Bacteriological and Nutritional Assessment of Fermented Maize (Ogi) Fortified with Ugba (*Pentaclethra macrophylla*)

Itaman, V. O.* and Nwachukwu, E.
Department of Microbiology, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria.
*Corresponding author: Email: itamanvivien@yahoo.com

Abstract: Fermented maize (*Ogi*) is a traditional porridge prepared from maize, sorghum or millet grains majorly used as important weaning food for infants in West Africa but poor in protein content. "*Ugba*" is a protein based fermented food condiment obtained from the seeds of the African oil bean (*Pentaclethra macrophylla*) and used to complement the nutritional content of soups and sauces. The aim of this study was to assess the bacteriological and nutritive quality of complementary food made from fermented maize fortified with varying levels (100:00, 90:10%, 80:20%, 70:30%, 60:40% and 50:50%) of *ugba* blends. The physicochemical properties, bacteriological quality, proximate composition and sensory parameters of the samples were analysed using standard methods. The pH of the fortified *ogi* decreased steadily from 4.8 to 4.2 with a corresponding increase in titratable acidity from 0.75 to 1.3. The bacterial isolates included; *Staphylococcus aureus, Escherichia coli, Bacillus subtilis, Bacillus licheniformis*, *Micrococcus luteus, Pseudomonas aeruginosa, Lactobacillus* species and *Proteus mirabilis*. The nutritional values of the fortified product were significantly higher ($p<0.05$) compared to fermented maize (control) and increased steadily with increase level of *ugba* blends of 10% to 50%. The results revealed that fortified *ogi* had high protein content (8.75% ± 0.18 for 50%), fiber (1.47%± 0.12for 50%), fat (5.40% ±0.04 for 50%) and ash content (1.77% ± 0.10 for 50%). Based on the findings of the study, fortifying fermented maize (*ogi*) with *ugba* would promote the nutritional quality of *ogi* and provide a readily available and affordable weaning diet for infants.

Keywords: Fermented maize, fortified, bacteria, standards, *ugba*.

INTRODUCTION

Food fortification is the deliberate increase of the micronutrient content of food originally present or absent in the food prior to refinement leading to enhancement of the nutritive value and providing healthy benefit with low health risks to communities (FAO, 2010).Fortification of traditionally fermented food products serve as an important means of improving the concentration and bioavailability of the nutritional content of the food to the level that always exceed the native contents (John *et al*., 2017).

Fortification of food with micronutrients is animportant food-based approach for reducing micronutrient malnutrition especially when existing food supplies fail to provide the adequate levels of therespective nutrients needed in the diet (FAO, 2010; John *et al*., 2017). Staple foods that are commonly fortified include cereals and cereal based products, milk and milk products, fats and oils, infant formulas, accessory food items, flours, bread, rice, milk, margarine, salt, sugar, cookies, soy milk and orange juice (Darnton-Hill and Mkparu, 2015).

Cereals like wheat, rice, maize and millets are staple food grain for most people across the globe because they are rich in supplying nutrients such as carbohydrates and calorie. Also, processing cereal grains to traditional products leads to the development of newer products that offer better, diversified products, cheaper and improved nutritional qualities. Maize grains undergo a variety of indigenous processes involving diverse microbes (such as Lactic acid bacteria and yeasts) in order to be transformed into an intermediate or finished product with a stable shelf-life, improved digestibility and desirable organoleptic properties (Sefa-Dedeh *et al*., 2000).

Fermented maize (*Ogi*) is a traditional porridge prepared from maize, sorghum or millet grains (Abioye and Aka, 2015) and majorly used as important weaning food for infants in West Africa.

Improvement of the nutritional or protein quality of *ogi* can be done by supplementing the products with a very high protein crop such as legume to be suitable as weaning foods. Hence, the need for the production and formulation of cereal-legume blends in the production of porridges for children of weaning age (Ajanaku *et al*., 2017; Okoye and Egbujie, 2018).

