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MICROBIOLOGICAL ANALYSES AND NUTRIENT COMPOSITION OF SORGHUM-BENISEED BLENDS

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ABSTRACT

This research investigated the production of fermented gruel from sorghum (ogi-baba) fortified with beniseeds (*Sesamum indicum* L) from four different preparations designated as samples A (100% sorghum), sample B (10% beniseeds), C (15% beniseeds) and D (20% beniseeds). Bacteria that were isolated from the samples were *Lactobacillus plantarum L. casei, Bacillus subtilis, B. licheniformis Leuconostoc mesenteroides, Streptococcus lactis, Staphylococcus aureus* and while fungal isolates include *Rhizopus nigricans, Aspergillus niger*, *Saccharomyces cerevisiae* and *Mucor mucedo.* All the blends were dominated by *L. plantarum* and *S. cerevisiae* which persisted throughout the fermentation period while *S. aureus* and the moulds were only isolated on the first day of fermentation. Bacterial and fungal counts increased significantly in all the blends till the end of the fermentation period. The pH of the fermenting samples decreased in all the blends with lowest value in sample A (3.36) while the highest value was found in sample D (3.41). Total titratable acidity (TTA) increased with fermentation time with the highest in sample A (2.94%) while sample D had the least TTA of 2.42%. Crude protein and crude fat contents of the fermented blends increased with increase in percentage supplementation while the crude carbohydrate contents decreased with decrease in percentage supplementation. Moisture, crude ash, crude fibre contents also decreased as the fermentation progressed in all the blends. Porridges prepared from all the blends were rated above average in terms of overall acceptability but significantly rated higher in sample B. The use of beniseeds as a fortifying agent can improve nutritive value of locally fermented carbohydrate foods which are economical compared to formulated foods.

KEYWORDS: Fermentation, Sorghum, Beniseed, Nutrient, Lactobacillus

INTRODUCTION

The most important staple foods for many people in the developed and developing countries are produced from cereals. In the developed countries, 70% of the cereal produced is used as animal feed while in the developing countries 68-98% of the cereal production is used for human consumption (Betschart, 1982).

Sorghum (*Sorghum bicolor*) is an ancient crop grown almost everywhere in the world. It is one of the five top cereal crops and ranks after maize (FAO, 1994). It has inferior organoleptic quality and reduced protein digestibility due to the presence of anti-nutritional factors such as tannins and phytates. The problems of anti-nutritional factors in sorghum can however be solved by adequate processing techniques such as sprouting, malting, decorticating and fermentation (Singh, 1994). Examples of fermented foods from sorghum include 'buchera', 'kunu-zaki', 'koko' and 'ogi-baba' (Adeyemi 1988; Adewusi *et al*., 1991; Muyanja *et al*., 2002). However, most of these fermented preparations are nutritionally poor and lack some essential amino acids.

'Ogi-baba' is a gruel produced from fermented sorghum grains. It is often used for the complementary feeding of infants and young children in Africa. The nutritional quality of 'ogi-baba' is poor in terms of crude protein content compared to the required composition of complementary food (Dewey and Brown, 2003; Lufter and Dewey, 2003; Owusu-Kwarteng *et al*., 2010) Many attempts have been made to fortify these cereals in order to make nutritionally superior and acceptable products (Oyarekua and Adewole 2009). This has been reported to improve their protein quality and their limiting amino acid contents (Annan *et al.*, 2005).

A number of legumes that are readily available but underutilised have been reported to possess nutrient potentials that could complement fermented cereal products if properly processed and blended (Fernandez *et al*., 2002; Compaoré *et al*., 2011).

Beniseeds (*Sesamum indicum L.*) also known as sesame, belongs to the family *Pedaliaceae*. The seeds are mucilaginous in nature and are among the most ancient oilseeds crop known to mankind. Beniseeds are grown in some parts of the world particularly in India, China, South America and Africa (Adeniyan *et al*., 2013). The local names of beniseeds in Nigeria include 'eluru' and 'ekuku' (Yoruba) and 'gorigo' (Ebiras). Beniseeds are used as a soup condiment in some northern Nigeria and some parts of Cross-river state (Agiang *et al*., 2010). The seeds are also sprinkled over cakes and breads, especially in Syria and Lebanon (Momoh *et al*., 2013).

