Fermentative Improvement of Nutritional Status of *ogi* Using Soybeans

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Abstract: *Ogi*, a common fermented food from maize is usually low in protein mostly when produced from maize alone. This research was carried out to determine the possibility of improving the nutritional value mostly protein, carbohydrate and ash content of pap using soybeans. The maize was steeped together with different percentages of parboiled soy bean (5-50%), and allowed to ferment for 0-72 hours. 0.1 ml of the fermentation water was aseptically inoculated unto appropriate media for isolation of fermenting microorganisms. The isolates include *Staphylococcus aureus, Streptococcus* spp, *Lactobacillus* spp, *Bacillus* spp, *Corynebacterium* spp, *Escherichia coli, Aspergillus flavus, Aspergillus* spp, *Mucor* spp, *Penicillium* spp, *Rhizopus* spp and *Saccharomyces cerevisiae. Lactobacillus* spp, *Bacillus* spp and *Saccharomyces cerevisiae* persisted throughout the fermentation time. *Ogi* sample from white maize without soybean (Control) has the lowest protein content (14.65±0.1%) while *ogi* from yellow maize with 50% boiled soybean has the highest protein content (53.31 ±0.1%). Processing maize with up to 50% soybean will tremendously improve nutritional value of pap consumed by infants and adults.

Keywords: Fermentation, maize, microorganisms, nutritional improvement, ogi, soybeans.

Introduction

Ogi (Pap or Akamu) is a fermented, semi-solid product manufactured from cereals commonly maize, sorghum, and or millet. It is a staple food in most African countries, with varying preparation methods and names. *Ogi* is commonly used as weaning food for babies and also for young children as a standard breakfast cereal in many homes, but some adults also enjoy this delicacy (Nago *et al.*, 2011). *Ogi* is a porridge prepared from fermented maize, sorghum or millet in West Africa. The traditional preparation of *Ogi* involves soaking of corn in clean water for about 1-3 days followed by wet-milling using a blender then sieving to remove bran, hulls and germ. The pomace is retained on the sieve and later discarded as an animal feed while the filtrate is fermented for about 2-3 days again to yield *Ogi* which is a sour white starchy sediment (Akinele *et al.*, 2010). During processing, nutrient including protein and minerals are lost from the grains thereby affecting nutritional quality adversely.

The high moisture content of *Ogi* predisposes it to spoilage. However, the reduction in moisture content of drying can enhance the shelf life, provide convenience and allow for easy reconstitution of the *Ogi* powder. Although drying may extend the shelf-life of food, it may also impact some undesirable changes in quality of food (Omemu *et al.*, 2017). Several traditional fermentations have been upgraded to high technology production systems and this has undoubtedly improved the general well-being of the people as well as the economy (Achi, *et al.*, 2015).

In some communities in southwestern Nigeria, uncooked *ogi* is normally administered to people having running stomach to reduce the frequency of stool.

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Studies have revealed that *Lactobacillus rhamnosus* and *L. reuteri* could colonize the vagina, kill viruses, and reduce the risk of infections, including bacterial vaginosis (Reid *et al.*, 2011; Cadieux *et al.*, 2012). The nutritional benefits of *ogi* have been investigated extensively but the therapeutic and preventive effects of *ogi* and LAB, which are responsible for the fermentation and organoleptic quality of *ogi* have been scantily reported. LAB has been implicated in the fermentation of *ogi* and has been frequently isolated.

Fermentation of pap most of the times is spontaneous but could also be induced. The combination of different types of cereals in the production of pap increase the protein quality and relative nutritive values which would have been lost during steeping, milling and sieving processes compared to use of single cereal. Several strategies have been used to increase the protein content and minimize nutrient loss (Inyang and Idoko, 2016). Currently in Africa, efforts are being made to modify the processing of pap with a view to enhancing its nutritive value and shelf-life. One of such methods of achieving this is by blending with legumes that are high in proteins such as soybeans seed. However, *Ogi* has two possible uses; as food and as medicine for running stomach. As food, *Ogi* can be used for the production of backed pap which is called by Yorubas, *Agidi* by Igbos and Calabars. It can also be used as food by mixing with boiled water to attain a jelly-like thick state, ready for drinking. Also, as medicine, raw part of the *Ogi*, when mixed with clean and well sterilized water has the ability to stop running stomach when taken in good quality (Ohenhen and Ikenebomeh, 2007). This research was aimed at improving the nutritional status of *ogi* through fermentation using soybeans.