Legumes are important in providing the human diet with essential amino acids, complex carbohydrates, dietary fibre, unsaturated fats, vitamins, essential minerals and phytochemical substances (Rungruangmaitree and Jiraungkoorskul, 2017). *Ugba* (a legume) is a protein based fermented food condiment obtained from the seeds of the African oil bean (*Pentaclethra macrophylla*) and used to complement the nutritional content of soups and sauces.The fermenting seeds undergo uncontrolled fermentation and it has beenobserved that the fermenting seeds harbor a variety of microorganisms such as *Staphylococcus* sp., *Micrococcus* sp, and *Bacillus* sp. and these organisms could come from different sources such as: the hands of handlers, utensils used in processing, water used for washing and the leaves used in packaging (Enujiugha, 2009).

In order to resolve the problems of micronutrient deficiencies and stop their reoccurrence, it is necessary to fortify these foods based on the nutritional needs of the country's population and their dietary practices (Barkley *et al*., 2015).The aim of this research is to determine the quality characteristics of fermented maize (*ogi*)fortified with fermented *ugba* blends.

MATERIALS AND METHODS

Sample collection

Maize grains (*Zea mays*) and African oil bean seeds (*Pentaclethra macrophylla)* used in this study were purchased from Isi-gate market located in Umuahia, Abia state, Nigeria. They were transported to the laboratory in cleaned polyethylene bags for further analyses.

Sample preparation and fermentation of maize seeds and African oil bean seeds

Cleaned selected maize grains were measured (1kg) and soaked in water for 24 - 72 hours at room temperature (28 ± 2°C). The steep water was discarded by decantation and the grainswet-milled in a stainless local corn mill using a disc attrition mill (Hunt No. 2A premier mill, Hunt and Co, UK) to an average particle size of less than 0.3 mm. The milled grain was then sieved through a fine mesh sieve (200µm/0.2mm) to obtain the fermented maize flour. The dough samples were allowed to ferment spontaneously at ambient temperature (28°C) for five days (Mbata *et al*., 2009).

The oil bean seeds were washed and boiled in an autoclave at a temperature of 121°C and a pressure of 15 pounds per square inch (psi) for 1 hour to soften the hard brown testa (shell). The shells were removed and the kernels washed, drained and rewashed with cold water five times. The washed kernels were cut into long thin slices. These slices were measured, mixed with salt, ground and allowed to ferment at room temperature for five days (Eze *et al.*, 2014).

Fortification of fermented maize (*Ogi*) with *ugba* blends

The fermented maize to *ugba* blends were in the ratios of 100:00, 90:10%, 80:20%, 70:30%, 60:40% and 50:50%. The 100% maize *ogi* served as the control sample. They were packaged in different air tight (closed) containers, labeled and the mixtures allowed to ferment for 5 days. They were stored at 4°C till further analyses.

Physico-Chemical Analysis

The samples (70% *ogi* and 30% *ugba*) were taken during fermentation and analyzed for total titratable acidity and pH in triplicates at 0, 48 and 96 hours.

pH determination: The pH of the samples was determined according to the method of AOAC(2002).

The pH of the slurry (by mixing 5g of the sample in 50ml of distilled water in triplicate) was determined using a digital pH meter (model METTLER DELTA 340, Tokyo, Japan) after calibration using pH 4.0 and pH 7.0 buffers (0.1N NaOHwith 1% phenolphthalein).

Total titratable acidity (T.T.A): The slury from 5g in 50ml of water was filtered using 1 drop of phenolphthalein as indicator and the acidity was calculated as grams lactic acid/100milliliters (Joslyn, 1970).

Isolation and identification of bacteria

1 gram each of the samples were serially diluted using ten-fold dilutions and 1 ml aliquots of selected (10^{-5},10^{-6},10^{-7}) dilutions were inoculated into sterile plates of Nutrient agar (NA), MacConkey agar (MCA), Mannitol salt agar (MSA), and De-Mann Rogosa-sharpe (MRS) agar, respectively using the pour plate technique (Theophilus *et al*., 2015). Nutrient agar (NA), MCA, and MSA plates were incubated at 37^0C for 24 hours; MRS plates were incubated anaerobically in an anaerobic jar at 30^0C for 48 to 72 hours (Theophilus *et al*., 2015). Distinct colonies were randomly selected and sub-cultured onto NA, MCA, MSA and MRS plates to obtain pure cultures. Identification of the selected isolates were carried out morphologically and biochemically. Thus, colonies were examined for their characteristic features macroscopically and microscopically and further, subjected to biochemical tests and Gram's reaction (Cheesbrough, 2006).

