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PHYSICOCHEMICAL, MICROBIOLOGICALLY NUTRITIONAL AND SENSORY EVALUATION OF OGI (A TRADITONAL CEREAL BASED BEVERAGE IN NIGERIA) PRODUCED FROM TWO VARIETIES OF SORGHUM

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ABSTRACT

Ogi is a traditional fermented cereal based beverage popularly consumed as weaning food. Therefore, there is need to investigate the physicochemical parameters, microorganisms involved, proximate and sensory analyses associated with its production. Two varieties of sorghum (Brown and White respectively) were collected inside sterile containers from Bodija market in Ibadan, Oyo State, Nigeria. Temperature, pH, titratable acidity, microorganisms involved in fermentation, moisture, ash, protein, fat, crude fibre and carbohydrate contents as well as sensory properties were determined using standard methods. The results showed that pH values decreased with simultaneous increase in titratable acidity during fermentation. Temperature, pH and titratable acidity ranged from: 28^{0}C to 30^{0}C, 4.02 to 6.25 and 0.05 to 1.53 respectively. Fermentation increased moisture, protein, fat and carbohydrate contents significantly at $p \leq 0.05$ while ash and crude fibre decreased significantly at $p \leq 0.05$. Sensory analyses were found within the acceptable ranges according to standard procedures. Lactic acid bacteria was found to be the predominant microorganism involved in the fermentation process which confirms the keeping quality of ogi produced from the two sorghum varieties. The two sorghum varieties (Brown and White) showed to serve as a good weaning food for infants but brown sorghum ogi seems to be more nutritious. Furthermore, the sorghum varieties can be malted during process to reduce bulkiness.

Contribution/Originality: This study contributes to the existing literature regarding the benefits of sorghum ogi as a weaning food for infants' formulation. However, this study revealed that of out of the two sorghum varieties used for the production of ogi, brown sorghum is more nutritious and widely acceptable than white sorghum ogi.

1. INTRODUCTION

Cereals constitute one of the world's major source of food and have significant impact on human diet (Adebayo & Aderiye, 2010). Sorghum is reported to be ranked as the 5th most important grain crop after wheat, rice, maize and barley (Food and Agricultural Organization (FAO), 2001; Smith & Frederiksen, 2000). It belongs to the family *Poaceae* and is consumed as a staple food crop by millions of people in the tropical continents. Food and Agricultural Organization (FAO) (1999) reported that it can be grounded into flour to make bread and pancakes, used for the production of animal feed, alcohol, industrial product, boiled foods, ogi and is an active ingredient in malt and beer

production. In addition, sorghum stalk and straw are used in the formulation of animal feeds and house building such as wall board and biodegradable packaging, feed stalk in biofuel production and contains approximately 16-18% fermentable sugars which can be directly fermented into ethanol by yeast (Almodares & Hadi, 2009)(Wylie, 2008). For example, In Australia, sorghum grain is used as the main source of feed stalk for bioethanol production (Biofuels Association pf Australia (BAA), 2012).

In addition, absence of gluten in sorghum makes it suitable to substitute wheat, rye and barley for those that cannot tolerate gluten (Farmcrowdy, 2017).

Nutritionally, it contains many nutrients such as: manganese (134%), carbohydrate (106.47%), iron (80.63%), phosphorus (79.295), leucine (77.46%), magnesium (75.48%), vitamin B6 (65.64%), copper (60.56%), tryptophan (54.09%), vitamin B1 (53.08%), valine (50.99%), isoleucine (49.095%), vitamin B3 (44.26%), selenium (42.55%), protein (40.78%) and dietary fiber by 48% of the recommended daily value (Beta, Rooney, & Waniska, 1995; Food and Agricultural Organization (FAO), 1995). The harvesting time is after 4-5 months period of cultivation. It requires an optimum growth temperature that ranges between 27-30°C (Food and Agricultural Organization of the United Nations (FAO/UN), 2015) rainfall that varies between 450-800mm, pH between 5.0-8.5, and it grows on different types of soil such as light loam, heavy clay, light sandy and acidic soils with moderate salinity (Cothren, Matocha, & Clark, 2000; Kimber, 2000).

It is reported that it contains resistant starch which impairs digestibility, notably for infants which can be improved by pre-fermentation and contains non-carbohydrate cell wall polymers such as lignin, having a proportion up to 20% of the total cell wall materials (Food and Agricultural Organization (FAO), 1995; Taylor, 2002).