Materials and Method

Sample preparation

The maize (white and yellow) and soybean that was purchased from Obo market in Ikot Inuen, Oruk Anam, Akwa Ibom State. The method of Adeleke *et al.*

(2010) with slight modification was used. Both maize and soybean samples were separated from their impurities manually. 400g of soybeans was boiled for 15 minutes and 200g was fermented together with the maize while 200g was added without fermentation to the fermented maize samples of different ratios 25g: 25g, 30g:20g, 35g:15g, 40g:10g, 45g:5g for maize and soybean respectively and coded as: FYM+BFB = fermented yellow maize + boiled fermented soy beans, FYM+BB = fermented yellow maize + boiled soy beans, FWM+BFB = fermented white maize + boiled fermented soy beans, FWM+BB = fermented white maize + boiled soy beans, FWM = fermented white maize (Control).. The measured samples were steeped in white, transparent, labelled plastic buckets with tap water and allowed to ferment for three days.

Fermentation of maize and soybeans for *ogi* production

The fermented samples wet milled and sieved to remove bran, hull and germ. The pomace was retained on the sieve and discarded as animal feed while the filtrate was fermented for 2 days to yield *ogi* which is sour, white starchy sediment (Baningo and muller, 2012).

Determination of fermentation physico-chemical parameters

pH

The pH was measured using Unicamp pH meter, (Model 291) equipped with glass electrode. 50 ml of the steep water was transferred into a 100 ml beaker and the electrode of the pH meter was dipped into the steep water sample and the pH value was taken.

Temperature

A calibrated mercury-in-glass thermometer was directly dipped into the fermenting steep water and the temperature value was recorded (Adeyemi, 2013).

Determination of Total Titratable Acidity

Titratable acidity was determined by the alkaline Titrimetric method (Coleman *et al* (2013)). 5 ml of the steep water was dispersed in 45ml of distilled water in a conical flask and shaken to mix well and allowed to stand for 10 minutes. 3 drops of phenolphthalamine were then added to it and was titrated against dilute alkali solution (0.1N NaOH solution). The acidity was calculated using the formula below

$$\% \text{ TTA} = = \frac{100}{W} \times titre \times N$$

Where:

N = normality of titrant
W = weight of sample used (Tsai *et al.*, 2015)

Microbiological analyses of Food samples

Isolation and identification of microorganisms

Ten fold serial dilutions of the fermenting steep was carried out and 0.1 ml aliquot of suitable dilution was inoculated by spread plate on De Man Rogosa Sharpe (MRS), Nutrient, McConkey and Sabourand Dextrose Agar (SDA). The Nutrient and McConkey agar were incubated for 24-48 hrs at 37°C while the SDA plates were incubated for 5 days at 22°C (Dhawale and Lamaster, 2013). The various plates were observed at the end of the incubation periods and the isolates were sub-cultured separately to get pure cultures which were later stored in agar slants and kept in the refrigerator.

Identification of microbial isolates

The various isolates recovered from the samples were subjected to Gram staining, sugar fermentation and biochemical tests to establish their identities.

Proximate analysis of *ogi*

This was carried out to determine the moisture, ash, fats, carbohydrate and crude protein contents of the ogi sample according to AOAC (2005).

Moisture Content

Flat silica Petri dish was washed and dried for about 1 hour in the oven to cool and weighed. 2.0 g of the sample was weighed and added into the Petri-dish. The sample was transferred into the oven for drying at 105°C for 3 hours. The sample was then cooled in the desiccator and the weight of the sample plus the dish was taken. The percentage moisture loss was calculated.

Calculation:

$$\% \text{ Moisture} = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

Where:

W_1 = Initial weight of the empty crucible
W_2 = weight of crucible + sample before drying
W_3 = final weight of crucible + sample after drying
Total solid =100 - % moisture (Tsai *et al.*, 2015).