Beniseeds are very rich in protein and minerals calcium, manganese, copper and phosphorus (Salunkhe, 1992). Beniseed oil has the highest concentration of Omega–6-fatty acids and two naturally occurring preservatives, sesamol and sesamin (Shittu *et al*., 2007; Ayo *et al*., 2012). Beniseed has also recognised for its medicinal properties. The seed has been reported to be good for increasing energy and prevention of aging (Hajimahmoodi *et al.*, 2008) and as a demulcent in respiratory infections and some gastrointestinal diseases. The seed powder is useful in amenorrhoea, dysmenorrhoea, ulcers and bleeding piles (Visavadiya and Narasimhacharya, 2008). Fermented liquor and methanol extract of the seeds were reported to possess antibacterial and immunostimulatory potentials (Momoh *et al*., 2012).

Therefore, supplementation and co-fermentation of beniseeds which are rich in protein and lysine, and medicinal properties could improve the nutritional quality of the fermented cereal foods. According to Ayo et al., (2010), beniseed paste, when added to a local drink, 'kunun-zaki', increased its protein, fat and energy contents by over 20%.

The aims of this research were to evaluate the preparation of ogi produced from sorghum ('ogi-baba') co-fermented with various percentages of beniseeds for their nutritive composition and sensory attributes

MATERIALS AND METHODS

Sample Collection

The fresh sorghum (*Sorghum bicolor*) samples were obtained from from Ibaka Market, Akungba-Akoko, while the beniseeds were obtained from Osele Market, Ikare-Akoko, Ondo State, Nigeria. These were immediately transported to the laboratory for analyses.

Formulation of the Sorghum-Beniseed Blend

Fresh beniseeds were washed thoroughly in clean water. They were then steeped in clean water for 2 hours in plastic air-tight containers. The water was decanted after two days and was wet milled into slurry. The slurry was dried in an oven at 55^{o}C for 48 hours.

The total weight of each blend was 500 g. The first blend (Sample A) consisted of only sorghum (100% sorghum) and served as the control. The first, second, third and the fourth blends were supplemented with 0%, 10%, 15% and 20% beniseeds respectively. Each blend was steeped in 1,500 ml of sterile distilled water for 48 hours after which the water was drained. The samples were washed and wet milled in a blender. They were then sieved using sterile muslin bags and the slurries were allowed to ferment for another 24 hours.

Microbiological Analysis

Ten grams of each of the samples were homogenized with 90 ml sterile peptone water solution and further serially diluted. Enumeration of the total bacteria, lactic acid bacteria and fungi was carried out on daily basis using nutrient agar, deMan, Rogosa and Sharpe (MRS) agar and potato dextrose agar (PDA) respectively. Fungal plates were incubated at 25°C for 3 to 5 days while bacterial cultures were incubated at 37°C for 1 to 2 days. MRS agar plates were incubated under anaerobic conditions. Representative colonies were picked from the plates and sub-cultured by repeated streaking on their respective media until pure cultures were isolated. The isolates were characterized by cultural, morphological and biochemical tests (Olutiola *et al.,* 2000)

Determination of Total Titratable Acidity (TTA)

The total titratable acidity of the fermenting samples was analyzed by measuring 20 ml distilled water into a beaker containing 2 g of macerated fermenting sample. Two drops of phenolphthalein (indicator) was added to the mixture. This was then titrated against 0.1ml 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 10ml suspension containing 1g of the sample homogenized in 9 ml of sterile distilled water. The apparatus was standardized with a buffer solution of pH 6.9, 4.2, 9.0 before use.

Analytical Methods

Moisture contents, crude protein contents, crude fat contents, total ash, crude fibre contents and carbohydrate contents were determined as described by AOAC (2006).

Sensory Evaluation

Hot water was used to prepare porridges (paps) from each of the blends by stirring in the hot water until a paste was formed. The porridges were served to 20 untrained judges to evaluate the sensory qualities (aroma, colour, texture, and overall acceptability) using a seven-point hedonic scale (1 and 7 representing extremely dislike and extremely like, respectively).

Statistical Analysis

Data obtained were subjected to analysis of variance (ANOVA), the means being tested for significance at $p<.05$ using Duncan's multiple range (DMR) test.

RESULTS

Seven bacterial species and four fungi were identified from the samples(Table 1) the bacteria were *Lactobacillus*

plantarum L. casei, Bacillus subtilis, Leuconostoc mesenteroides, Streptococcus lactis, Staphylococcus aureus and *Bacillus licheniformis* while fungal isolates include *Rhizopus nigricans, Aspergillus niger*, *Saccharomyces cerevisiae* and *Mucor mucedo* Lactic acid bacteria particularly *L. plantarum* and *Leuconostoc* species and the yeast *S. cerevisiae* were the most dominant microorganisms from all the blends and they persisted throughout the fermentation period (Table1).