Proximate Analysis

The samples were analyzed by standard procedures as adopted by America Organization of Analytical Chemist (AOAC, 1990, 1998, and 2000) methods for protein, carbohydrate, moisture, fat, ash and fibre contents. Moisture content was determined by weight loss of 5g of sample after heating in an oven at 105 ^{o}C for 3hrs. The ash content was measured by burning the sample at 550^0C in a muffle furnace until a light grey ash was observed and constant weight obtained. Protein content was determined by Kjeldahl method. The total nitrogen (N_2) was determined and multiplied by factor 6.25. Fat content was determined by ether extraction method using a glass soxhlet. The crude fibre content was determined using fibretec extraction. The total carbohydrate content was determined by difference between 100 and total sum of the percentage of fat, moisture, ash, crude fibre and protein content.

Sensory Analysis

Sensory characteristics of the supplemented samples were assessed by a panel of 15 professionals drawn from nursing mothers, women and men among the students and staff of Microbiology and Centre for Molecular Bioscience and Biotechnology (CMBB), Michael Okpara University of Agriculture, Umudike, Abia state. Ready to serve blends of fermented maize pudding (*ogi*) from various blends and the control were prepared by the traditional method of mixing the flour with little amount of water and then adding boiling water to the paste until a pudding-like consistency was obtained. The samples were served hot on randomly coded plates. They were assessed and rated for their colour, texture, flavour (aroma), taste and overall acceptability while instructing the panelists to sip water before and after assessing each product. The sensory characteristics rating of each sample was done using the 8 - point hedonic scale as described by Ihekoronye and Ngoddy (1985), where 1 = dislike extremely and 8 = like extremely. Each treatment was evaluated three times by each panelist.

Statistical Analysis

All data collected were analyzed using one-way analysis of variance (one-way ANOVA) by using the Statistical Package for Social Sciences (SPSS Inc, Chicago, USA) program version 17.0. Duncan test was used to determine the significant differences between the variables at $p < 0.05$.

RESULTS

Figure 1 shows the pH changes in the fermenting samples. The pH of the fortified samples (70% *ogi*: 30% *ugba*) decreased from 4.8 ± 0.10 at 0 hr to 4.2 ± 0.10 at 96 hrs. In figure 2, an increase in the TTA value was observed. The fortified samples increased from 0.75 ± 0.00 at 0 hr to 1.3 ± 0.28 at 96hrs.

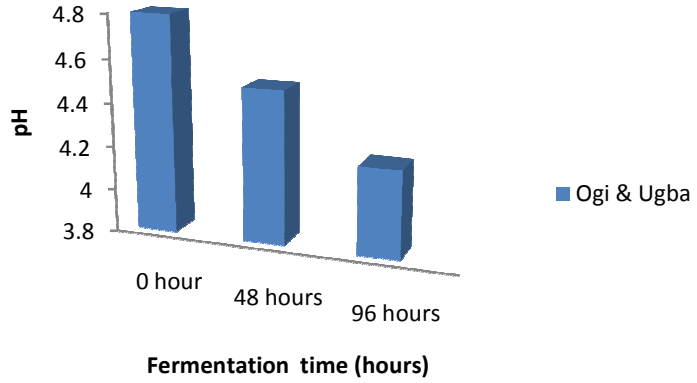

Figure 1: pH of Fermented Maize (*Ogi*) Fortified with *Ugba*at 0 to 96 Hours of Fermentation Period.

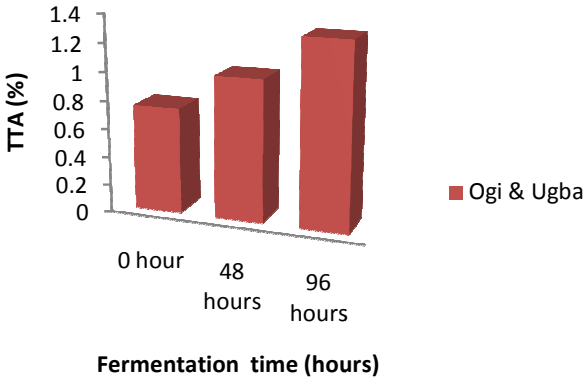

Figure 2: Titratable Acidity (TTA) of Fermented Maize (*Ogi*) Fortified with *ugba*at 0 to 96 Hours of Fermentation Period.

