



## Effect of enrichment with turmeric and ginger on some quality characteristics of fermented maize *Ogi*

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### ABSTRACT

*Ogi* is a fermented maize product which is commonly used as weaning food for children and as breakfast for adults. This study was conducted to evaluate the effect of enrichment with turmeric and ginger on some quality parameters of *ogi* flour. Turmeric and ginger slurries were prepared and added to the *ogi* slurry at different percentages as follows: 0CC (100% *ogi*), GN1 (95% *ogi* + 5% ginger), GN2 (90% *ogi* + 10% ginger), GN3 (85% *ogi* + 15% ginger), TM1 (95% *ogi* + 5% turmeric), TM2 (90% *ogi* + 10% turmeric) and TM3 (85% *ogi* + 15% turmeric). The samples were fermented for 48 h, dried at 55 °C for 24 h to flour and then packaged. Microbial, pH and total titratable acidity (TTA) evaluations were carried out on the samples during fermentation. Nutritional and anti-nutritional contents were also determined. Results showed that the pH of the spiced *ogi* slurry decreased as total titratable acidity increased during fermentation. The proximate composition showed significant differences ( $p \leq 0.05$ ) and increased with the addition of ginger and turmeric, respectively. Considering the ash, crude fat and crude protein contents, the sample TM1 had the highest value of 1.21, 5.92, and 11.89%, while the sample 0CC had the lowest value of 0.64, 3.64, and 5.58%, respectively. The vitamin determinations showed that the sample TM3 had the highest values of vitamin B<sub>2</sub>, B<sub>6</sub> and D. The highest value was recorded in Vitamin C for the sample GN3 (85% *ogi* + 15% ginger), while the lowest value was recorded in the sample TM1 (95% *ogi* + 5% turmeric). Tannin, phytate and trypsin inhibitor showed the highest values in the sample TM3. The sensory evaluation showed that the sample GN1 was the most preferred sample. The study established that the enrichment of *ogi* with turmeric and ginger slurries will improve the nutritional status of major consumers of *ogi*.

## Introduction

Traditional fermented foods are prepared from the most common types of cereals (such as corn, wheat or sorghum). They are well known in many parts of the world (Wakil and Daodu, 2011). One common example of indigenous fermented foods in Nigeria is *ogi*. It is a fermented starchy paste which is traditionally obtained by the submerged fermentation of some cereals (Awoyale et al., 2016). It is made from some cereal based feedstock such as maize (*Zea mays*), millet (*Pennisetum typhoides*), sorghum (*Sorghum bicolor*) or Guinea

corn (*Sorghum spacers*) (Adegbehingbe, 2014). *Ogi* porridge has a smooth texture similar to a hot blancmange and a sour taste reminiscent of yoghurt. The colour of *ogi* depends on the colour of the used cereal; cream or milk-white for maize, reddish-brown for sorghum and dirty grey for millet. Traditionally, *ogi* is processed, prepared and consumed without the addition of spices. However, in the recent time, local consumption pattern has moved towards the inclusion of different single or combined spices by the local processors with the view to improving the quality of the products. Spices are culinary herbs which have aromatic or pungent flavour. They are dried seeds, fruit or vegetable substances used in

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the preparation of foods to enhance the flavour of such food (Shakuntala and Shadaksharaswamy, 2008). Spices do not only excite taste, they are composed of high-quality phytonutrients, essential oils, antioxidants, minerals and vitamins that are essential for overall health sustenance (Umesh, 2014). Ginger (*Zingiber officinale*) is a flowering plant that is closely related to turmeric and cardamom. The health benefits of ginger are largely due to its antioxidant, anti-inflammatory properties and the content of therapeutic compounds like gingerol, shogaol, paradol and zingerone. Turmeric (*Curcuma longa*) is a flowering plant of the ginger family *Zingiberaceae*, the roots of which are used in cooking (Priyadasini, 2014). Some of the challenges facing the production of *ogi* are nutrient losses which occur at different stages of its production (Awoyale et al., 2016), contamination by microorganisms, as well as consumer acceptability of white *ogi*. Therefore, food ingredients that could be added to alter its nutrient composition, prevent microbial contamination and at the same time impart colour and taste are needed. This study aimed at investigating the effect of the addition of ginger and turmeric on the nutritional and microbial quality of *ogi* produced from white maize.