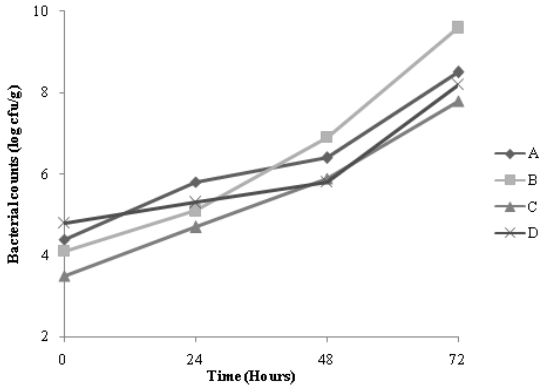
There was a significant increase in the bacterial counts increased in all the blends with the highest of 9.6 cfu/g and 7.8 cfu/g from 10% blend and 20% blend respectively (Figure 1). Fungal counts also increased in all the samples but however as the percentage of supplementation decreased, that is, the highest and the lowest counts were obtained from 0% blend (5.9%) and 20% blend (4.%) respectively (Figure 2).

The pH values decreased in all the samples (Table 2). Unblended 'ogi-baba' and 20% blend had the lowest and the highest pH of 3.36 and 3.41 respectively at the end of the fermentation period. However, the total titratable acidity (TTA) increased significantly in all the samples. The highest TTA was found in 'ogi-baba' while the least content was found in 20% blend (Table 3).

Temperature increased throughout the fermentation period in 100% 'ogi-baba' and 10% blend while decreases were observed in 15% and 20% blends after 48 hours (Table 4). The highest and the lowest temperature values in the fermented samples were found in ogi-baba (31.5^{o}C) and 20% blend (29.0^{o}C) respectively.

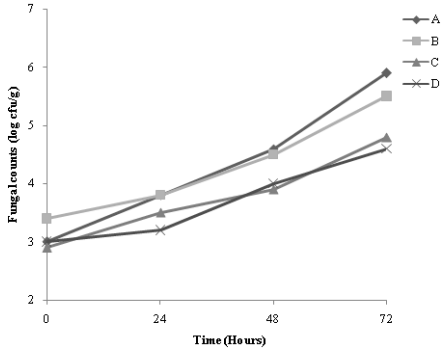
Moisture contents reduced in 'ogi-baba' and 10% blend while increased were found in 15 % blend and 20% blend. Crude protein contents increased in all the samples after fermentation with the highest and the lowest content from 10% blend (14.33%) and ogi-baba (11.68%) respectively. The crude fat contents increased slightly in the entire samples. The highest and the lowest fat contents were found in 20% blend and 'ogi-baba' respectively. Total ash contents also increased while crude fibre and carbohydrate contents were found to reduce in all the samples (Table 5).

Table 6 shows the sensory evaluation of all the samples as tested by panelists. 'Ogi-baba' prepared with 10% blend was not significantly different from the 'ogi-baba' samples in all the parameters tested. All the parameters decreased as the supplementation increased in all the blends. The results of overall acceptability revealed that 10% blend could compete favourably with the unblended sample.



Legend: Sample A=100% sorghum, Sample B =10% beniseeds,
Sample C=15% beniseeds, Sample D =20% beniseeds

Figure 1: Bacterial Counts of the Fermenting Sorghum-Beniseed Blends



Legend: Sample A=100% sorghum, Sample B =10% beniseeds,
Sample C=15% beniseeds, Sample D =20% beniseeds

Figure 2: Fungal Counts of the Fermenting Sorghum-Beniseed Blends

Table 1: Occurrence of Microbes Isolated from the Sorghum Beniseed Blends

	Time (Hours)															
	0				24				48				72			
Isolates	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**
Bacillus subtilis	+	+	-	+	-	-	+	+	-	-	-	-	-	-	-	-
Bacillus licheniformis	-	-	+	+	+	+	+	+	-	-	-	-	-	-	-	-
Streptomyces lactis	-	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+
Lactobacillus plantarum	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Leuconostoc mesenteroides	-	-	-	+	+	+	+	+	+	+	+	-	+	+	+	-
Lactobacillus casei	-	-	-	-	-	+	+	+	+	+	+	-	+	+	+	-
Staphylococcus aureus	+	+	+	+	+	+	+	+	+	+	-	-	+	+	-	-
Aspergillus niger	-	-	+	+	+	+	+	+	+	+	+	-	-	-	-	-
Rhizopus nigricans	-	-	-	-	-	+	+	+	+	+	+	+	+	-	-	-
Saccharomyces cerevisiae	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Mucor mucedo	-	-	+	+	+	+	+	+	-	-	-	-	-	-	-	-