Table 1 shows the total bacteria counts, total coliforms counts, total lactic acid bacteria counts and total *Staphylococcus* counts of the samplesduring fermentation from 0 hour to 96 hours. The bacterial isolates present in the samples during the fermentation hours were; *Staphylococcus aureus, Escherichia coli, Bacillus subtilis, Bacillus licheniformis*, *Micrococcus luteus, Pseudomonas aeruginosa, Lactobacillus* species and *Proteus mirabilis* (Table 2).

Table 1: Bacterial Counts of *Ogi* Fortified with *Ugba* during Fermentation.

Samples/ Fermentation Hours	0 hour	48 hours	96 hours
Total Bacteria Counts (cfu/g)	$1.4\times10^{6} \pm 2.65^{b}$	$1.0\times10^{6} \pm 4.00^{f}$	$4.2\times10^{5} \pm 0.00^{g}$
Total Coliforms Counts (cfu/g)	$2.9\times10^{6} \pm 2.08^{a}$	$1.3\times10^{5} \pm 3.06^{f}$	$6.0\times10^{4} \pm 1.00^{g}$
Total Lab Counts (cfu/g)	$3.3\times10^{5} \pm 2.65^{e}$	$5.0\times10^{5} \pm 2.65^{d}$	$8.0\times10^{5} \pm 4.00^{b}$
Total Staphylococcus Counts (cfu/g)	$2.4\times10^{6} \pm 3.60^{a}$	$0.0\times10^{4} \pm 0.00^{f}$	$0.0\times10^{4} \pm 0.00^{f}$

Values are means of triplicate analysis ± standard deviation. Figures with different superscripts in the same column are significantly different ($P \leq 0.05$).

Table 2: Biochemical Characterization of Bacteria

Isolate code	Gram stain reaction	Cellular morphology	Catalase	Oxidase	Coagulase	Motility	Indole	Methyl red	Vp	Citrate	No_3	Spore	Sugar Fermentation: Glucose	Lactose	Sucrose	Maltose	Fructose	Mannitol	Probable organism
1	+	Clustered oval (cocci)cells	+	-	+	-	-	+	-	-	+	-	+	+	+	+	+	+	*Staphylococcus aureus*
2	-	Short rods	+	-	-	+	+	+	-	-	+	-	+	+	+	+	-	+	*Escherichia coli*
3	+	Single rods	+	-	-	+	-	-	+	+	+	+	+	-	+	+	+	+	*Bacillus subtilis*
4	+	Clustered rods	+	-	-	+	-	-	+	+	+	+	+	+	+	+	+	+	*Bacillus licheniformis*
5	+	Oval cells in single and pairs (clusters)	+	+	-	-	-	-	+	+	-	-	-	-	-	-	-	-	*MicrococusLuteus*
6	-	Short rods	+	+	-	+	-	+	-	+	+	-	+	-	-	-	-	+	*Pseudomonas aeruginosa*
7	+	Short rods	-	-	-	-	-	-	+	-	-	-	+	+	+	+	+	-	*Lactobacillus* species
8	-	Short rods	+	-	-	+	-	+	-	+	+	-	+	-	-	-	+	-	*Proteus mirabilis*

Table 3 shows the proximate composition of fermented maize (*ogi*) supplemented with levels (10 – 50%) of *ugba* blends. The supplemented product (*Ogi* and *ugba* blends) had higher values of ash, crude protein, fibre, and total fat, while fermented maize (*ogi*) alone, had higher values in moisture and carbohydrate than in the fortified samples (Table 3). The control sample (100%*Ogi*) had high carbohydrate content (36.69%), but low crude protein content (5.78%).