Ogi is an acidic traditionally fermented cereal gruel made from maize (*Zea mays*), sorghum (*Sorghum vulgare*) and millet (*Pennisetum americanum*) (Ohenhen & Ikenebomeh, 2007). It consumed as a breakfast meal by different ages in Africa because of its attractive characteristic taste, texture and colour (Nout & Motarjemi, 1997). The art of production of ogi involve spontaneous fermentation of sorghum for 1-3 days, involving the presence of naturally occurring microbes such as the genera lactic acid bacteria and yeast which are responsible for its outstanding organoleptic properties (Chelule, Mbongwa, Carries, & Gqaleni, 2010; Omemu, Oyewole, & Bankole, 2007). It is one of the popularly known traditional health sustaining fermented food in Nigeria and serves as a weaning food for infants (Afolyan, Ayeni, & Ruppitsch, 2017). It is marketed in Nigeria as a wet cake wrapped in leaves or transparent polythene bags and prepared by making into paste and boiled into pap or cooked and turned into a stiff gel called "agidi" or "eko" prior to consumption. It can be consumed with hot beans balls (akara) or cooked beans as a breakfast meal (Adegunwa, Alamu, Bakare, & Godwin, 2011). it can be easily produced at home because the grains are easily accessible, readily available and cheaper if compared to industrially produced infants meals (Wakil & Daodu, 2011).

This study is designed to investigate the microorganisms associated with the traditional production of ogi from two varieties of sorghum and to evaluate its proximate sensory composition.

2. MATERIALS AND METHODS

2.1. Sample Collection

The two varieties of sorghum used for this study were collected inside from Bodija market in Ibadan, Oyo state, Nigeria and were immediately transported inside a sterile polythene to the food laboratory of University of Ibadan.

2.2. Preparation and Processing of Sorghum Ogi

Five hundred gram (500g) each of two (2) varieties of sorghum grains were steeped separately in separate 2 litre conical flasks containing 1 liter of water for 72 hrs. They were wet milled, sieved and allowed to ferment for 48 hrs at 30°C. The slurry was dissolved in small quantity of water and hot water was added to make ogi porridge.

2.3. Isolation of Microorganisms Involved in the Fermentation of Sorghum Ogi

Nutrient agar, De Man Rogosa and Sharpe agar and potato dextrose agar were used for the isolation of bacteria, lactic acid bacteria and fungi respectively. One ml of water was taken from the fermenting sorghum grains and serially diluted to obtain a dilution 10^{-7}. Using a sterile pipette, 0.1ml was taken from the 10^{-7} dilution and aseptically transferred differently into the sterile Petri dishes. Twenty (20) ml of MRS agar, nutrient agar and PDA was poured differently into these Petri dishes. MRS agar plates were incubated anaerobically at 37^0C for 48 hr, nutrient agar plates were incubated at 37^0C for 48 hr while PDA plates were incubated at 30^0C for 7 days. The plates were examined for microbial growth and the number of colonies counted. Pure isolates were obtained by streaking and stored on slants in McCartney bottles and kept inside the refrigerator at 4^0C.

2.4. Physicochemical Studies

2.4.1. ph Measurement:

The pH of the fermenting water was determined using a pH meter (model 213 Sigma-Aldrich) at 12 hr interval.

2.5. Temperature Measurement:

The temperature of the fermenting water was assessed using a thermometer (Bimetallic Model A52).

2.6. Determination of Titratable Acidity:

The titratable acidity of the fermenting water was determined by weighing 2g of sorghum grain and milled in 10 ml of distilled water using a blender. The solution was filtered using No 1 Whatman filter paper and the filtrate was titrated with 0.1 ml NaOH using 3 drops of phenopthalien as indicator.

2.7. Identification of Bacterial Isolates

The isolated bacteria were identified based on morphological and biochemical characterization with reference to Bergey's manual of systematic bacteriology.

2.8. Identification of Fungal Isolates

The fungal isolates obtained during the fermentation of brown and white sorghum ogi were identified using microscopic and macroscopic characterization with reference to compendium of fungal or Alexopoulos.

2.9. Proximate Analysis

The fermented brown and white sorghum ogi samples were analyzed for moisture content, protein, ash, crude fibre, carbohydrate and fat according to the method described by AOAC (2012).

2.10. Sensory Analysis

Ogi was prepared by adding hot water to the ogi slurry and allowed to cool to about 45^0C. The prepared ogi was dished into plates labeled randomly. Sensory evaluation was carried out by a panel of 10 people from the University of Ibadan who are familiar with the food product. The parameters tested for were: texture, aroma, flavor, color, taste and overall acceptability using the Hedonic scale ranging from 9= like extremely to 1= dislike extremely.