Legend: Sample A=100% sorghum, Sample B =10% beniseeds, Sample C=15% beniseeds, Sample D =20% beniseeds

Table 2: pH of the Fermenting Sorghum- Beniseed Blends

	pH			
Time (hours)	**A**	**B**	**C**	**D**
0	5.92^{a}	5.84^{a}	5.76^{a}	5.71^{a}
24	4.38^{c}	4.57^{b}	4.61^{a}	4.62^{a}
48	3.72^{d}	3.90^{c}	4.12^{b}	4.25^{a}
72	3.36^{c}	3.39^{bc}	3.40^{a}	3.41^{a}

Values with the same superscript letter(s) across the row are not statistically significantly (P>0.05) different.

Legend: Sample A=100% sorghum, Sample B =10% beniseeds,
Sample C=15% beniseeds, Sample D =20% beniseeds

Table 3: Total Titratable Acidity (Tta) of the Fermenting Sorghum-Beniseed Blends

		(TTA)		
Time (hours)	**A**	**B**	**C**	**D**
0	0.92^{d}	0.98^{c}	1.02^{b}	1.15^{a}
24	1.52^{d}	1.59^{c}	1.72^{b}	1.79^{a}
48	2.41^{a}	2.22^{b}	2.17^{c}	2.04d
72	2.94^{a}	2.85^{ab}	2.64^{c}	2.42^{c}

Values with the same superscript letter(s) across the row are not statistically significantly (P>0.05) different.

Legend: Sample A=100% sorghum, Sample B =10% beniseeds,
Sample C=15% beniseeds, Sample D =20% beniseeds

Table 4: Temperature of the Fermenting Sorghum-Beniseed Blends

Time (Hours)	Temperature (^oC)			
	A	B	C	D
0	27.0^a	27.2^a	27.2^a	27.5^a
24	28.0^a	28.5^a	29.0^a	28.0^a
48	30.5^a	30.0^a	29.5^a	30.0^a
72	31.5^a	30.5^a	28.0^c	29.0^b

Values with the same superscript letter(s) across the row are not statistically significantly (P>0.05) different.
Legend: Sample A=100% sorghum, Sample B =10% beniseeds,
Sample C=15% beniseeds, Sample D =20% beniseeds

Table 5: Proximate Composition of the Fermented Samples

Blends	Moisture		Protein		Fat		Ash		Fibre		Carbohydrate	
	NN	FF	NN	FF	NN	FF	NN	FF	NN	FF	NN	FF
A	10.11	9.85	7.91	11.68	4.21	4.93	1.97	1.69	2.05	1.67	73.75	70.18
B	10.92	10.13	9.22	14.33	5.16	6.91	1.99	1.96	2.26	1.16	70.54	65.51
C	11.28	12.74	10.34	13.26	6.29	7.67	1.88	0.92	2.71	1.15	67.5	64.26
D	11.96	12.85	11.17	13.21	6.71	7.88	1.76	0.86	3.32	1.29	65.08	63.91

Legend: Sample A=100% sorghum, Sample B =10% beniseeds, Sample C=15% beniseeds, Sample D =20% beniseeds

Table 6: Sensory Characteristics of the Preparations

Sample	Aroma	Colour	Texture	Taste	General Acceptability
Sample A	5.2^a	5.5^a	5.2^a	6.2^a	5.6^a
Sample B	4.9^a	5.5^a	4.9^{ab}	5.9^{ab}	5.2^{ab}
Sample C	4.2^b	5.3^{ab}	4.2^c	5.1^c	4.2^c
Sample D	3.5^c	4.8^b	3.8^d	4.4^d	4.1^c

Values with the same superscript letter(s) down a column are not statistically significantly (P>0.05) different.
Legend: Sample A=100% sorghum, Sample B =10% beniseeds,
Sample C=15% beniseeds, Sample D =20% beniseeds

DISCUSSIONS

The microorganisms that were isolated from all the 'beni-ogi' blends were peculiar to many fermented foods (Odunfa and Adeleye, 1985; Omemu, *et al*., 2007a). Previous studies suggested that microorganisms are associated with cereal grains also served as inoculum for their natural fermentation process (Odunfa and Adeleye, 1985).

