



## Microbiological assessment and nutritional quality of *ogi* made from maize, sorghum and their mixture

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### Abstract

#### Keywords:

Fermentation, *ogi*, cereals, microorganisms, weaning food.

This study was designed to evaluate the microbiological assessment and nutritional quality of *ogi* made from maize, sorghum and their mixture. Gruels produced from these grains and their mixture were fermented for 72 hours. The pH, total titratable acidity, temperature of the fermenting samples, proximate analysis and the organoleptic properties were also monitored on daily basis. Microbial counts increased in all the samples in which the mixed sample and sorghum sample had the highest and the lowest microbial counts throughout the fermentation period respectively. The microorganisms isolated were *Lactobacillus acidophilus*, *Streptococcus mutans*, *Enterococcus faecium*, *Escherichia coli*, *Enterobacter agglomerans*, *Corynebacterium amycolatum*, *Staphylococcus aureus*, *Bacillus subtilis*, *Aerobacter aerogenes*, *Citrobacter freundii*, *Klebsiella oxytoca*, *Brevibacterium linens*, *Penicillium citrinum*, *Aspergillus niger*, *Fusarium graminearum*, *Candida krusei*, *Saccharomyces cerevisiae*, *Rhodotorula mucilaginosa* and *Sceudosporium apiospermum*. The pH of the fermenting samples decreased with TTA increase in which sorghum and mixed samples had the highest and the lowest pH of 4.3 and 3.1 when fermented while the least and the highest TTA were obtained from the same samples respectively. Moisture and protein contents increased after fermenting the samples with the highest from the mixture and maize samples. The fat, ash, crude fibre and carbohydrate contents decreased in all the *ogi* samples. The odour and the taste were rated strongly acceptable and sour respectively in all the samples while the colour was variably rated. The improvements observed in the nutritional contents of *ogi* from unmixed maize and sorghum grains suggest their potential in the formulation of complementary weaning foods for infants.

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### INTRODUCTION

Around the world today, cultivation of cereals crop form the major activities of most farmers as main measure in boosting economy and supply essential diet for man use (Odufa and Oyewole, 2000). Cereals are known to constitute major nutritional advantages which supply required calories needed for metabolic activities (Afoakwa et al., 2007).

Microbial fermentation of cereals and cereals products helps in shelf life stability, reduction in volume of material to be transported, inhibition of microbial growth, improvement of organoleptic and sensory properties of some foods reduce time and energy required for preparing food, food safety and enhancement of nutritive value (Oyerakua, 2011). Sorghum is one of the five top cereal crops ranked after maize and it is grown globally around the

world (FAO, 1994). Nutritionally, sorghum contain low amount of protein when compared to maize, its inferior organoleptic quality, problem of protein digestibility and presence of anti-nutritional factors such as tannins and phytates has limit its use and this could be eliminated by adequate processing techniques such as sprouting, malting, decorticating and fermentation (Singh, 1994). Sorghum also forms major ingredient in animal feed formulation.

Maize (*Zea mays*) or corn is the third most important cereal grain in the world, supplying nutrients for human and animals, serving as raw material for food and agro-allied industries throughout the world (FAO, 1992). The white, yellow and red maize are the most common types. The white and yellow varieties are common type found in Nigeria and other countries like Ghana. Maize is rich in vitamins A, C and E, carbohydrates, essential minerals, and protein (9%) (Oladeji et al., 2014). Freshly harvested maize can be boiled or roasted in order to quench hunger mostly during the famine and lack of insufficient food. Maize can be processed and prepared in various forms depending on the country, such flour and porridge (Mbata et al., 2009).

*Ogi* is a semi-solid, smooth texture product traditionally prepared by steeping cereal (maize, sorghum, millet) in cold water and the ferment, followed by wet milling and wet sieving through muslin cloth (Farinde, 2015). In Western part of Nigeria, *ogi* is known as *eko*, *agidi*, *akamu* and *koko*. *Ogi* can be processed into different form such *ogi-baba* from sorghum, *agidi* from thick *ogi*, *eko-elewe*, *eko-kolobo* from semi gelatinized *ogi* (Ajanaku et al., 2012). In some traditional settings, *ogi* is usually taken when warm with *akara* (fried bean cake or bean balls) or with *moinmoin* (steamed bean paste). The colour of *ogi* depends on the colour of cereal type used such as cream for maize, light or reddish brown for sorghum and dirty grey for millet (Akanbi et al., 2010). *Ogi* is often taken by nursing mother because of its easy digestibility and stimulate milk production for infant feeding and also as breakfast for the old people in some ethnic group. The sour taste of *ogi* resemble that of yoghurt which contributes to its acceptability enjoyed by commercial (baby weaning) products like Ceralac when fortified with other ingredients (Bolaji et al., 2011). Local fortification for taste includes the use of sugar, milk, chocolate, *kulikuli* (groundnut cake), fried beans (beans cake or *akara* or *kose*), or fruits and seeds/berry often to dose the sour taste or enhance it (Sanni et al., 2001). Generally, *ogi* produced from sorghum has been implicated for kwashiorkor among infant due to its low protein content and this has led to several attempts to fortify it to improve its nutritional value with plant protein sources such