Ash Content Determination

A clean silica dish was weighed to a constant weight. 2.0 g of each sample was measured into the dish. The sample was ignited using a heating mantle in the fume cupboard until charred and no more smoke given off (pre-ashing). Using a pair of tong, the sample was transferred into a muffle furnace at a temperature of 550°C until fully ashed. The percentage ashed was calculated as follows:

Calculation:

$$\% \text{ Ash} = = \frac{\text{Weight } of \text{ } ash}{\text{Weight of original sample}} \times 100 = \frac{W_3 - W_1}{W_2 - W_1} \times 100$$

Where:

W_1 = weight of empty dish
W_2 = weight of dish + sample before drying
W_3 = weight of dish + ash (Tsai *et al.*, 2015)

Fat Content Determination

Solvent extraction in a Soxhlet reflux apparatus was used. 250ml boiling flasks were thoroughly washed and dried in an oven. They were transferred into the desiccators to cool and each was weighed accordingly after which the Soxhlet reflux apparatus was set up. 5.0 g of the sample was accurately weighed and put into a labeled thimble with a cotton wool. 200ml of petroleum ether was filled in the boiling flasks and heated using a heating mantle set at 100°C. The Soxhlet apparatus was allowed to reflux for about 6 hours. The thimble was carefully removed and the petroleum ether was recollected using a rotary evaporator and drained into a bottle for re-use. The flask was removed and dried at 105°C for 1 hour in an oven. The flask was then transferred from the oven into

desiccators using a pair of tong and allowed to cool. After cooling, the flask containing the oil was then weighed.

Calculation:

$$\% \text{ Crude Fat Content} = \frac{W2 - W1}{W3} \times 100$$

Where:

W_1 = weight of the empty extraction flask
W_2 = weight of the flask and the oil extracted
W_3 = weight of the sample (Tsai *et al.*, 2015).

Carbohydrate Determination

The Nitrogen free extract method was used. The carbohydrate was calculated as weight by different between 100 and the summation of other proximate components as nitrogen free extract (NFE).

Calculation:

$$\% \text{ N F E} = 100 - \% (a + b + c + d + e)$$

Where:

a = protein content
b = fat content
c = fibre content
d = ash content
e = moisture content (Tsai *et al.*, 2015).

Protein Content Determination

The protein content was determined by Kjeldahl method according to the AOAC (2015). 0.2g of the sample was weighed into a filter paper and transferred into a neat dried Kjeldahl flask. Exactly 25ml of Conc. Sulphuric acid was added to the flask and 2 tablets of selenium catalyst. The flask was heated gently in a fume cupboard using a heating mantle in an inclined position and allowed to digest (digest is complete when the liquid is clear and free from black or brown colour). The flask was allowed to cool and was diluted with 200ml of distilled water. A distillation apparatus consisting of 500ml flask with stopper carrying a dropping funnel and a splash head adaptor and a vertical condenser in which a straight delivery tube is attached was used. Approximately 50ml of boric acid solution was measured into 500ml Erlenmeyer titration flask and a few drops of screened methyl red indicator were added and the Erlenmeyer Flask placed on the receiving end of the delivery tube dipping just below the level of the boric level. Some anti-bumping agent granules and 75ml of NaOH solution were added to the distillation flask. Exactly 50ml of distilled water was added and was gently shaken to ensure mixing of contents. The flask was connected to distillation bulb and boiled vigorously,until about 100ml of the distillate was obtained. The distillate was titrated with 0.1M Hcl till first trace of pink colour.

Calculation:

$$\% \text{ N} = \frac{Tv \times 1.4 \times 0.1}{W}$$

Where:

W = weight of sample in grams
Tv = Titre value
% crude protein = N X conversion factor (Tsai *et al.*, 2015)

Statistical analysis

Data obtained were analyzed by finding the standard deviation. The variant means were separated by the Least Significant Difference while the significant result was accepted at ($P \leq 0.05$).

Results

Table1 shows the morphological and biochemical characteristics of bacterial isolates. The isolates include *Staphylococcus aureus*, *Escherichia coli*, *Enterobacter* spp, *Pseudomonas* spp, *Micrococcus* spp, *Lactobacillus* spp and *Bacillus* spp.

Table 2 shows the fungal isolates recovered from the samples and they are *Aspergillus flavus*, *Aspergillus niger*, *Penicillium* spp, *Rhizopus* spp and *Mucor* spp

Table 3 shows the succession of bacteria during steeping of Maize and soybeans. Only *Lactobacillus* and *Bacillus* spp persisted throughout the fermentation period.