The predominance of lactic acid bacteria during the during this study has been reported by many authors on fermented cereal products (Omemu, 2011; Opere *et al*., 2012) Lactic fermentation has been reported to reduce the levels of proteinase inhibitors in cereal porridges thereby increasing the availability of essential amino acids such as lysine, methionine and tryptophan thereby improving the protein quality of cereal grains (Holzapfel, 2002; Opere *et al*., 2012). Previous workers have found several yeasts species in spontaneous lactic fermenting cereals including species of *Saccharomyces* and *Candida* (Jespersen, 1994). Their presence in fermenting foods has been found to improve the aroma and flavour of fermented foods (Adegbehingbe and Fakoya, 2007). The *Saccharomyces cerevisiae* which also persisted throughout the fermentation period in all the blends agreed with Vieira-Dalode *et al*. (2007) while fermenting maize for mowe production. The coexistence and symbiotic association between lactic acid bacteria and yeasts in traditional fermented products have been reported by several authors (Jespersen *et al.,* 1994; Hounhouigan *et al.,* 1993; Omemu *et al.,* 2007b). Besides they have been observed to be responsible for flavour development in fermented foods (Omemu *et al.,* 2007b; Vieira-Dalode *et al*., 2007).

The molds isolated in the study are commonly present as contaminants in cereals. Their sources could also be from the utensils, the processing water or the environment (Oyelana and Coker, 2012). Ijabadeniyi (2007) and Omemu (2011) isolated *Penicillium* and *Aspergillus, Mucor* and *Rhizopus* in maize fermentation during the early stage of maize fermentation for ogi production. Jespersen (1994) attributed their early disappearance of moulds to the low oxygen tension in the fermenting porridge for 'kenkey' production. The presence of *Staphylococcus* probably originated from the air, human handlers and other materials.

The higher total titratable acidities with respect to decrease in percentage of the blends could be due to higher lactic acid bacteria in these blends. Lactic acid bacteria have been known for production of lactic acid and minor amounts of acetic and formic acids. This is one of the attributes of cereal fermented foods and beverages. A similar increase in acid production had been observed by Afoakwa *et al*. (2007) during the production of weaning food from maize-cowpea blends. Reduction in pH values of fermented foods inhibits growth of spoilage and pathogenic organisms (Opere *et al*., 2012).

The decrease in moisture contents with increase in fermentation time was similar to Wakil and Kazeem (2012) on weaning foods produced from fermented cereal legume blends using starters. The observed increase in protein content of the blends may be due to the structural proteins that are an integral part of the microbial cell (Silhavy *et al*., 2010).

The highest crude protein content in 10% blend might be due to the fact that the blend composition contained adequate nutrients which supported the growth of the fermenting microorganisms in forms of single cell protein. It has also been reported that *Bacillus* spp. are important producers of extracellular proteases in some fermented legumes which could hydrolyze complex plant proteins to amino acids and short chain peptides, thereby causing an increase in total nitrogen content (Fogarty and Griffin, 1973; Adegbehingbe, 2013).

The slight decrease in the ash contents of fermenting samples was in agreement with the results obtained by Esenwah and Ikenebomeh (2008) while fermenting African locust bean seeds. Loss in ash contents may be due to leaching of soluble inorganic salts into the processing water during the fermentation period (Osman, 2007; Ogbonnaya *et al.,* 2010) or the fermenting microflora used it for their metabolism (Reebe *et al*., 2000; Onweluzo and Nwabugwu, 2009).

The increase in the fat contents which might be due to the activities of the fermenting microbes (Oyewole and Odunfa, 1990) was in agreement with Ayo *et al*. (2012) on his work on masa-beniseed blends.