## Materials and methods

### Collection of samples

Maize (*Zea mays*), turmeric (*Cucuma longa*) and ginger (*Zingiber officinale*) used in this study were purchased from open market in Ota, Sango Ota metropolis, Ogun state, Nigeria.

### Processing methods

The maize grains were sorted to remove extraneous materials and unwholesome grains, after which the grains were washed and steeped in clean water for 48 h at room temperature. The water was decanted after 48 h and the maize was wet-milled into slurry using the Imex 100901231 Attrition mill (Europe). Sieving was done using a muslin cloth to separate the pomace from the filtrate. The spices were processed separately by washing manually with clean water, peeled with a sharp knife, sliced, weighed and then milled into slurry, using a sterile Euro 750 Laboratory Blender (Harsh Electricals, India). Then, ginger and turmeric slurries of different weight were added to the *ogi* slurry to give rise to 7 different percentages of spiced *ogi* as follows; 100% *ogi* (control, 0CC), 95% *ogi*+ 5% ginger (GN1), 90% *ogi*

+ 10% ginger (GN2), 85% *ogi* + 15% ginger (GN3), 95% *ogi* + 5% turmeric (TM1), 90% *ogi* + 10% turmeric (TM2), 85% *ogi* + 15% turmeric (TM3). The new formulations were allowed to ferment for 48 h, after which they were dewatered and dried using a laboratory oven (Uniscope SM 9123, Surgifriend Medicals, England) at 55 °C for 24 h. The dried samples were milled using a sterile laboratory blender and sifted using a 500 µm sieve in order to obtain fine spiced *ogi* flour. After sieving, each sample of spiced *ogi* flour was later carefully packaged in ziplock polythene bags, labelled and stored at room temperature for further analyses (Fig. 1).

### Microbial analysis

Total bacterial counts, lactic acid bacterial count, fungal counts and coliforms counts were determined at 0, 24 and 48 h of fermentation to evaluate the effect of spices (ginger and turmeric) on fermenting microorganisms, spoilage organisms and total bacterial counts. The method described by Atanda and Akano (1997) was used. Each sample (10 g) was added to 90 mL 0.9% saline to make a stock solution. This formed the initial dilution from which subsequent ten-fold dilutions were made and used for analyses. Portions (1 mL) of 4<sup>th</sup> diluent (10<sup>-4</sup>) was pour plated on Nutrient agar for the total bacterial count, Man-Rogosa Sharpe (MRS) agar for the lactic acid bacterial count, Potato Dextrose agar for fungal count and MacConkey agar for the coliform count. Analyses were carried out under aseptic conditions. Plates were incubated for 24 h at 37 °C for the bacterial count and 48 h at 25 °C for the fungal count. Colonies were counted and multiplied by the dilution factor and expressed as CFU/g sample.

### Determination of pH and titratable acidity

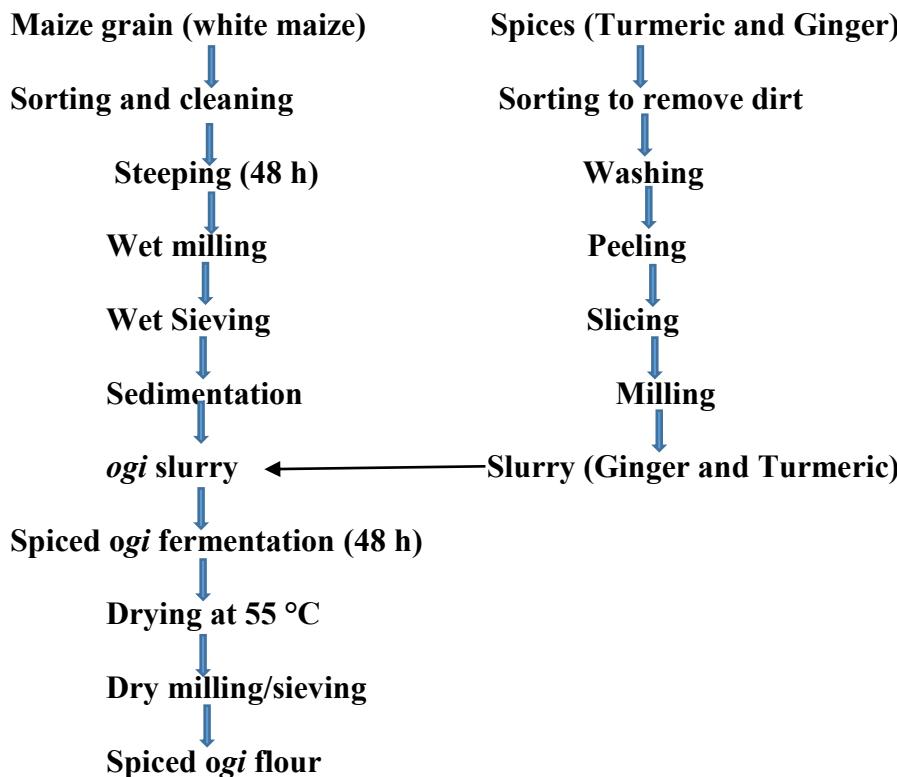
The pH of different percentages of *ogi*/spices slurries was determined during fermentation, at 0, 24 and 48 h, using the method described by AOAC (2000).