Table 3: Proximate Analysis of Fermented Maize (*Ogi*) Fortified with *Ugba* Blends

Blending Ratios of Fermented Maize And Ugba Blends(%)	Crude Protein (%) ± SD	Fat (%) ± SD	Fibre(%) ± SD	Ash (%) ± SD	Moisture Content (%) ± SD	Carbohydrate (%) ± SD
A (100:00)	5.78± 0.18 ^{d}	0.23±0.01^{e}	0.33±0.12 ^{d}	0.53± 0.12 ^{d}	56.53±0.12 ^{a}	36.60 ± 0.03^{a}
B (90:10)	6.10± 0.10 ^{c}	1.20±0.01^{d}	0.36±0.12 ^{d}	0.56± 0.11^{c}	55.57±0.03^{b}	36.21 ± 0.19^{b}
C (80:20)	6.29 ± 0.10 ^{c}	2.21±0.02^{c}	1.30±0.12 ^{c}	0.58± 0.11 ^{c}	54.67±0.04 ^{c}	34.95± 0.25^{c}
D (70:30)	7.52± 0.12 ^{b}	3.43±0.03^{b}	1.40± 0.12^{b}	1.73 ± 0.12^{b}	53.47±0.12 ^{d}	32.45 ± 0.23^{d}
E (60:40)	8.29 ±0.15^{a}	5.11±0.05^{a}	1.45± 0.12^{a}	1.76 ± 0.10^{a}	52.52± 0.24^{e}	30.87 ± 0.45^{e}
F (50:50)	8.75 ± 0.18 ^{a}	5.40±0.04^{a}	1.47± 0.12^{a}	1.77 ± 0.10^{a}	52.10± 0.10^{e}	30.51±0.88^{e}

Values are means of triplicate analysis ± standard deviation. Figures with different superscripts in the same column are significantly different ($P \leq 0.05$).

Key:A= 100%: 0 (*Ogi*), B= 90% *Ogi*:10%*Ugba,* C= 80% *Ogi*:20%*Ugba,* D=70% *Ogi*:30%*Ugba,* E= 60% *Ogi*:40% *Ugba*, and F= 50% *Ogi*:50%*Ugba*

A comparison of the mean sensory evaluation of *ogi* pudding prepared from fermented maize blended with *ugba* at different ratios (B= 90:10%, C= 80:20%, D=70:30%, E= 60:40% and F= 50:50%) and 100% *ogi* pudding (A= 100: 0; control) are shown in Table 4. The mean sensory score of the control pudding and those of the blended pudding differed in flavour, colour, taste, texture and total acceptability. Sample A differed significantly from samples B, C, D, E and F in terms of flavour and colour and was most preferred while sample F (5.53) was the least preferred.

There were no significant differences among samples D (6.53) and E (6.40) in terms of the colour as they were liked moderately, sample B (7.73) and A (7.86) were liked very much as there was also no significant difference between them but sample A was most preferred while sample F (5.20) was the least preferred. Also, a dissimilar trend was seen in terms of taste as sample D (7.13) was rated highest as it was liked very much especially by the nursing mothers, this was followed by sample E (7.09) that was also liked very much. Although, there were no significant differences between samples A and B in terms of texture, the texture preferences reduced as the blending increases from 5% to 25%. Sample A (7.86) was rated best followed by sample B (7.27) while sample F (5.00) was rated least.

Table 4: Sensory Evaluation of *Ogi* Blended with *Ugba* at Different Ratios

Parameters	Flavour	Colour	Taste	Texture	Total acceptance
A (100% O)	7.13± 1.21^{a}	7.86± 1.73^{a}	7.13± 1.33^{a}	7.86± 1.53^{a}	7.73± 1.33^{a}
B (90% O:10%U)	7.00± 1.16^{a}	7.73± 1.53^{b}	7.07± 1.27^{b}	7.27± 1.43^{b}	7.53± 1.27^{b}
C (80% O:20%U)	6.34± 1.10^{c}	6.93± 1.32^{c}	7.00± 1.16^{d}	6.80± 1.29^{c}	7.00± 1.18^{d}
D (70% O:30%U)	6.93± 1.12^{b}	6.53± 1.28^{d}	7.13± 1.33^{a}	6.33± 1.28^{c}	7.07± 1.21^{c}
E (60% O:40%U)	6.73± 1.11^{b}	6.40± 1.17^{e}	7.09± 1.29^{b}	6.07± 1.26^{d}	7.05± 1.21^{c}
F (50% O:50%U)	5.53± 1.08^{d}	5.20± 1.10^{f}	5.73± 1.07^{c}	5.00± 1.03^{e}	5.67± 1.11^{e}

Values are means of triplicate analysis ± standard deviation. Figures with different superscripts in the same column are significantly different ($P \leq 0.05$).