3. RESULTS

Figure 1 shows the result of total bacterial count during primary fermentation of brown and white sorghum ogi. It was observed that the microbial load increased from 1.1×10^3 at 0 hr to 2.14×10^{12} at 72 hr and 4.0×10^2 at 0hr to 2.01×10^{12} at 72 hr for the brown and white sorghum ogi respectively.

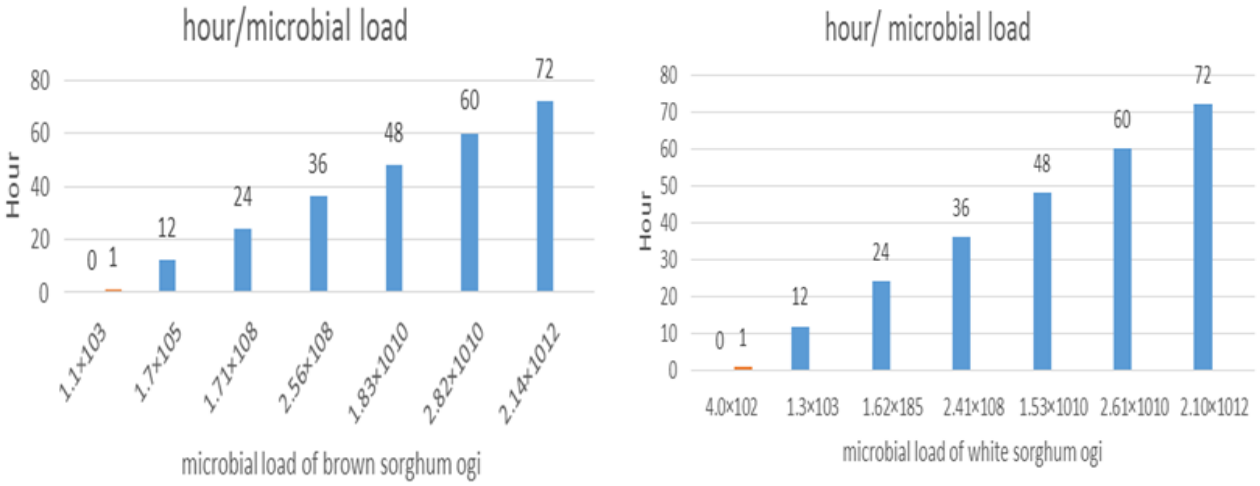

Figure-1. Total bacterial count during primary fermentation of brown and white sorghum ogi.

The bacterial load of brown and white sorghum ogi during primary fermentation (1^0) ranged from 1.1×10^3 and 4.0×10^2 at 0 hr to 2.14×10^{12} and 2.10×10^{12} at 72 hr respectively.

The result of the total bacterial counts during secondary fermentation of brown and white sorghum ogi is shown in Figure 2. It was observed that the microbial load increased from 1.68×10^4 at 0 hr to 9.8×10^9 at 48 hr and 1.23×10^6 at 0 hr to 2.22×10^8 at 48hr for the brown and white sorghum ogi respectively.