The reduction in the total ash after fermentation agrees closely with Ayo et al (2008) on effect of groundnut-maize blends on the qualities of 'masa'. They observed decrease in ash content from 2.1 to 0.8% after fermentation. The reduction in crude fibre contents of the blends after fermentation conforms with Onweluzo and Nwabugwu (2007) while fermenting pigeon pea seeds for flour production. The loss in crude fibre and ash contents could be due to their leaching into the fermenting medium or they were being metabolised by the fermenting microorganisms

The total carbohydrate content of the samples decreased steadily during the fermentation period. This is in agreement with the result of Adegbehingbe and Fakoya (2007; 2013). It may be as a result of the utilization of some of the sugars by fermenting organisms for growth and metabolic activities and also as a result of apparent increase in protein contents of the samples (Adegbehingbe, 2013).

There were no significant differences ($P>0.05$) in the odour, texture and colour, and the overall acceptability of ogi-baba and 10% blend. This shows the 10% blend could compete favourably well with ogi-baba.

CONCLUSIONS

In conclusion, the results from this work shows that the use of beniseed as a fortifying agent improved the protein contents of the blends and that 10% blend was the most acceptable among the blends. Therefore it could be used to fortify sorghum and may be recommended for solving the problem of protein-energy malnutrition (PEM) among infants in developing countries.

REFERENCES

1. Adegbehingbe, K. T. and Fakoya, S. (2013). Effect of Fermentation on Nutrient and Anti-nutrient Contents of Cocoyam Corm. *Journal of Pharmacy and Nutrition Science.* 31: 71-177.
2. Adegbehingbe, K. T. (2013). Microbiological and Nutrient Studies of fermented cooked Lima beans (*Phaseolus lunatus*). *Global Journal of Biology, Agriculture and Health sciences.* 2: 94-101.
3. Adegbehingbe, K. T. and Fakoya, S. (2007). Fermentation of 'ogwo' using starter cultures. *Journal of Applied and Environmental Sciences*. 3(2): 137-142.
4. Adeniyan, O. O., Ibukun, E. O., Ogunbolude, Y. and Eseigbe, M. I. (2013),. Effect of boiling on the nutritional composition and antioxidant properties of beniseed (*Sesamum indicum L.*). *Food Science and Quality Management*. 11: 39-49.
5. Adewusi, S. R. A., Orisadare, B. O. and Oke, O. L. (1991) Studies on weaning diets in Nigeria. I. Carbohydrate sources. *Cereal Chemistry*. 68: 165-169.
6. Adeyemi, I. A. (1988). Ogi quality of sorghum flour dry-milled from fermented sorghum grains. *Journal of Food Science*. 53: 641-642.
7. Afoakwa, E. O., Sefa Dedeh, S., Budu, A. S., Sakyi-Dawson, E. and Asomaning, J. (2007). Cowpea fortification of traditional foods. Presented *at the World Cowpea Research Conference III Ibadan, Nigeria*, September 2000, 4-7.
8. Agiang, M. A., Umoh, I. B., Essien, A. I., and Eteng, M. U. (2010): Nutrient changes and antinutrient contents of beniseed and beniseed soup during cooking using a nigerian traditional method. *Pakistan Journal of Biological Sciences* 13: 1011-1015.
9. Ajanaku KO, Ajanaku CO, Edobor-Osoh A, Nwinyi OC (2012). Nutritive value of sorghum-ogi fortified with groundnut seed (*Arachis hypogeal L.*). *African Journal of Food Technology*. 7: 82-88.
10. AOAC, (2006). Official Methods of Analysis (18th ed). Association of Official Analytical Chemists, Washington, D. C. British Pharmacopoiea (1993). Biological assay of antibiotics HMSO, London.
11. Annan, T. N., Poll, L., Sefa-Dedeh, S., Plahar, A. W. and Jakobsen M. (2003). Influence of starter culture combination of *Lactobacillus fermentum, Saccharomyces cerevisiae* and *Candida krusei* on aroma in Ghanaian maize dough fermentation *European Food Research and Technology*. 216: 377-384.

12. Ayo, J. A., Onuoha, G., Agu, H., Ayo, V. A., Avu, E. O., Sosanya, M. and Adeosun, F. (2012). Effect of added beneseed paste on the quality of millet-based masa. *African Journal of Food Science and Technology*. 3(10): 236-243.

13. Ayo, J. A., Agu, H., Ayo, V. A. and Famorjo, O. F. (2008). Effect of groundnut paste on the quality of maize based masa. *Pakistan Journal of Nutrition.* 7(4): 557-560.

14. Ayo, J. A., Onuoha, O. G., Ikuomola, D. S. Esan, Y. O., Ayo, V. A. and Oigangbe, I. G. (2010). Nutritional evaluation of Millet-beniseed composite based kunun-zaki. *Pakistan Journal of Nutrition*. 9(10): 1034-1038.