Key: A= 100% *Ogi* pudding; B= 90% *Ogi* pudding and 10% *ugba* flour blends; C= 80% *Ogi* pudding and 20% grinded *ugba* flour blends;D= 70% *Ogi* pudding and 30% grinded *ugba* flour blends; E= 60% *Ogi* pudding and 40% grinded *ugba* flour blends; F= 50% *Ogi* pudding and 50% grinded *ugba* flour blends.

DISCUSSION

In this study, decrease in pH during fermentation of the samples (*Ogi* and *ugba*) with a corresponding increase in total titratable acidity were observed (figure 1 and 2) which is in accordance with previous reports. A similar increase in acid production had been observed by Sefa-Dedeh *et al*. (2001) during the production of weaning food from maize-cowpea blends. Several authors have reported a decrease in pH and an increase in titratable acidity during steeping of whole maize grains and fermentation of maize dough in *kenkey* production (Halm *et al*., 1993; Halm *et al*., 2004). This could probably be due to availability of more nutrients for enhanced metabolic activities and microbial proliferation leading to the production of acids by the fermentative organisms especially Lactic Acid Bacteria (Ojo and Enujiugha, 2016; Modu *et al.* 2013; Adesokan *et al*., 2009). It could also be as a result of the utilization of free sugars by yeasts and Lactic acid bacteria (LAB) as these fermenting organisms are able to produce amylolytic enzymes capable of breaking down starch substrates to reducing sugars (Wakil and Daodu, 2011). These microbial activities during fermentation lead to improved nutritional content of the fermented product. The early production of carboxylic acid and the consequent rise in total titratable acidity is important in preventing the proliferation of undesirable organisms that may lead to poor fermentation. The increase in acidity is of great importance in infants that consume fermented maize pudding as it has been reported to reduce the incidence of diarrhea in these infants (Mensah *et al*., 1990).

A wide variety of microorganisms were found associated with *ogi* fortified with *ugba* in this study. Bacteria isolated were *Staphylococcus aureus, Escherichia coli, Bacillus subtilis, Bacillus licheniformis*, *Micrococcus luteus, Pseudomonas aeruginosa, Lactobacillus* species and *Proteus mirabilis*. Emeka-Ike *et al.* (2019) isolated *Lactobacillus* sp., *Bacillus* sp., *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Escherichia coli*, *Saccharomyces cerevisiae*, *Penicillium* sp. and *Aspergillus* sp. from powdered pap made from maize and malted maize with carrot. Similarly, Ihuoma *et al.*, (2021), Ezendianefo and Dimejesi, (2014) and Ogodo *et al.* (2015) have reported the presence of similar bacteria and fungi genera in powdered *ogi* fortified with walnut flour in commercialized *ogi* sampled from different locations. Some of these microbial genera were also reported in this study. The bacteria in the fermenting maize fortified samples may be derived from the grains and/ or flours, utensils, handlers and possibly from the tap water used for mixing (Mbata *et al*., 2009). The presence of these different bacterial genera could deteriorate the quality of food and probably cause food borne diseases.

The supplemented product (*ogi*and *ugba* blends) had higher values of ash, crude protein, fibre, and total fat. The consistent increase in protein content with increasing levels of *ugba* blends supplementation could be attributed to higher protein content in *ugba* blends. This implies that percentage protein increase in *ogi* could be enhanced by fortifying it with *ugba*. This could lead to the improvement of the nutritional status of *ogi*.

The protein content obtained was lower than the one obtained by Enujiugha, (2006) and Theodore *et al*., (2009) who reported protein values of up to 33.25% at a ratio of 60:40 and 16.4% at a ratio of 80:20 fortifying *Ogi* using *ugba* flour and bambara nut flour respectively. The result is consistent with other reports on the improvement in quality of cereals as observed by Onilude *et al.* (2004); Wakil and Onilude (2009) and Adeyemo and Onilude (2013). This result showed that the carbohydrate content of the *ogi*decreases when fortified with various blends of *ugba*.

The decrease in the carbohydrate content could be attributed to the fortification of *ogi* (carbohydrate source) with African oil bean (*ugba*) at different ratios. This agrees with the results reported by Onilude *et al.* (2004) and Wakil and Onilude (2009) that addition of legume decreases the carbohydrate content cereal based traditional foods. Also, the action of microorganisms degrading starch into sugars during fermentation could result in an increase in sugar content and a decrease in starch level (Huang and Zhang, 2011). This degradation would improve the nutritive value and further enhance absorption and digestibility of the gruel produced.

