipo, 2011). *Lactobacillus* spp., *Corynebacterium* spp., *Saccharomyces cerevisiae* were the predominant organisms isolated from all samples. The isolation of these organisms is in agreement with earlier reports (Amusa *et al.,* 2005; Oyarekua, 2011). The presence of both lactic acid bacteria (*Lactobacillus* spp. and *Corynebacterium*spp.) and yeast (*Saccharomyces cerevisae)* are very significant. The lactics degrade starch in the substrates with the production of various organic acids and lowers the pH. The yeast produces a variety of aldehyde and esters that are responsible for the characteristic desirable taste and aroma of fermented products (Oyarekua, 2011; Oyeyipo, 2012; Onasoga *et al.,* 2014). The inhibition of enteropathogens in both maize ogi and maize-African breadfruit ogi confirms the probiotic effect of lactic acid bacteria in fermented foods (Amusa *et al.,* 2005; Onasoga, 2014).

The subsequent disappearance of moulds/yeasts could probably be due to the low oxygen tension in the fermenting medium. This is because the amount of available oxygen to eukaryotic cells is a critical factor in determining their overall cellular metabolism. As most eukaryotic fungi are generally considered obligate aerobes, oxygen availability during fungi metabolism may play a critical role in their multiplication (Oyeyipo, 2011). *Saccharomyces* and *Candida* species have been reported in spontaneous lactic acid fermentation of cereals (Oyarekua, 2011). Total plate counts were higher in maize-African breadfruit ogi compared to maize ogi counts, perhaps due to the solubilization of protein contained in the African breadfruit seed which might have buffered the acid produced, thus giving less inhibitory effect. Total plate counts showed both homofermentative and heterofermentative bacteria. This is in agreement with the findings of Oyarekua (2011).

Sensory evaluation of maize-ogi and maize-African breadfruit ogi revealed that maize ogi recorded higher in consistency and visual appearance, while maize-African breadfruit ogi recorded higher scores in taste and aroma. Ratings on visual appearance demonstrated that supplementation of ogi with African breadfruit slightly affected the colour. The prepared maize-African breadfruit ogi had better perceptible aroma than prepared maize ogi sample. The prepared maize-African breadfruit ogi was described to have a fruity-acid aroma while prepared maize ogi was described as having an acid aroma. The differences in aroma ratings between prepared maize ogi and prepared maize-African breadfruit ogi may be attributed to the processes applied. The acid aroma may be attributed to the organic acids produced during the fermentation process (Oyeyipo, 2011). Prepared maize-African breadfruit ogi had more perceptible fruity-acid flavour while prepared maize ogi sample had acid flavour. These results logically follow the observations made in the corresponding aroma attribute. Although consumers accepted the supplemented product, maize ogi was more acceptable. This may be attributed to the fact that consumers are more familiar with maize and its products (Adelekan and Oyewole, 2010). Proximate analyses revealed that ash and moisture contents of maize ogi and maize-African breadfruit ogi were comparable. The carbohydrate content of maize ogi was higher than that of maize-African breadfruit ogi sample. This agrees with the observations of Oyarekua (2011) and Modu and Milala (2004); that the addition of legumes decreased the carbohydrate of cereal based traditional foods. In contrast, higher lipid was observed in maize-African breadfruit ogi than maize ogi samples, the high lipid content is attributable to the higher lipid content of African breadfruit seed compared to maize seed (Oyeyipo, 2011; Onasoga, 2014). Similarly, crude protein content was higher in maize-African breadfruit ogi than in maize ogi sample. This is due to the supplementation of maize with African breadfruit seed. The significant increase recorded in protein level of maize-African breadfruit ogi is consistent with earlier reports (Modu and Milala, 2004; Oyarekua, 2009). A good supplemental relationship thus exists between maize and African breadfruit seed in this study. MABO gave a dual advantage in that protein content was increased and enteropathogens were inhibited and is therefore recommended for consumption in areas where protein intake is inadequate and food safety is an issue.

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