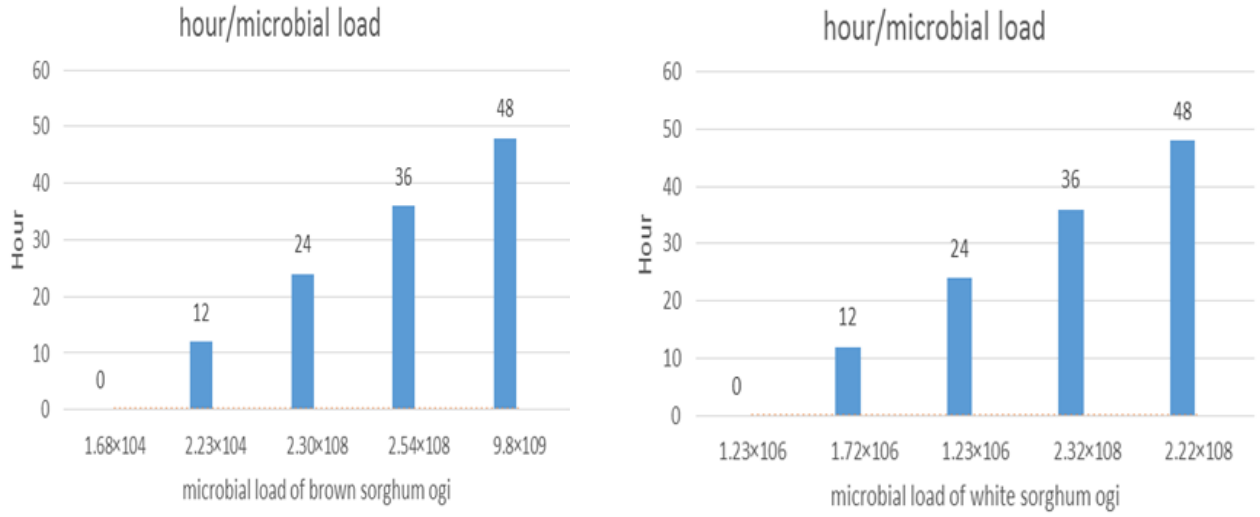

Figure-2. Total bacterial counts during secondary fermentation of brown and white sorghum ogi.

The bacterial load of brown and white sorghum ogi during secondary fermentation (2^0) ranged from 1.68×10^4 and $1.23.0\times10^6$ at 0 hr to 9.8×10^9 and 2.22×10^8 at 72 hr respectively.

Figure 3 shows the result of total fungal counts during primary fermentation of brown and white sorghum ogi . It was observed that the microbial load increased from 4.0×10^2 at 0 hr to 6.2×10^3 at 72 hr and 6.0×10^2 at 0 hr to 7.9×10^3 at 72 hr for the brown and white sorghum ogi respectively.

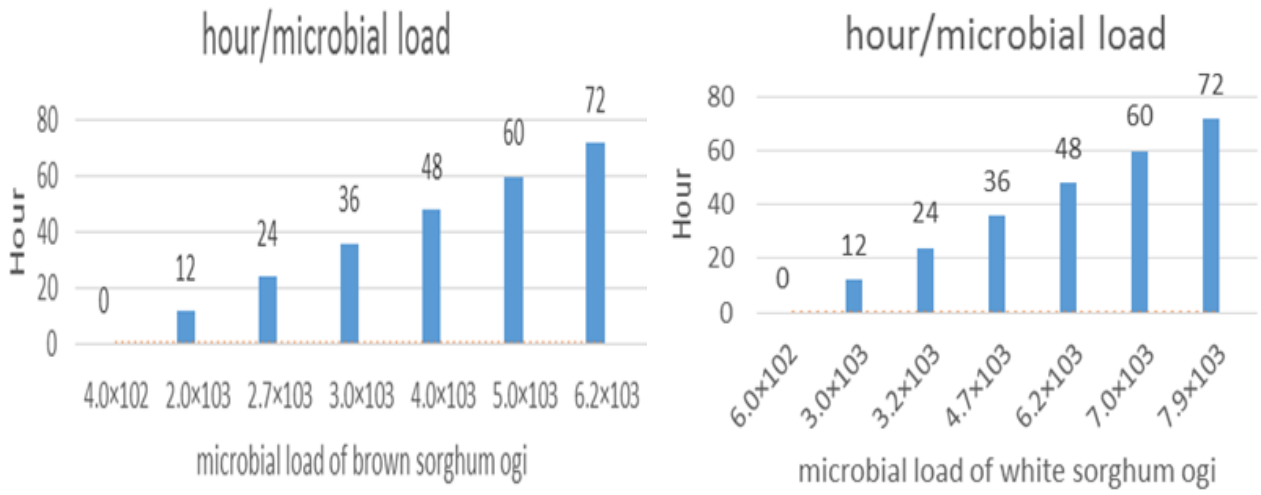

Figure-3. Total fungal count during primary fermentation of brown and white sorghum ogi.

The fungal load of brown and white sorghum ogi during primary fermentation (1^0) ranged from 4.0×10^2 and 6.0×10^2 at 0 hr to 6.2×10^3 and 7.9×10^3 at 72 hr respectively.

The result of the total fungal counts during secondary fermentation of brown and white sorghum ogi is shown in Figure 4. It was observed that the microbial load increased from 4.0×10^3 at 0 hr to 3.06×10^9 at 48 hr and 3.0×10^3 at 0 hr to 7.0×10^9 at 48hr for the brown and white sorghum ogi respectively.