Fat content of the blends increased significantly ($p<0.05$) with increase level of *ugba* fortification. This increase is obviously linked with the fat content of *ugba*. This is in contrast to Enujiugha, (2006) who did a similar work and reported higher fat values of up to 17.7% at a ratio of 60:40. Fat serves as energy store in the body that can be broken down in the body to release glycerol and free fatty acids. Fats help in the development of baby's brain, 60% of the brain and sheath surrounding the nerves are composed of fat (Ajala *et al*., 2014).The results showed that *ugba* is a good source of fats and variation in the values maybe due to different factors such as the use of different varieties and subjecting them to different experimental conditions.

Fibre content of the blends increased significantly ($p<0.05$) with increase level of *ugba* fortification, but all the samples had fiber contents that were within the recommended range for diets which is usually less than 5 g dietary fiber per 100 g dry matter (Ajala *et al*., 2014). The values obtained were comparable with those obtained by Enujiugha, (2006) and Ahaotu *et al.* (2021). It is of utmost importance for weaning foods to contain low fiber content as it will help children in consuming more nutrient-dense foods, thereby enabling them to meet up vital nutrient requirements and their daily energy (Shima *et al*., 2019).

The ash content of the food blends increased significantly ($p<0.05$)with the increased addition of *ugba*. This result showed that the values of the ash contents of the samples in thiswork were higher when compared to the values reported by Onilude *et al.*, 1999 which ranged from 0.4-0.8%.This result indicated that the samples could be good sources of nutritionally essential minerals and trace elements if further examined. Ash content is a function of the amount of minerals available to enhance the diet. It depicts total mineral of foods (Farinde, 2015) indicating that the supplementation improved the mineral content of the fermented maize (*ogi*). Dietary minerals play important nutritional roles such as manufacture of blood cells (calcium), osmoregulation by the electrolytes (potassium and sodium), functioning as cofactors (selenium, manganese and zinc) and immune boosters (phosphorus) (Farinde, 2015).

The moisture content of the fortified *ogi*was found to be lower than the control (unfortified *ogi* sample) which is an indication of good shelf life. This is because food spoilage organism thrives where there is adequate moisture (Edema *et al*., 2005). Variations in carbohydrate (decrease) were consequent upon the changes in the other components of proximate. The carbohydrate content decreased with increased protein content; thus resulting in a high energy protein balanced food. This had similar scenario with other research works (Ajanaku *et al*., 2012; Fikiru ***e****t al*., 2017) that made use of fortification process with groundnut, roasted pea, soybeans and yam flour. Fortifying *ogi* with *ugba* will result in meeting the nutritional demands for weaning infants and adult feeding in developing countries.

The results obtained on the sensory evaluation of pudding prepared from fermented maize (*og*i) complemented with *ugba* blends and the control (*ogi*) is shown in Table 4. The mean sensory score of the control and the various blends of the

complemented pudding differed in flavour, colour, taste, texture and total acceptability.

The variation in the proportion of the *ugba* blends resulted in differences in the sensory attributes measured. The control A (100:0) had overall acceptability in all the sensory attributes studied. This could be because of the familiarity in taste, flavour and colour of *ogi*. However, sample blend in the ratio (90:10) of sample B was most generally accepted among the blended samples, followed by sample blend of ratio (70:30) of sample D. In a related study, Barber and Obinna-Echem (2017) reported that the level of likeness of wheat-African walnut cookies in terms of appearance, taste, texture, flavor and overall acceptability reduced with increase in proportion of African walnut flour added to wheat flour. The acceptability of the *ogi* pudding with 10% and 30% of *ugba* blends were better preferred by the test panelists owing to the improved nutritional and organoleptic status of the *ogi.*

CONCLUSION

This study revealed that fortification of fermented maize (cereal) with *ugba* blends (legume) helped to increase the protein and mineral (ash) content and reduce the carbohydrate content which are essential for child growth and development. A good indication from this study revealed *ugba* as a healthy nourishment that is beneficial, readily available and affordable blend in maize-*Ogi* weaning diet for infants. A good supplemental relationship thus exists between fermented maize and *ugba.*

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