Table 4 shows the succession of fungi during steeping of maize and Soybeans. Only *Saccharomyces cerevisiae* persisted throughout the fermentation time.

Table 5 shows the pH and of fermented Maize and Soybeans. The pH values were in the range of 5.5-3.1

Table 6 shows temperature values of fermented Maize and Soybeans. The temperature values were in the range of 28.9-28.6

Table 7 shows the Total Titratable Acidity values of the fermented Maize and Soybeans and the values are in the range of 5.5-1.00.

Table 8 shows the Proximate analysis values of the fermented Maize and Soybeans. The values were in the ranges: 19.04 - 12.86 (moisture content); 53.31- 14.65 (crude protein); 0.38 – 0.20 (crude fibre), 2.91 - 0.86(fats) and 75.96 - 34.72 (carbohydrate).

Table 9 shows the Antibiotics susceptibility of the bacterial isolates. All the isolates were susceptible to at least one antibiotic.

Table 1: Cultural and biochemical characteristics of bacterial isolates from *ogi*

Colonial morphology	Gram reaction	Spore stain	Motility	Catalase	coagulase	Oxidase	Methyl red	Indole	Starch hydrolysis	Glucose	Lactose	Sucrose	Maltose	Frutose	Galactose	Manitol	Xylose	Probable isolates
Shinny surface on NA	+ Cocci	-	-	+	+	-	+	-	+	A/-	A/G	A/-	A/G	A/-	A/G	A/-	A/-	*Staphylococcus aureus*
Large round colony on NA	+ Cocci	-	-	-	-	-	+	-	+	A/-	A/G	A/G	A/-	-	-/G	-	-	*Streptococcus* spp
White creamy rough colony on MRSA	+ rod in chain	-	-	-	-	-	+	-	+	A/-	A/G	A/-	A/G	A/G	A/-	A/-	A/G	*Lactobacillus* spp
White dry surface on NA	+ Straight long rods	+	-	+	-	-	-	-	+	A/G	-	A/-	-	-	A/G	A/G	A/-	*Bacillus* spp
White creamy colonies in clusters on NA	+ Slightly curved rods	-	-	-	-	-	+	-	-	-	A/G	A/-	A/G	-	+	-/G	+	*Corynebacterium* spp
Smooth pink colonies on MacConkey	+ Short rods	-	+	+	-	-	+	+	-	A/-	A/G	A/G	A/-	A/-	A/G	-	-	*Escherichia. coli*

Key: G – Gas production
A – Acid production

Table 2: Morphological characteristics of fungal isolates from ogi

Surface	Elevation	Spore colour	Type of Mycelium	Mode of Reproduction	Septation	Probable Isolates
Powdery	Raised	Black	Conidiospore	Sexual	Septate	*Aspergillus* spp
Cottony	Elevated	Brown	Sporangiospore	Asexual	Non Septate	*Mucor* spp
Powdery	Raised	Green	Sporangiospore	Assexual	Septate	*Penicillium* spp
Cottony	Raised	Black	Sporangiospore	Asexual	Non Septate	*Rhizopus* spp
Cottony	Raised	Black	Sporangiospore	Sexual	Septate	*Saccharomyces cerevisiae*

Table 3: Bacterial succession during steeping of maize and soy beans

	Time (h)			
Isolates	**0**	**24**	**48**	**72**
Staphylococcus aureus	+	-	-	-
Streptococcus spp.	+	-	-	-
Lactobacillus spp.	+	+	+	+
Bacillus spp.	+	+	+	+
Corynebacterium spp.	+	+	-	-
Escherichia coli	+	+	-	-

Key: + = Present
- = Absent

Table 4: Fungal succession during steeping of maize and soybeans

	Time (h)			
Isolates	**0**	**24**	**48**	**72**
Aspergillus spp.	+	+	-	-
Mucor spp.	+	+	-	-
Penicilium spp.	+	-	-	-
Rhizopus spp.	+	-	-	-
Saccharomyces cerevisiae	+	+	+	+