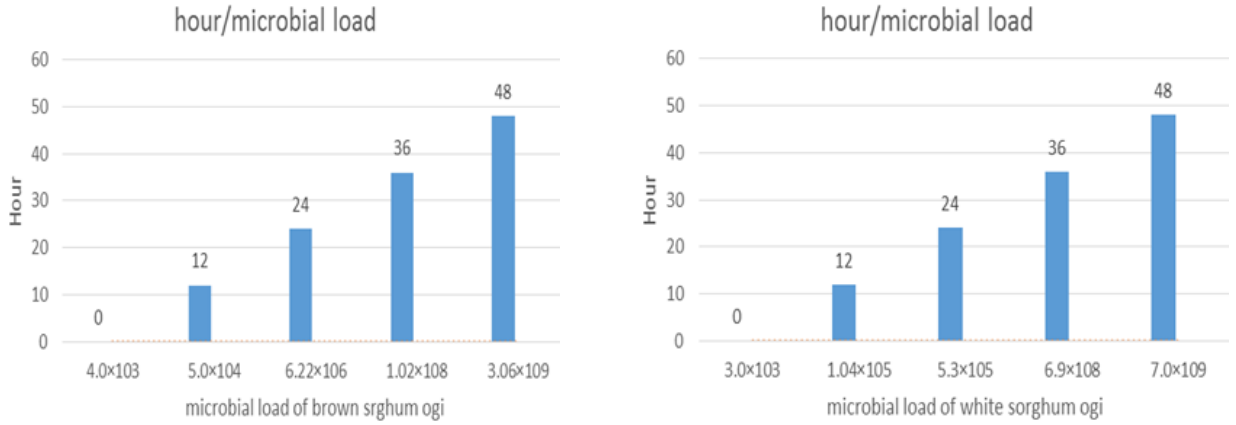

Figure-4. Total fungal counts during secondary fermentation of brown and white sorghum ogi.

The fungal load of brown and white sorghum ogi during secondary fermentation (2^0) ranged from 4.0×10^3 and 3.0×10^3 at 0 hr to 3.0×10^9 and 7.0×10^9 at 72 hr respectively.

The result of temperature, pH and titratable acidity changes during primary fermentation of brown sorghum ogi is shown in Table 1. It was observed that the temperature decreased slightly from 30^0C at 0 hr to 29^0C at 72 hr while pH also decreased from 6.06 at 0 hr to 4.63 at 72 hr. However, titratable acidity increased from 0.14 at 0 hr to 0.9 at 72 hr.

Table-1. Temperature, pH and TTA changes during the primary fermentation of brown sorghum (BS) ogi.

Sample	Hour	Temperature	pH	Titratable Acidity
BS	0	30^0C	6.06	0.14
BS	12	28^0C	5.66	0.54
BS	24	30^0C	5.43	0.63
BS	36	30^0C	5.25	0.72
BS	48	28^0C	5.18	0.81
BS	60	30^0C	4.95	0.86
BS	72	29^0C	4.63	0.90

Key: BS= brown sorghum ogi

Table 2 shows the result of the temperature, pH and titratable acidity changes during primary fermentation of white sorghum ogi. It was observed that the temperature decreased slightly from 30^{0}C at 0 hr to 29^{0}C at 72 hr while pH decreased from 6.25 at 0 hr to 4.02 at 72 hr. However, titratable acidity increased from 0.05 at 0 hr to 1.53 at 72 hr.

Table-2. Temperature, pH and TTA of white sorghum (WS) ogi during primary fermentation.

Sample	Hour	Temperature	pH	Titratable Acidity
WS	0	30^{0}C	6.25	0.05
WS	12	28^{0}C	5.05	0.54
WS	24	29^{0}C	4.51	0.63
WS	36	30^{0}C	4.26	1.08
WS	48	29^{0}C	4.23	1.08
WS	60	29^{0}C	4.06	1.26
WS	72	29^{0}C	4.02	1.53

Key: WS= white sorghum ogi

The result of temperature, pH and titratable acidity changes of brown sorghum ogi during secondary fermentation is shown in Table 3. It was observed that the temperature increased from 28^{0}C at 0 hr to 30^{0}C at 48 hr while pH decreased from 6.18 at 0 hr to 4.36 at 48 hr. However, titratable acidity increased from 0.18 at 0 hr to 1.13 at 48 hr.

Table-3.Temperature, pH and TTA changes of brown sorghum(BS) ogi during secondary fermentation.