as melon, okra, cowpea, soy bean, and animal protein sources (Nnam, 2000). Therefore, this study intended to evaluate the microbial contents as well as nutritional quality of *ogi* made from maize and sorghum and mixture.

## METHOD AND MATERIALS

### Collection of samples

The samples (maize and sorghum) were purchased from Ibaka and Okusa markets in Akungba-Akoko, Ondo State, Nigeria in a sterile polyethylene bag and then transported to Microbiology laboratory for further microbiological and chemical analyses.

### Sample preparation

The healthy cereal-grains were separately dried, sorted and sifted to remove the dirt's and grits. Two hundred grams (200 g) each of the samples were weighed, steeped in 1 liter of distilled water in a transparent plastic container and then allowed to ferment for 72 hours. The fermented grains were decanted and grind into slurry. The ground mixture was allowed to settle in a bowl made up of inert material and then allowed for further fermentation prior microbial isolation.

### Isolation of microorganisms

Serial dilution and pour plate methods were used for the isolation of microorganisms from the fermented samples. One milliliter of *ogi* slurry was pipetted into 9 ml sterile distilled water and serially diluted. One milliliter of diluent of each sample was pipetted with the sterile needle and syringe into Petri dishes and cooled molten agars (at 45°C) was poured upon it. The agar was allowed to gel and the plates were then incubated at 37°C for 24 for bacteria and 25°C for 72 hours for fungi respectively. Pure culture was obtained by repeated streaking on fresh media. The isolates were kept in 30% glycerol and stored in refrigerator at 4°C. Characterization and identification of microorganisms were done using standard morphological and biochemical methods. This includes Gram staining, sugar fermentation and hydrolytic reactions (Olutiola et al., 2000).

### Determination of total titratable acidity (TTA)

The total titratable acidity of the fermenting samples was carried out by weighing 2.0 g of macerated sample and then put in a beaker containing 20 ml sterile distilled water and then homogenized. The mixture was filtered, two drops of phenolphthalein (indicator) was added to the 10 ml of the filtrate and then titrated against 0.1M NaOH (sodium hydroxide) and readings recorded.

### Determination of pH

An acid-base pH meter with glass electrodes was used to measure the pH. This was done by inserting the electrode into fermenting medium. The apparatus was standardized with a buffer solutions of pH 4 and 7.

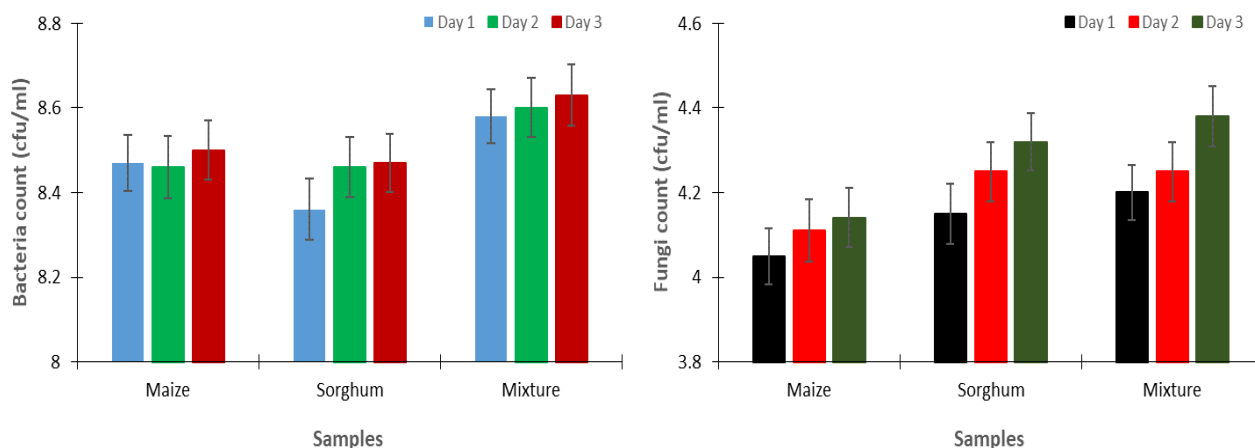
The organoleptic properties of the *ogi* samples were assessed by 10 trained panelists. The panelists assessed the physical state of the samples for colour, taste and odour during the fermentation period using 8-point hedonic scale ranging from 9= extremely like to 1 = extremely dislike. Triplicate assessment was carried out per sample.