Key: + = Present
- = Absent

Table 5: pH values of fermented Maize and Soy beans steep water in ratios

Samples	Time (h)	25 :25	30 :20	35 :15	40 :10	45:5
FYM + BFB	0	4.8	4.9	4.8	4.2	4.6
	24	4.5	4.7	4.6	3.8	3.8
	48	4.1	4.0	4.3	3.4	3.4
	72	3.5	3.4	3.2	3.1	3.1
FYM + BB	0	5.5	5.3	5.2	5.0	5.1
	24	5.0	4.8	4.9	4.7	4.8
	48	4.5	4.4	4.4	4.3	4.5
	72	4.0	3.8	4.0	3.9	4.0
FWM + BFB	0	5.1	4.9	4.9	4.8	4.8
	24	4.9	4.4	4.4	4.3	4.2
	48	4.5	4.2	4.2	3.9	3.8
	72	3.9	4.0	3.8	3.6	3.4

FWM + BB	0	5.0	4.6	4.8	4.7	4.9
	24	4.7	4.0	4.6	4.3	4.6
	48	4.4	3.6	4.1	4.0	4.2
	72	3.9	3.1	3.6	3.7	3.9
FWM(control)		NO PROPORTION				
	0	5.4				
	24	4.2				
	48	3.6				
	72	3.2				

Key: FYM+BFB = fermented yellow maize + boiled fermented soy beans.
FYM+BB = fermented yellow maize + boiled soy beans.
FWM+BFB =fermented whites maize + boiled fermented soy beans.
FWM+BB = fermented white maize + boiled soy beans.
FWM =fermented white maize (Control)

Table 6: Temperature of fermented maize and soy beans steep water in ratios

Samples	Time (h)	25 :25	30 :20	35 :15	40 :10	45:5
FYM + BB	0	28.6	28.6	28.6	28.6	28.6
	24	28.7	28.7	28.7	28.7	28.7
	48	28.8	28.8	28.8	28.8	28.8
	72	28.9	28.9	28.9	28.9	28.9
FYM + BFB	0	28.6	28.6	28.6	28.6	28.6
	24	28.7	28.7	28.7	28.7	28.7
	48	28.8	28.8	28.8	28.8	28.8
	72	28.9	28.9	28.7	28.9	28.9
FWM +BB	0	28.6	28.6	28.6	28.6	28.6
	24	28.7	28.7	28.7	28.7	28.7
	48	28.8	28.8	28.8	28.8	28.8
	72	28.9	28.9	28.9	28.9	28.9
FWM + BFB	0	28.6	28.6	28.6	28.6	28.6
	24	28.7	28.7	28.7	28.7	28.7
	48	28.8	28.8	28.8	28.8	28.8
	72	28.9	28.9	28.9	28.9	28.9
FWM (Control)		NO PROPORTION				
	0	28.6				
	24	28.7				
	48	28.8				
	72	28.9				

Key: FYM+BB = fermented yellow maize + boiled soy beans.
FYM+BFB = fermented yellow maize + boiled fermented soy beans.
FWM+BB = fermented white maize + boiled soy beans
FWM+BFB =fermented whites maize + boiled fermented soy beans.
FWM =fermented white maize (Control)

Table 7: Total Titratable Acidity (TTA) of maize and soybeans steep water in ratios

Samples	Time (h)	25 :25	30 :20	35 :15	40 :10	45:5
FYM + BB	0	1.01	1.01	2.90	2.91	1.00
	24	1.90	1.90	3.51	3.52	1.91
	48	2.51	2.51	4.21	4.20	2.50
	72	4.21	4.25	4.40	4.39	4.26
FYM+BFB	0	1.00	1.01	2.91	2.90	1.01
	24	1.90	1.90	3.50	3.51	1.90
	48	2.51	2.51	4.22	4.21	2.51
	72	4.21	4.25	4.38	4.40	4.25
FWM + BFB	0	1.21	1.21	2.23	2.23	1.21
	24	2.23	2.23	3.01	3.01	2.23
	48	3.01	3.01	5.02	5.02	3.01

	72	5.02	5.50	5.50	5.50	5.50
FWM + BB	0	1.01	1.01	2.90	1.90	1.01
	24	1.90	1.90	3.51	3.51	1.90
	48	2.51	2.21	4.21	4.21	2.51
	72	4.21	4.25	4.90	4.90	4.25
FWM(Control)		NO PROPORTION				
	0	1.28				
	24	3.20				
	48	5.01				
	72	7.02				