Sample	Hour	Temperature	pH	Titratable Acidity
BS	0	28^{0}C	6.18	0.18
BS	12	29^{0}C	4.78	0.72
BS	24	30^{0}C	4.63	0.90
BS	36	30^{0}C	4.43	1.08
BS	48	30^{0}C	4.36	1.13

Key: BS= brown sorghum ogi

Table 4 shows the result of the temperature, pH and titratable acidity of white sorghum ogi during secondary fermentation. It was observed that the temperature increased slightly from 28^{0}C at 0 hr to 29^{0}C at 48 hr while pH decreased from 4.85 at 0 hr to 4.38 at 48 hr. However, titratable acidity increased from 0.72 at 0 hr to 1.26 at 48 hr.

Table-4. Temperature, Ph And TTA Changes Of White Sorghum(WS) Ogi During Secondary Fermentation.

Sample	Hour	Temperature	pH	Titratable Acidity
BS	0	28^{0}C	4.85	0.72
BS	12	28^{0}C	4.79	1.08
BS	24	29^{0}C	4.53	1.08
BS	36	29^{0}C	4.44	1.13
BS	48	29^{0}C	4.38	1.26

Key: WS= white sorghum ogi

The result of morphological and sugar fermentation pattern of bacterial isolates during the primary and secondary fermentation of brown and white sorghum ogi is shown in Table 5.

Table-5. Morphological and sugar fermentation pattern of bacterial isolates during the primary and secondary fermentation of brown and white sorghum ogi.

S/no	Isolate Code	Cellular morphology	Gram's Reaction	Catalase	Oxidase	Motility test	Growth at 4°C	Growth at 45°C	Growth at 4% NaCl	Methyl red	Voges proskauer	Glucose	Xylose	Sucose	Fructose	Mannitol	Lactose	Probable organism
1	Sa	rods	-	+	-	+	+	+	+	+	-	+	+	+		+	+	*Escherichia coli*
2	Sb	cocci	+	+	-	-	+	+	+	+	+	+	+	+	+	+		*Staphylococcus aureus*
3	Sc	rods	-	-	-	-	-	+	+	-	+		+	+	-	-	+	*Klebsiella pneumoniae*
4	Sd	rods	-	+	-	+	-	+	+	+	-	+	-	+		-	+	*Proteus mirabilis*
5	Se	cocci	+	-	-	-	-	+	-	+	-	+	-	-	+	-	+	*Lactobacillus fermentum*
6	Sf	cocci	+	-	-	-	+	-	+	+	-	+	+	+	+	+	+	*Lactobacillus plantarum*

Key: += positive -= negative

Figure 5 shows the percentage of microorganisms isolated from brown and white sorghum ogi during primary and secondary fermentation. It was observed that *Lactobacillus fermentum* had the highest level of occurrence (15.71%) while *Saccharomyces pombe* had the least level of occurrence (4.26%).