### Proximate Analysis

Proximate compositions of the *ogi* samples were carried out according to the procedure of AOAC (2012). The proximate parameters considered were moisture content, ash content, crude protein, fiber, fat and total carbohydrate contents of the samples.

### RESULTS

The bacterial loads obtained from all the *ogi* samples were significantly higher than the fungal counts (Figure 1). *Ogi* from the mixed sample had the highest bacterial counts of 8.46 cfu/ml with the least count of 8.36 cfu/ml from sorghum while fungal counts increased from 4.05 sfu/ml to 4.14 sfu/ml, 4.15 sfu/ml to 4.32 sfu/ml and 4.20 sfu/ml to 4.38 sfu/ml in the gruels from maize, sorghum, and their mixture respectively.



**Figure 1: Total microbial loads of the *ogi* samples during fermentation**

The twelve bacterial and seven fungal genera were identified during the fermentation of the samples. The bacteria were *Lactobacillus acidophilus*, *Streptococcus mutans*, *Enterococcus faecium*, *Escherichia coli*, *Enterobacter agglomerans*, *Corynebacterium amycolatum*, *Staphylococcus aureus*, *Bacillus subtilis*, *Aerobacter aerogenes*, *Citrobacter freundii*, *Klebsiella oxytoca* and *Brevibacterium linens* while the fungi were *Penicillium citrinum*, *Aspergillus niger*, *Fusarium graminearum*, *Candida krusei*, *Saccharomyces cerevisiae*, *Rhodotorula mucilaginosa* and *Scedosporium apiospermum* (Table 1).

*Lactobacillus fermentum*, *Streptococcus mutans*, *Corynebacterium glutamicum*, *Staphylococcus aureus*, *Bacillus subtilis*, *Aspergillus niger* and *Scedosporium apiospermum* were present in all the samples. *Aerobacteria aerogenes*, *Fusarium oxysporum* and *Penicillium chrysogenum* were found only in maize sample. *Citrobacter freundii*, *Klebsiella oxytoca*, *Brevibacterium linens* and *Scedosporium apiospermum* were isolated only from *ogi* produced from sorghum and mixture.

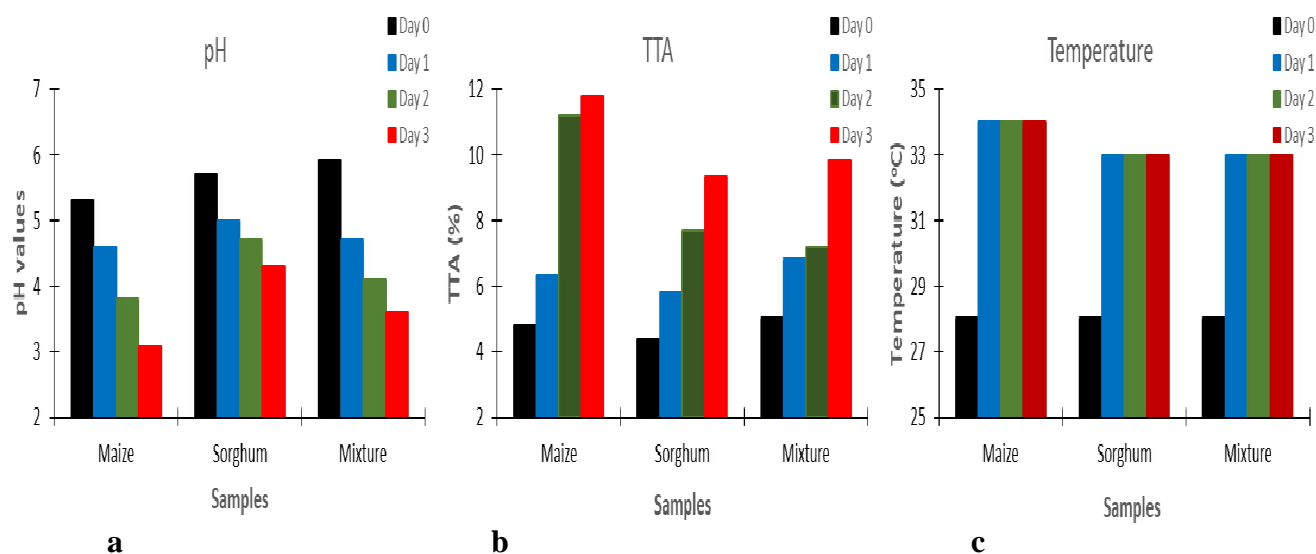
**Table 1: Occurrence of microorganisms from the *ogi* samples**