### Proximate analyses

Proximate analyses were carried out on the samples using standard AOAC (2010) methods. Moisture content was calculated after drying at 105 °C to constant weight in an air oven (Uniscope SM9053, England). Fats were estimated by the extraction of a known weight of samples with petroleum ether using rapid Soxhlet extraction apparatus (Gerhardt Soxtherm SE- 416, Germany). Determination of protein was done using Kjeldahl method. The

efficiency of the nitrogen values was corrected with acetanilide values and multiplied by the factor of 6.25 to obtain the protein value. Ash was determined gravimetrically after incineration in a muffle furnace for 24 h at 550 °C. The crude fibre was obtained by the difference after the incineration of the ash-less

filter paper containing the insoluble materials from the hydrolysis and washing of moisture-free defatted sample (0.5 g). Carbohydrate content was determined by the difference: 100% - (% MC + % Ash + % Crude protein + % Fat + % Crude fibre).



**Fig. 1.** Flow chart for the production of the spiced *ogi* flour (Akingbala et al., 2003)

#### Determination of vitamins

Vitamins B<sub>2</sub>, B<sub>6</sub> C and D of the different formulations of the spiced *ogi* flour were determined immediately after production according to standard methods as described by AOAC (2010).

#### Determination of vitamin B<sub>2</sub> (riboflavin)

Vitamin B<sub>2</sub> was determined as described by AOAC, (2010). Accurately weighed 1.5 g of sample was introduced into a 200 mL volumetric flask; 100 mL of acetic acid: water mixture (50:50) was added and heated on a boiling water bath at 100 °C for 30 min. The mixture in the flask was cooled to 20 °C, then made up to the mark with the acetic acid-water solution. The mixture was stirred for 10 min using the stirrer and then filtered in the dark. The first

20 mL of the filtrate was discarded, 0.5 mg of riboflavin standard solution was prepared, and 10 mL of the standard solution was transferred into a 200 mL volumetric flask and treated similarly as the sample above. The fluorescence of the standard and sample solutions was read using a spectrophotometer at 460 nm wavelength. The amount of riboflavin in each sample was calculated.

#### Determination of vitamin B<sub>6</sub> (pyridoxine)

Vitamin B<sub>6</sub> was determined as described by (AOAC, 2000). Sample (1 g) was weighed into a 100 mL beaker, 0.5 g of ammonium chloride, 45 mL of chloroform and 5 mL of absolute alcohol were added to extract all the pyridoxine (Vit. B<sub>6</sub>). The mixture was thoroughly mixed in a separating funnel by shaking properly for 30 min. Five milliliters of

distilled water was added to the mixture in the separating funnel to separate the aqueous layer from the chloroform layer. The chloroform layer containing the pyridoxine was filtered into a 100 mL volumetric flask and made up to mark with chloroform. 0-10 ppm of vitamin B<sub>6</sub> or Pyridoxine standard were prepared from 100 pm stock standard solution of pyridoxine and treated in a similar way as sample to obtain the gradient factor. The absorbance of a yellowish colour solution developed was measured on a Cecil 505E Spectrophotometer at a wavelength of 415 nm. Vitamin B6 in mg/100 g was calculated using the formula;

$$\text{Vit. B}_6 \text{ (mg/100g)} = \frac{\text{Absorbance of sample} \times \text{Gradient factor} \times \text{Dilution factor}}{\text{Weight of sample} \times 100}$$