15. Betschart, A. A. (1982). World food and nutrition Problems. *Cereals Food World.* 27: 562.

16. Compaoré, W. A., Nikièma, P. A., Bassole, H. I. N., Savadogo, A., Hounhouigan, D. J., Mouecoucou, J., and Traoré, S. A. (2011). Nutritional properties of enriched local complementary flours. *Advance Journal of Food Science and Technology* 3(1): 31-39.

17. Dewey, K. G. and Brown, K. H. (2003). Update on technical issues concerning complementary feeding of young children in developing countries and implications for intervention programs. *Food and Nutrition Bulletin*. 24: 5-28.

18. Esenwah, C. N. and Ikenebomeh, M. J. (2008). Processing effects on the nutritional and anti-nutritional contents of African locust bean (*Parkia biglobosa* Benth.) seed. *Pakistan Journal of Nutrition.* 7(2): 214-217.

19. FAO (1994). Cereals utilization for animals feed on the increase food and Agricultural Organization, Rome Ceres.

20. Fernandez, D. E., D. J. Vanderjagt, M. Williams, Y. S. Huarg, C. Lut-te, M. Millson, R. Andrew, A. Pastuszyn and R. H. Glew, 2002. Fatty acids, amino acids, and trace mineral analyses of five weaning foods from Jos, Nigeria*. Plant Foods for Human Nutrition*. 57: 257-274.

21. Fogarty, W. M. and Griffin, P. J. (1973). Production andpurification of metalloproteases of *Bacillus polymyxa. Journal of Applied Microbiology.* 26: 191-195.

22. Makinde, F. M. and Akinoso, R. (2014). Comparison between the nutritional quality of flourobtained from raw, roasted and fermented sesame (*Sesamum indicum* L.) seed grown in Nigeria *Acta Sci. Pol., Technol. Aliment*. 13(3) 2014, 309-319.

23. Hajimahmoodi, M., Oveisi, M. R., Sadeghi, N., Jannat, B., Bahaeddin, Z. and Mansoori, S. (2008). Gamma tocopherol content of Iranian sesame seeds. *Iranian Journal of Pharmaceutical Research.* 7: 135-139.

24. Holzapfel, W. H. (2002). Appropriate starter technologies for small scale fermentation in developing countries. *International Journal of Food Microbiol*ogy. 75: 197-212.

25. Ijabadeniyi, A. O. (2007). Microorganisms associated with ogi traditionally produced from three varieties of maize. *Researsh Journal of Microbiology*. 2(3): 247-253.

26. Jespersen, L., Halm, M., Kpodo, K. and Jakobsen, M. (1994). Significance of yeasts and moulds occurring in maize dough fermentation for Kenkey production. *International Journal of Food Microbiology.* 24, 239–248.

27. Lutter, C. K. and Dewey, K. G. (2003). Nutrient composition for fortified complementary foods: proposed nutrient composition for fortified complementary foods. *Journal of Nutrition*. 133: 3011.

28. Momoh, A. O., Adebolu, T. T., Ogundare, A. O. (2012). Antimicrobial activities of fermented beniseeds against selected diarrhoeagenic bacteria. *Journal of Research in Science and Management*. FUTA, Nigeria.

29. Momoh, A. O., Adebolu, T. T. and Ogundare, A. O. (2013). Evaluation of beniseed extract and fermented liquor in treatment of diarrhoea in albino rats infected with *Salmonella typhi. European Journal of Biology and Medical Science Research*. 1 (2): 16-23.

30. Muyanja, C. M. B. K., Narvhus, J. A., Treimo, J. and Langsrud, T. (2002). Isolation, characterization and identification of lactic acid bacteria from bushera: a Ugandan traditional fermented beverage. *International Journal of Food Microbiology*. 80: 201-210.

31. Odunfa, S. A. and Adeyele, S. (1985) Microbial changes during traditional production of ogi-baba, a West African fermented sorghum gruel. *Journal of Cereal Science.* 3: 173-180.

32. Ogbonnaya, C. A., Orhevba, B. A. and Mahmood, B. A. (2010). Influence of hydrothermal treatments on proximate composition of fermented locust bean (*dawadawa*). *Journal of Food Chemistry,* 8(3): 99-101.