Isolates	Maize	Sorghum	Mixture
<i>Lactobacillus acidophilus</i>	+	+	+
<i>Streptococcus mutans</i>	+	+	+
<i>Enterococcus faecium</i>	+	-	+
<i>Escherichia coli</i>	+	-	+
<i>Enterobacter agglomerans</i>	+	+	-
<i>Corynebacterium amycolatum</i>	+	+	+
<i>Staphylococcus aureus</i>	+	+	+
<i>Bacillus subtilis</i>	+	+	+
<i>Aerobacter aerogenes</i>	+	-	-
<i>Citrobacter freundii</i>	-	+	+
<i>Klebsiella oxytoca</i>	-	+	+
<i>Brevibacterium linens</i>	-	+	+
<i>Penicilliumcitrinum</i>	+	-	-
<i>Aspergillus niger</i>	+	+	+
<i>Fusarium graminearum</i>	+	-	-
<i>Candida krusei</i>	+	+	-
<i>Saccharomyces cerevisiae</i>	+	+	+
<i>Rhodotorula mucilaginosa</i>	+	-	+
<i>Scendosporum apiospermum</i>	-	+	+

Key: + = present, - = absent

Decreases in pH with increases in total titratable acidity (TTA) were observed during the fermentation of the *ogi* samples (Figure 2). The pH values of the *ogi* samples from maize, sorghum and their mixture decreased from 5.3 to 3.1, 5.7 to 4.3 and 5.9 to 3.6 while their total titratable acidities

increased from 4.8% to 11.8%, 4.4% to 9.3% and 5.0% to 9.8% respectively. The initial temperature of all the *ogi* samples was 28°C. The temperature however increased to 33°C in sorghum sample and mixed samples and also to 34°C in the maize sample.



**Figure 2: pH, TTA and temperature of the fermenting *ogi* samples**

There was significant ( $p < 0.05$ ) increase in the moisture and protein contents of the fermented *ogi* samples when compared with unfermented sample (Figure 3). The mixed fermented sample had the highest moisture content while maize sample had the highest protein content. The fat and ash contents of the samples were not significantly different before fermentation but decreased after fermentation. The crude fibre and carbohydrate

contents of the fermented sample showed significant decrease when compared to the unfermented sample, except for maize samples with high fibre content after fermentation. High moisture contents higher than 50% were obtained from fermented maize, sorghum and mixture, which were significantly higher than the unfermented samples.