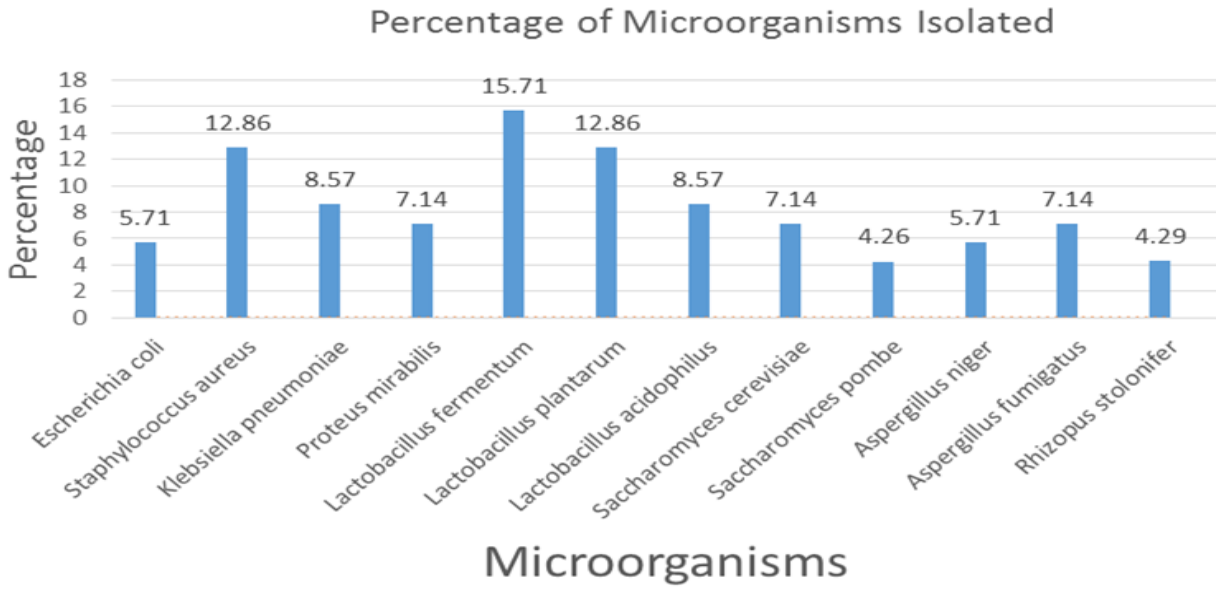

Figure-5. Percentage (%) of microorganisms isolated from brown and white sorghum ogi during primary and secondary fermentation.

The proximate analysis of fermented brown and white sorghum ogi is presented in Table 6. It was observed that brown sorghum ogi has higher amounts of moisture content (9.360±0.020), fat (3.766±0.015), crude fiber (12.110±0.015) and carbohydrate (67.521±0.020) than white sorghum ogi. However, white sorghum ogi has higher amounts of ash (1.510±0.010) and protein (13.010±0.020) than brown sorghum ogi.

Table-6. Proximate analysis of brown and white sorghum ogi.

Sample	Moisture content	Ash	Protein	Fat	Crude fibre	CHO
BS (fermented)	9.360±0.020^{b}	1.510±0.010^{b}	12.230±0.020^{b}	3.766±0.015^{a}	2.110±0.015^{b}	72.521±0.020^{b}
Control (unfermented)	5.110±0.000^{a}	2.540±0.000^{a}	6.000±0.020^{a}	1.081±0.015^{b}	3.201±0.015^{a}	57.281±0.020^{a}
WS (fermented)	8.120±0.020^{a}	1.560±0.010^{a}	13.010±0.020^{a}	2.681±0.015^{b}	1.231±0.015^{a}	69.131±0.020^{a}
Control (unfermented)	5.310±0.020^{b}	2.130±0.010^{b}	7.110±0.020^{b}	1.161±0.015^{a}	2.321±0.015^{b}	55.100±0.020^{b}

Note: Values in the same row with different subscripts and/or superscripts are significantly different at $p<0.05$
Key:
BS= brown sorghum.
WS= white sorghum.

Table 7 shows the sensory analysis result of brown and white sorghum ogi. It was observed that brown sorghum ogi had a higher preference in flavor, color, taste, aroma texture and overall acceptability than white sorghum ogi.

Table-7. Sensory analysis of brown ans white sorghum ogi.

Sample	Flavor	Color	Taste	Aroma	Texture	Overall acceptability
BS	9.10±1.00^{b}	9.48±0.24^{b}	7.56±0.81^{a}	8.61±1.89^{a}	8.04±1.24^{b}	7.69±0.10^{a}
WS	7.32±1.01^{a}	7.46±0.16^{b}	7.23±0.10^{a}	7.01±0.26^{b}	7.12±0.21^{a}	7.10±0.01^{a}

Note: Values in the same row with different subscripts and/or superscripts are significantly different at $p<0.05$.

4. DISCUSSION

This study was designed to investigate the physico-chemical parameters (such as temperature, pH and titratable acidity), microorganisms involved, proximate and sensory analyses of fermented brown and white sorghum for the production of ogi. The temperature of the brown and white sorghum during primary and secondary fermentation ranged between 28^{0}C to 30^{0}C while the pH decreased and titratable acidity increased. Earlier reports have documented that the pH of fermenting cereal grains usually decreases to a point that is sufficient to inhibit the growth of pathogenic microorganisms (Ekwem & Okolo, 2017; Omemu et al., 2007). Omemu et al. (2007) had earlier reported that inhibition level by low pH depends entirely on the fermenting microorganisms, buffering capacity of the food and acids produced which acts by penetrating the bacterial cell wall to slow down metabolic activities. In addition Ayo (2004) and Ojokoh, Daramola, and Oluoti (2013) had earlier observed this trend in millet-acha based kunun zaki and bread fruit cowpea. Organisms such as lactic acid bacteria associated with fermentation have been reported to have the ability to degrade carbohydrates, leading to the acidification of the fermenting medium (Ojokoh et al., 2013) which confers microbial stability on the food, thereby, reducing the incidence of diarrhea in consumers. The sources of microorganisms isolated during the primary and secondary fermentation of brown and white sorghum ogi could be through the cereals itself, indigenous microflora of grains prior to fermentation, utensils used and the producers (Osuntogun & Aboaba, 2004). However, their individual role is not quite understood but some researchers have identified lactic acid bacteria to be involved in acidification, flavour enhancement and production of antimicrobial substances (Adams & Nicolaides, 1997; Hernández-Ledesma, Amigo, Ramos, & Recio, 2004; Steinkraus, 2006).