#### Determination of vitamin C (Ascorbic acid)

Vitamin C was determined as described by (AOAC, 2000). The sample (10 g) slurry was weighed into a 100 ml volumetric flask and diluted to 100 mL with 3% meta phosphoric acid solution (0.0033 M EDTA). The diluted samples were filtered using a Whatman filter paper No.3. The filtrate (10 mL) was pipetted into a small flask and titrated immediately with a standardized solution of 2,6-dichlorophenol-indophenol to a faint pink end point. The ascorbic acid content was calculated from the relationship below:

$$\frac{V \times T}{W} \times 100 = \text{mg ascorbic acid per 100 g sample}$$

Where:

V = mL dye used for titration of an aliquot of diluted sample

T = ascorbic acid equivalent of dye solution expressed as mg per ml of dye

W = gram of sample in aliquot titrated

#### Determination of anti-nutritional contents

##### Determination of tannin

The Folin-Denis spectrophotometric method as described by Ezegbe (2012) was used. A measured weight of each sample 1 g was dispersed in 10 mL distilled water and agitated. It was left to stand for 30 minutes at room temperature, and then shaken every 5 minutes. At the end of the 30 minutes, the sample was centrifuged and the extract obtained. The

supernatant 2.5 mL was dispersed into a 50 mL volumetric flask. Folin-denis reagent (1 mL) was measured into each flask; followed by 2.5 mL of saturated Na<sub>2</sub>CO<sub>3</sub> solution. The mixture was then diluted to the mark in the flask (50 mL) and incubated for 90 minutes at room temperature. The absorbance was measured at 250 nm in a Genway model 6000i electronic spectrophotometer. Reading was taken with the reagent blank at zero. The tannin content was given as follows;

$$\% \text{ Tannin} = \frac{\text{AuAs} \times \text{C} \times 100 \times \text{W} \times \text{VfVa} \times \text{D}}{\text{Weight of sample}}$$

Where;

Au = Absorbance of test sample

As = Absorbance of standard tannin solution

C = Concentration of standard tannin solution

W = Weight of the used sample

Vf = Total volume of the extract

Va = Volume of the analysed extract

D = Dilution factor (if any)

##### Determination of phytate

Phytate was determined as described by (AOAC, 2000). Two grams of each sample were weighed into a 250 mL conical flask. One hundred millilitres of 2% hydrochloric acid was added to soak each sample in the conical flask for 3 hours. This was filtered through a double layer of hardened filter paper. 50 mL of each filtrate was placed in a 0.5 mL conical flask and 107 mL distilled water was added in each case to give proper acidity. Ten millilitres of 0.3% Ammonium Thiocyanate (NH<sub>4</sub>SCM) solution were added into each solution as indicated. This was titrated with standard iron (III) chloride solution which contained 0.00195 g iron per mL. The endpoint was slightly brownish-yellow, which persisted for 5 min. The % phytic acid was calculated using the formula:

$$\% \text{ Phytic Acid} = \frac{\text{Titre value} \times 0.00195 \times 1.19 \times 100 \times 3.55}{\text{Weight of sample}}$$

##### Determination of trypsin inhibitor

This was determined using the procedure described by (Saito et al., 1990). 0.2 g of defatted ground sample was weighed into a centrifuge tube. Ten milliliters of 0.1 M phosphate buffer were added and shaken on a shaker at room temperature for 1 hour. The suspension was centrifuged at 5000 rpm in a centrifuge for 5 min. The content was later filtered through a Whatman No. 42 filter into a 250 mL