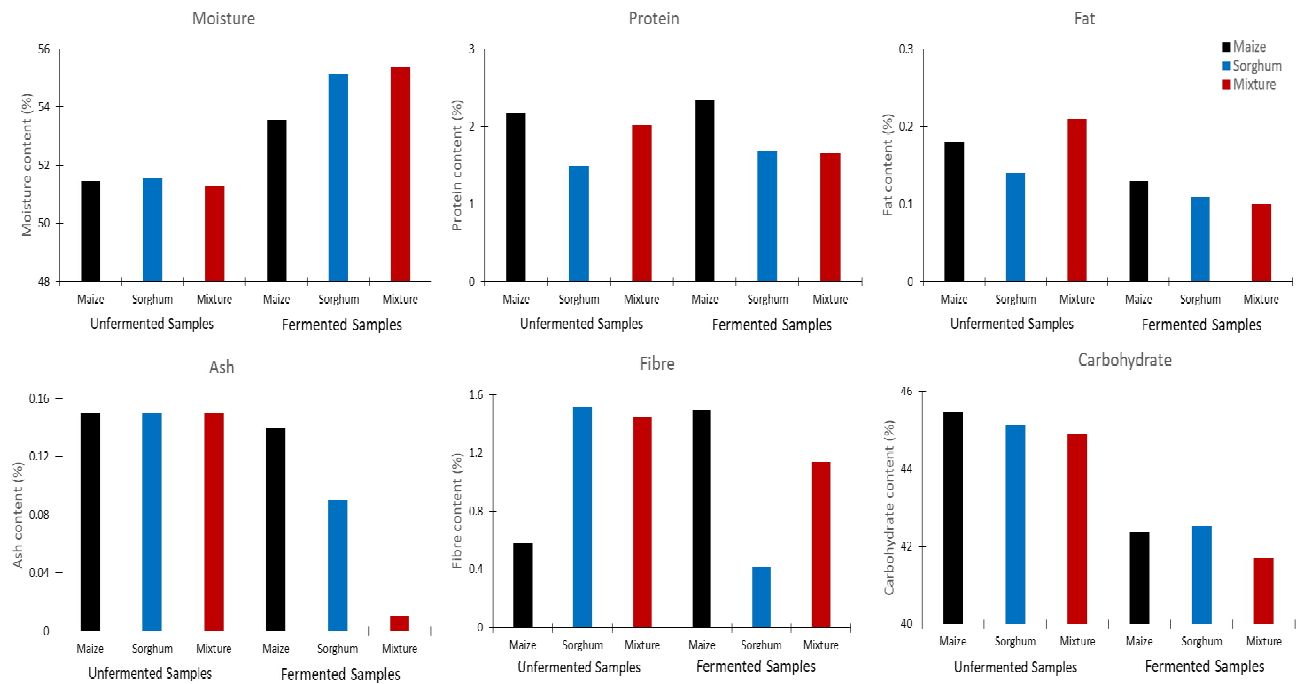


Figure 3: Percentage proximate composition of the samples

Slight changes in the organoleptic parameters were observed in the fermented sample (Table 4). At day 0 and 1, the odour was very and moderately pronounced, slightly pronounced at day 2 and at

day 3 it was very slightly pronounced. Colour changes were observed in the fermented samples. All the fermented samples had sour taste.

Table 4: Sensory parameters of *ogi* sample

FT (days)	Colour			Odour			Taste		
	MZ	SG	MX	MZ	SG	MX	MZ	SG	MX
0	A	A	A	Milky	FW	FW	Sour	Sour	Sour
1	B	B	B	Creamy	FW	FW	Sour	Sour	Sour
2	C	C	C	Creamy	LDRB	FW	Sour	Sour	Sour
3	D	D	D	FY	DRB	FW	Sour	Sour	Sour

**Key:** A= Strongly acceptable, B= Acceptable, C= Slightly pronounced, D= Not acceptable, FW= Faded wine, FY = Faded yellow, DRB = Dark reddish brown, LRB = Light reddish brown, FT- Fermentation period, MZ = Maize, SG = Sorghum, MX = Mixture

## DISCUSSION

The present study accounted for the array of microorganisms isolated from the fermented cereal and grains. There was a progressive trend in the microbial loads of the three *ogi* samples with fermentation time. This might be due to its textural flexibility of the sample suitable for ease microbial metabolic activities, the surrounding environment, sources of the sample and unhygienic practices by the processors/handlers (Berghoferz *et al.*, 2003).

The differences observed in the microbial loads could be attributed to the nature and nutritional contents of the substrate, uncontrolled and spontaneous nature of the fermentation, cross contamination from other food items from the residue build up in milling machine (Adebayo-Tayo and Needum, 2011). Increase in microbial loads of fermented sorghum-beniseed blends has been reported (Adegbehingbe, 2014). Similar findings have been reported by Teniola and Odunfa (2002) while fermenting maize for *ogi* production. At low pH, lactic acid bacteria might cause the fermentation process to take place with inhibitory effect on the other pathogenic microorganisms present in the fermentation medium. Predominant of lactic acid bacteria in fermented cereals has been reported (Opere *et al.*, 2012). Isolation of *Bacillus* specie from fruit juices had been reported (Addo *et al.*, 2008).

The presence *Escherichia coli*, *Citrobacter freundii*, *Klebsiella oxytoca* might be an indication of fecal contamination during the soaking, processing, milling and handling (Adebolu *et al.*, 2007). The natural occurrence of fungi isolate in the sample play an important role in food safety such as mycotoxins producers with varied implications on health and the economy most especially in developing countries including Nigeria. Isolation of *Aspergillus* and *Penicillium* specie from dry maize and sorghum have been reported (Teniola and Odunfa, 2002; Adebolu *et al.*, 2008).