Key: FYM+BB = fermented yellow maize + boiled soy beans
FYM+BFB = fermented yellow maize + boiled fermented soy beans.
FWM+BFB =fermented whites maize + boiled fermented soy beans.
FWM+BB = fermented white maize + boiled soy beans.
FWM =fermented white maize (Control)

Table 8: Proximate Analysis of *ogi* (%)

Ogi Sample	Moisture content	Crude protein	Crude fibre	fats	Carbohydrate
FYM+BFB	16.73±0.67	44.47±0.17	0.31±0.1	0.87±0.3	35.88±0.1
FYN+BB	18.04±0.1	53.31±0.1	0.38±0.1	0.86±0.1	34.74±0.1
FWM+BFB	16.73±0.3	44.44±0.6	0.31±0.6	0.89±0.4	35.86±0.1
FWN+BB	19.04±0.1	43.33±0.1	0.37±0.1	0.87±0.1	34.72±0.6
FWN (control)	12.86±0.2	14.65±0.1	0.20±0.7	2.91±0.13	75.96±0.2

Key: FYM+BFB = fermented yellow maize + boiled fermented soy beans.
FYM+BB = fermented yellow maize + boiled soy beans.
FWM+BFB =fermented whites maize + boiled fermented soy beans.
FWM+BB = fermented white maize + boiled soy beans.
FWM =fermented white maize (Control)

Table 9: Antibiotic susceptibility pattern of bacterial isolates

Isolates	Cotrimoxazol (25µg)	Ciprofloxacin (5µg)	Erythromycin (5 µg)	Gentamycin (10 µg)	Augmentin (30 µg)	Streptomycin (10 µg)	Tetracyclin (10 µg)	Chloramphenicol (10 µg)
Staphylococcus aureus	13	23	13	21	27	15	25	13
Steptococcus spp	19	27	15	19	12	15	27	17
Lactobacillus spp.	10	15	0	0	18	0	15	8
Bacillus spp.	13	23	13	21	27	15	15	13
Corynebacterium spp	14	19	27	15	27	17	11	12
Escherichia coli	10	15	0	12	0	27	15	19

Discussion

In this research work, white and yellow maize samples were fermented together with boiled soy beans of varied ratios for the improvements of nutritional status of fermented maize, *ogi*. The bacterial isolates are found to be associated with traditional fermentation of cereals and legumes as reported by Achi *et al.*, 2015 and Omemu *et al.*, 2017. The fungal isolates were found to have participated greatly in maize and soy bean fermentation as it's involved in alcohol production (Mbata *et al.*, 2010).

All the bacterial isolates were present at 0 h fermentation, but some gradually disappeared as the fermentation proceeded. The disappearance of *Staphylococcus aureus*, *Streptococcus* spp, *Corynebacterium* spp and *Escherichia coli* at the end of the fermentation could be attributed to their inability to survive and thrive in an acidic and alcoholic conditions caused by *Lactobacillus* spp and *Saccharomyces cerevisiae* respectively. However, the persistence of *Lactobacillus* spp, *Bacillus* spp, from the beginning of the fermentation to the end proves their ability to endure the metabolic by-products of the starter cultures. The organic acids, diacetyl, bacteriocins and hydrogen peroxides produced by the Lactic acid bacteria with the alcohols and Carbon dioxides produced by *Saccharomyces cerevisiae* in the fermentation medium helped in eliminating the food borne pathogens (*Staphylococcus aereus*, *Streptococcus* spp, *Corynebacterium* spp and *Escherichia coli*) thereby ensuring the safety of the ogi.

Among all the fungal isolates, only *Saccharomyces cerevisiae* was found at the end of the fermentation. *Aspergillus* spp, a food borne pathogen was eliminated from the fermentation by the mixture of antagonistic metabolites from Lactic acid bacteria and *Saccharomyces cerevisiae*. *Mucor*, *Penicillium* and *Rhizopus* species which are food spoilage organisms were also eliminated towards the end of the fermentation. Their disappearance encourages increase in the shelf life of the ogi especially in the rural localities where modern food refrigeration strategy is largely lacking. This finding is in agreement with Odunfa *et al.*, 2010 who said that *S. cerevisiae* can survive up to 60 hours during fermentation.