33. Olutiola, P. O., Famurewa, O. and Sontag, H. G. (2000). An Introduction to General Microbiology. A practical Approach. 2nd edition. Heideberger Verlagsanstait and Druckerei Gmb. Heldelberg Publisher.

34. Omemu, A. M., Oyewole, O. B. and Bankole, M. O. (2007a). Significant of yeasts in the fermentation of maize for ogi production. *Food Microbiology.* 24: 571-576.

35. Omemu, A. M., Oyewole, O. B., Bankole, M. O. and Akintokun, A. K. (2007b). Yeasts and moulds associated with *ogi* – a cereal based weaning food during storage. *Research Journal of Microbiology.* 2 (2): 141-148.

36. Omemu, A. M. (2011). Fermentation dynamics during production of *ogi*, a Nigerian fermented cereal porridge. *Report and Opinion*. 3(4): 8-17.

37. Onweluzo, J. C. and Nwabugwu, C. C. (2009). Fermentation of millet (*Pennisetum americanum*) and pigeon pea (*Cajanus cajan*) seeds for flour production: effects on composition and selected functional properties. *Pakistan Journal of Nutrition*. 8 (6): 737-744.

38. Opere, B., Aboaba, E. O. Ugoji O. O. and Iwalokun A B. A. (2012). Estimation of Nutritive Value, Organoleptic Properties and ConsumerAcceptability of Fermented Cereal Gruel (OGI). *Advance Journal of Food Science and Technology.* 4(1): 1-8, 2012.

39. Osman, M. A. (2007). Effect of different processing methods on nutrient composition, antinutritional factors and *in vitro* protein digestibility of Dolichos lablab bean (*Lablab purpuresus* (L) Sweet). *Pakistan Journal of Nutrition.* 6: 299-303.

40. Owusu-Kwarteng, J., Akabanda, F and Glover, R. L. K. (2010). Effect of soybean fortification on fermentation characteristics and consumer acceptability of Hausa koko, a Ghanaian fermented porridge. *Journal of Applied Biosciences*. 28: 1712 – 1717.

41. Oyarekua M. A. and Adewole E. I. (2009). Comparative evaluation of the nutritional quality, functional properties and amino acid profile of maize/cowpea and sorghum/cowpea ogi as infant complementary food. *Journal of Clinical Nutrition*. (1(1): 31-39.

42. Oyelana, O. A. and Coker, A. A. (2012). Microbial contamination at different stages of production of ogi in Mowe: a rural area community, Southwest, Nigeria. *Bacteriology Journal.* 2(1): 1-11.

43. Oyewole, O. B. and Odunfa, S. A. (1990). Characterization and distribution of lactic acid bacteria in cassava fermentation during fufu production. *Journal of Applied Bacteriology*. 68: 145-152.

44. Reebe, S., Gonzalez, V. N. and Rengifo, J. (2000). Research on trace elements in the common beans. *Food and Nutrition Bulletin,* 2: 1387-391.

45. Salunkhe (1992). A handbook of world food legumes, volume. 45; 53Achi OK (1992): Microorganisms associated with natural fermentation of Prosopis africana seeds for the production of okpiye. *Plant Foods for Human Nutrition* 42: 297-304.

46. Shittu, L. A. J., Bankole, M. A. and Ahmed T. (2007). Antibacterial and antifungal activities of essential oils of crude extracts of *Sesame radiatum* against some pathogenic microorganisms. *Iranian Journal of Pharmacology and Therapeutics*. 6: 165-170.

47. Silhavy, J. T., Kahne, D. and Walker, S. (2010). The bacterial cell envelope. *Cold Spring Harb Perspect Biol.* 2(5):a000414.

48. Singh, U. (1994). The inhibition of Digestive Enzymes by Polyphenols of Chick Pea: *Nutrition Reports International.* 29: 74.

49. Vieira-Dalode, G., Jespersen. L., Hounhouigan, J., Moller, P. L. Nago, C. M. and Jakobsen, M. (2007). Lactic acid bacteria and yeasts associated with gowe production from sorghum in Benin. *Journal of Applied Microbiology*. 103: 342–349.

50. Visavadiya, N. P. and Narasimhacharya, A. V. (2008). Sesame as a hypocholesteraemic and antioxidant dietary component. *Food and Chemical Toxicology*. 46(6): 1889-1895.

51. Wakil, S. M. and Kazeem, M. O. (2012). Quality assessment of weaning food produced from fermented cereal-legume blends using starters. *International Food Research Journal,* 19(4): 1679-1685