An increase in total titratable acidity might be due to the presence of fermenting lactic acid bacteria capable of producing organic acid such as lactic acid, ascorbic acid, butyric acid etc in the fermentation medium. Afoakwa *et al.* (2007) reported total titratable acidity increase of fermented maize-cowpea blends for the production of weaning food.

pH is one of the major factors affecting the growth and survival of microorganisms in a fermentation medium. Microorganisms can be grouped based on their pH requirements i.e. minimum, optimum and maximum. The decrease observed in pH value of all the *ogi* samples could be attributed to the

activities of lactic acid bacteria secreting organic acid (lactic acid) into the fermentation medium, which might be unfavourable to the growth of other microorganisms (Muyanja *et al.*, 2003; Opere *et al.*, 2010; Adebayo-Tayo and Needun, 2011). Decrease in pH value of fermented *ogi* from malted milled from 5.75 to 3.26 has been reported by Inyang and Idoko, (2006). Similar finding was reported by Oladeji *et al.* (2014) while fermenting yellow maize *ogi* and carrot blend.

Water availability in substrates enhances rapid growth of microorganisms. The increase in the moisture content after fermentation might be due to water addition through microbial activities in breaking down carbohydrate to produce water, carbon dioxide and energy production in form of Adenosine triphosphate (ATP) (Osman, 2011; Adegbehingbe, 2013). The result obtained was contrary to the findings of Wakil and Daodu (2011) who reported a decrease in moisture content of fermented cereal legume using starter culture to produce weaning foods. The reason for this reduction could be due to the use of water by the fermenting organisms for other metabolic processes.

Structural protein forms an integral part of the microbial cell (Silhavy *et al.*, 2010). An increase in protein content might be due to the increase in cell biomass, availability of nutrients supporting the growth of fermenting microorganisms in forms of single cell protein and ability of microorganisms to secrete protease (Adegbehingbe, 2013). Adebayo-Tayo and Needum (2011) reported increase in protein content of fermented cereal blends.

The decreases observed in the ash contents of all the samples might be due to leaching of soluble inorganic salts into the processing water during fermentation period (Ogbonaya *et al.*, 2010). The result obtained from this study however different from the findings of Apena *et al.* (2015) who reported ash content 1.5% and 2.2% for fermented and unfermented maize and 1.20% and 1.24% for fermented and unfermented sorghum during fermentation.

The reduction in the fat contents of the three *ogi* samples might be due to the lipolytic enzyme activity which breaks down the triglyceride to simple fatty acids, sterol esters and polar lipids or loss during soaking and fermentation (Osman, 2007). Adebayo-Tayo and Needum (2011) and Ayo *et al.* (2012) reported increase in fat contents of *ori-ese* and masa-beniseed blends respectively which they attributed to synthesis of fat by the fermenting microorganisms. The reduction in the fat contents of all the *ogi* samples after fermentation could enhance their usefulness as weaning feeds because feed with high fat could be difficult to mix, which

might also require antioxidants for preventing the feed from oxidative rancidity (Emiola *et al.*, 2007) The reduction in carbohydrate content might be attributed to apparent increase in protein contents of the samples, enzymatic action of microorganisms in breaking down the starch or carbohydrate to digestible sugar and selective utilization of some of the sugars as energy source by fermenting microorganisms (Osman, 2011; Adegbhingbe, 2013). The result obtained agreed with the findings of Adebayo-Tayo and Needum (2011) who reported a decrease in carbohydrate content of *ori-ese* blend from 72.02% to 43.39%.

There was no significant different ( $p < 0.05$ ) in the organoleptic parameters of the sample. The consistency of the sample depends on the storage environment and type of maize and sorghum used. The variation observed in the organoleptic qualities of *ogi* depends on the production area and the fermentation time (Oyererekua and Eleyinmi, 2004). Ikya *et al.* (2013) reported a the highest grades in colour, consistency, flavor and overall acceptability of *agidi* produced from whole maize grains than the ones supplemented with the various quantities soy bean seeds (maize/soy blends).

## CONCLUSION

The predominance of *Lactobacillus* spp producing organic acid in all the *ogi* samples was responsible for the improvement in the organoleptic properties (sour taste). The improvements in their protein contents emphasized their usefulness as weaning food for infants. Proper hygiene procedure is very important while producing these gruels.

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