conical flask. These test tubes were arranged into a water bath maintained at 37 °C. A blank was prepared by adding 6 mL of 5% TCA solution to one set of triplicate tubes. Two millilitres of 2% casein solution were added to all the tubes which were previously kept at 37 °C to incubate for 20 min. The reaction of casein was stopped by the addition of 6 mL of 5% TCA solution and this was allowed to proceed for 1 hour at room temperature. The mixture was later filtered at room temperature through a Whatman No. 42 filter paper into a 100 mL conical flask 0.2, 0.4, 0.6, 0.8 and 1.0 mL of stock trypsin solution were also pipetted into a triplicate set of test-tubes (one set for each level of trypsin) as above and treated similarly as a sample to the point of filtration. The absorbance of the filtrates of both samples and standard trypsin solution was read on a spectrophotometer at a wavelength of 280 nm. The actual absorbance of the sample is the difference between the absorbance of stock trypsin filtrate and that of sample filtrate. The absorbance of blank is also read. Trypsin inhibitor in mg/g is calculated using the formula:

$$\text{Absorbance of sample} - \text{absorbance of blank} \times \text{dilution factor}$$

$$19 \times \text{sample weight}$$

#### Sensory evaluation

Each sample (40 g) of spiced *ogi* flour was constituted at different storage temperatures in 100 mL of clean water and was introduced into 200 mL of boiling water to give 20% (w/v) concentration. It was then heated for 2 min with constant stirring to give a consistent paste. A panellist consisting of 10 judges were asked to indicate their preference for the samples using a 9-point hedonic scale, where score 9 indicated extremely liked attribute and score 1 indicated extremely disliked. Samples were coded with three-digit random numbers and presented in random order. The evaluated characteristics, were appearance, aroma/flavour, mouthfeel, colour, taste and overall acceptability. The data obtained were analysed in order to determine the significant differences, if any, between the samples.

#### Statistical analysis

Data generated were subjected to analysis using the Statistical Package for Social Scientist (SPSS) version 20 (SPSS Inc., USA). Mean, standard deviation and analysis of variance (ANOVA) were

performed. Mean was separated by Duncan's multiple range tests at a 5% significance level.

## Results and discussion

### Effect of turmeric and ginger on fermenting organisms in *ogi* slurry

Table 1 shows the microbiological changes that takes place in spiced *ogi* samples during fermentation. Lactic acid bacteria in the sample ranged from  $7.3 \times 10^6$  cfu/g in sample GN2 at 0 h to  $2.02 \times 10^6$  cfu/g in sample 0CC at 48 h. There was a minor change in the lactic acid bacteria count of all samples at 24 h. The prevailing action of lactic acid bacteria was sustained till the end of the fermentation period (48 h), with sample 0CC having the highest counts. Kolapo et al., (2007) reported that the antimicrobial activity of spices, but in the present study, turmeric and ginger, did not negatively affect LAB populations in the sample as shown over the 48 h of fermentation. The predominant organisms, which play essential roles during the secondary fermentation of *ogi*, were the *Lactobacillus* species. These include *Lactobacillus plantarum*, *Lactobacillus fermentum*, and *Lactobacillus acidophilus* and *Lactobacillus brevis* (Ijabadeniyi, 2007). These organisms were reported to have bacteriostatic, bactericidal, viricidal, and antitumor effects in the consumer. The total bacterial count of spiced *ogi* samples was generally low at 0 h and 24 h of fermentation. At 48 h, a total bacterial count of  $1.0 \times 10^4$ ,  $2.0 \times 10^4$  and  $8.0 \times 10^4$  CFU/g was recorded in the samples GN2, TM2 and 0CC, respectively. No count was recorded in the remaining samples. The total plate count recorded during the 48 h of fermentation was below the range of  $2.48 \times 10^6$  to  $3.26 \times 10^6$  CFU/g reported by Adesokan et al., (2010). The low total plate count recorded in the *ogi* slurry sample treated with spices can be attributed to the antimicrobial properties of turmeric and ginger (Table 1).