The fermentation mediums had different maximum and minimum pH values. Studies show that the lower the pH, the safer the food as the high acidic content of the food will help preserve the food for a longer by eliminating food borne pathogens and spoilers (Mbata *et al.*, 2010). This research shows that fermentation lowers the pH of the final product thus exerting preservative effect on the food. The low pH values of the fermented foods assists in longer stay of fermented foods in the rural area where refrigeration is not common.

The fermentation occurred at approximately the same temperature ranges (28.6-28.9°C). This slight increase in temperature may be attributed to the

metabolic activities of the microorganisms and represents the most active and important period of the fermentation. Studies have revealed that the α-amylase, proteolytic and lipolytic enzyme activities attained their maximum levels at 12-48 hr of fermentation. Thus, it could be the enzymes already produced rather than the presence of the microorganisms that continued the fermentation later (Odunfa *et al.*, 2010).

The Total Titritable acidity (TTA) values of the fermentation was found to be inversely proportional to the pH values as observed in the research work. This implies that the higher the TTA values in a particular sample, the lower the pH value of the same sample. This means that the lower the TTA values, the safer the food sample becomes (Omafube *et al.*, 2014). This means sample FYM + BB and the control would last longer than other food as they are most acidic samples.

An increase in moisture content shows a significant effect of thermal processes and is believed to have occurred as a result of hydrolytic activities of the organisms present (Akinele *et al.*, 2010). High moisture contents of fermented food makes it to spoil very easily as it cannot stand longer storage time especially in the absence of modern storage facility. Our result agrees with the work of Oshodi *et al.*, 2008 who recorded higher moisture content with the same sample.

The ash content of the *Ogi* was found to be very low in all the soybeans - containing samples compared with the control. The reduction in ash contents were most in the ogi samples fortified with boiled soy beans alone. This implies that boiling removes greater part of the ash content in the soy beans samples. Reduced ash contents have been reported by Enujuigha and Agbede (2000) in fermented yellow maize seeds and Oseni and Akindahunsi (2011) in fermented sorghum.

The high value of fats recorded from the unfermented maize sample shows that maize is a good source of fats. However, this finding is opposed to the result of Achi *et al,* (2015) which stated that fats are found more in fermented foods that their unfermented counterparts.

The sharp reduction in the carbohydrate values of the soy-beans fortified ogi samples could be due to the metabolic breakdown of the carbohydrates in the maize sample and utilization of the ensuing sugars as source of energy. Thermal processing (boiling) of soybeans led to greater loss of carbohydrates as seen in the lower carbohydrate values of the *ogi* fortified with boiled soybeans compared with the boiled and fermented soybeans. This study shows that the carbohydrate content of *Ogi* from fermented white maize (FWM) has a higher value compared to others that contain soybeans. The increase in the carbohydrate content observed was probably due to the inability of microbial enzymes amylase converting carbohydrate into sugars (Odunfa *et al.*, 2010, Sarkar *et al.*, 2017). The carbohydrate content in this study were higher when compared to the value obtained from Fermented yellow maize + boiled fermented beans as reported by Alinnor and Oze (2011). *Ogi* is an energy giving food and its carbohydrate is usually hydrolyzed through fermentation my microbial enzymes (Achi *et al.*, 2015). Thus, *ogi* is a good source of energy for its consumers.

This research noted that fermented yellow maize + BB has the highest protein content. Thus, a soy bean-protein containing *ogi* is good for the improvement of health status of the consumers. Hence, the *ogi* fortified with soy bean is a good source of protein which is needed in daily meal as it help reduce the rate of protein deficiency (Kwashiokor) among infants of the low and average income earners. The high mortality rate of infants and most susceptible young adults in West Africa is primarily as a result of poor nutritious content of their daily meals especially the cereals that are the staple foods in this region. Most diseases such as kwashiorkor normally occur as a result of poor diet (mostly food devoid of protein) (Achi *et al.*, 2015). Similar result in the fermentative improvement of nutritional status of *ogi* using Soybean has been recorded by Adeleke *et al.*, 2010.

Antibiotic susceptibility test shows that among all the bacterial isolates, 40.8% of them were resistant to the tested antibiotics while 50.2% were susceptible. This means that in case of outbreak of infections from the isolated pathogens, suitable antibiotics will be used to treat such infections.

Conclusion

This work shows that the nutritional status of *Ogi* was improved by fermentation through the addition of soy beans to the maize.

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