The observed lower counts of fungi and yeast could be due to the production of inhibitory substances produced by lactic acid bacteria such as organic acids, lactic acid, propionic acid, bacteriocins and hydrogen peroxide which inhibited their growth (Odumodu & Inyang, 2006)(Oliveira *et al.*, 2014). The total elimination of enterobacteriaceae occurred during the secondary fermentation which could also be due to the inhibitory compounds produced by lactic acid bacteria. This trend had earlier been reported by Adeyemi and Umar (1994) during the fermentation of kunun-zaki made from sorghum and millet. However, the increase in lactic acid bacteria as seen this this work is in

agreement with the findings of Jespersen, Halm, Kpodo, and Jakobsen (1994); Omemu et al. (2007); Akinleye et al. (2014). The differences in the population of lactic acid bacteria, yeasts, fungi and enterobacteriaceae could be due to the acidic nature of the fermenting medium which explains the gradual elimination of pathogenic bacteria during the secondary fermentation.

In this study, higher moisture content was observed in white sorghum ogi than in brown sorghum ogi. This suggests that brown sorghum ogi is more microbiologically stable than white sorghum ogi. Alozie, Iyam, Lawal, Udofia, and Ani (2009) documented that low moisture content in food increases its storage period while high moisture content in food encourages microbial growth which causes food spoilage (Temple, Badamosi, Ladeji, & Solomon, 1996). The presence of protein in the two varieties of sorghum ogi contradicts the earlier reports that states that cereals are usually devoid of protein which warrants their fortification with legumes. The amount of protein recorded in this study is similar to the one documented by Izah, Kigigha, and Okowa (2016) which confirms the findings of several authors (Ijabadeniyi & Adebolu, 2005; Iken, Amusa, & Obatolu, 2002; Ikhtiar & Alam, 2007; Mustafa & Magdi, 2003; Oko, Ubi, Efisue, & Dambaba, 2012). However, the values obtained in this work is in the range suggested by The Proteins Advisory Group of the United Nations (Proteins Advisory Group (1975); Iken et al. (2002); Ijabadeniyi and Adebolu (2005)). Furthermore, Bello, Bello, Amoo, and Atoyebi (2018) stressed that plant foods that contains 12% of its calorific value from a protein source is considered a good source of protein. The lower fat content observed in brown sorghum ogi confers its better keeping capacity than white sorghum ogi. Low percentage of fat enhances the storage as high fat content in food products causes rancidity over a long storage period. This occurrence might be due to peroxidation of polyunsaturated fatty acid that produces unpleasant odor (Mustafa & Magdi, 2003); (Ikram, Ali, & Farooqi, 2010). Fat provides the essential fatty acids required for optimum neurological, immunological and functional developments in children (Ikya, Gernah, & Sengev, 2013).

The lower fibre content of the brown sorghum ogi when compared to the raw samples might have emanated from excessive leaching that occurred during soaking. According to this study, the observed higher content of ash in white sorghum ogi may be due to the high level of non-endosperm components that are present in it. Ash contents sighnifies an index of mineral contents (Evers, 2012). Equally, brown sorghum ogi had the higher carbohydrate content, and according to Food and Agricultural Organization (FAO) (2001) staple foods such as sorghum, maize and millet are rich in starch which are bulky when processed. Infants need to consume a good proportion to get the required energy and nutrient and this seems difficult due to the bulkiness of starchy cereals consequent to their low stomach digestive capability.Therefore, there is need to solve this problem if infants food cereals such as maize, sorghum and millet are malted during processing (Food and Agricultural Organization (FAO), 2001; Ikujenlola & Fashakin, 2005).

Going by the result of the sensory analyses, the general acceptability of brown sorghum ogi might be due to its better taste, aroma, flavor, color and texture as previously reported by Ekwem and Okolo (2017).

5. CONCLUSION

From this results of the proximate analyses carried out, brown and white sorghum ogi can serve as weaning foods for infants but brown sorghum ogi seems to be more nutritious.

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Competing Interests: The authors declare that they have no competing interests.
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