Fungal count ( $10^4$ ) was recorded in all the samples at 0 h of fermentation, steady increase was observed at 24 and 48 h. Count ranged from  $1.0 \times 10^4$  CFU/g in the sample GN3 at 0 h to  $3.6 \times 10^5$  CFU/g in the sample 0CC (control) at 48 h. Fungi (mainly yeasts) are responsible for imparting the characteristic flavour and aroma during fermentation of *ogi*. Akharaiyi and Omaya (2008) reported that fungi isolated during his study on fermentation of *ogi* are *Saccharomyces cerevisiae*, *Candida stellata*, *Penicillium italicum*, *Aspergillus flavus*, *Fusarium* spp., and *Rhizopus stolonifer*. A steady decrease in

the coliform count was recorded in the spiced *ogi* samples during the period of fermentation. At 0 h, coliform count ranged from  $2.3 \times 10^5$  CFU/g (sample GN3) to  $5.6 \times 10^5$  CFU/g (sample 0CC). At 24 h, a count of  $1.0 \times 10^4$  CFU/g was recorded in the sample GN2 and the sample TM2. Coliform was not detected on other samples treated with spices, except for the sample 0CC (100% maize), which had a count of  $2.8 \times 10^5$  CFU/g at 24 h and  $2.1 \times 10^5$  CFU/g at 48 h. The population of coliform count during the fermentation of *ogi* samples containing different concentrations of turmeric and ginger was relatively low. This might be due to the presence of antibacterial compounds in turmeric and ginger (Kolapo et al., 2007).

#### *Effect of turmeric and ginger on pH and titratable acidity of the *ogi* slurry*

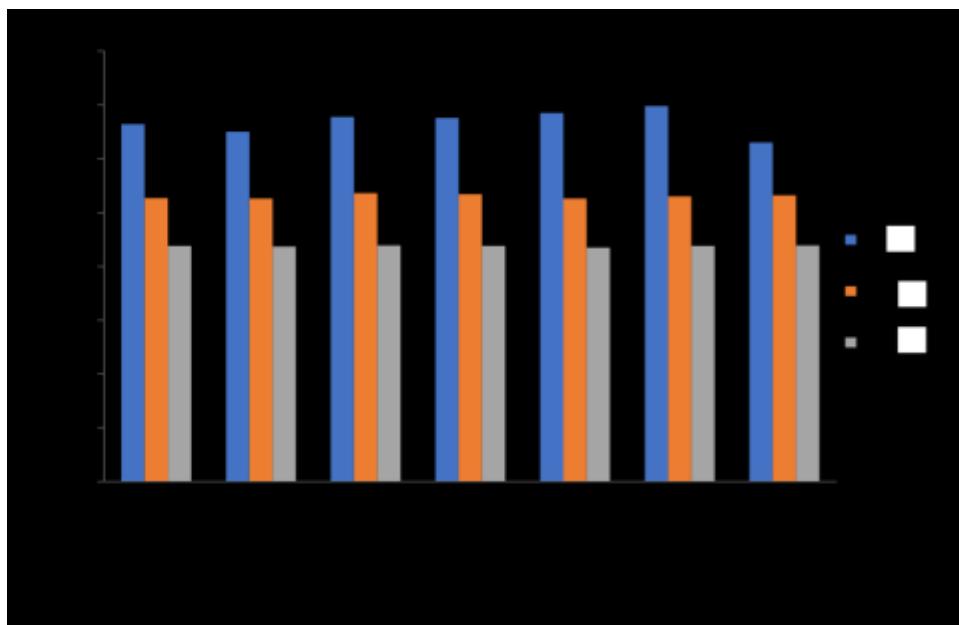
Figure 2 shows that the effect of spices on the pH of the fermented *ogi* slurry. A steady decrease in the pH

value from 6.98 at 0h to 4.31 at 48 h of fermentation was recorded. The highest pH was recorded in the sample TM2 at 0 h, while the least pH was recorded in the sample GN1 at 48 h. Figure 3 shows the effect of spices on total titratable acidity (TTA). There was a significant increase in TTA of all the *ogi* samples as fermentation progresses. Values increased from 0.35 at 0 h to 1.80 at 48 h. A steady decrease in the pH and an increase in TTA during fermentation of *ogi* have been reported by Omemu (2011). This might be a result of the consumption of free sugar in the sample and the production of lactic acid by fermentative organisms responsible for the fermentation of *ogi*. In this study, there was a steady decrease in the pH during the fermentation, indicating an increase in the acidity of the samples, while there was a significant increase in the TTA in all the *ogi* samples. This observation is in agreement with the report of previous studies of Ijabadeniyi (2007) and Adegbekingbe (2013).

**Table 1.** Effect of turmeric and ginger on fermenting organisms in *ogi* slurry

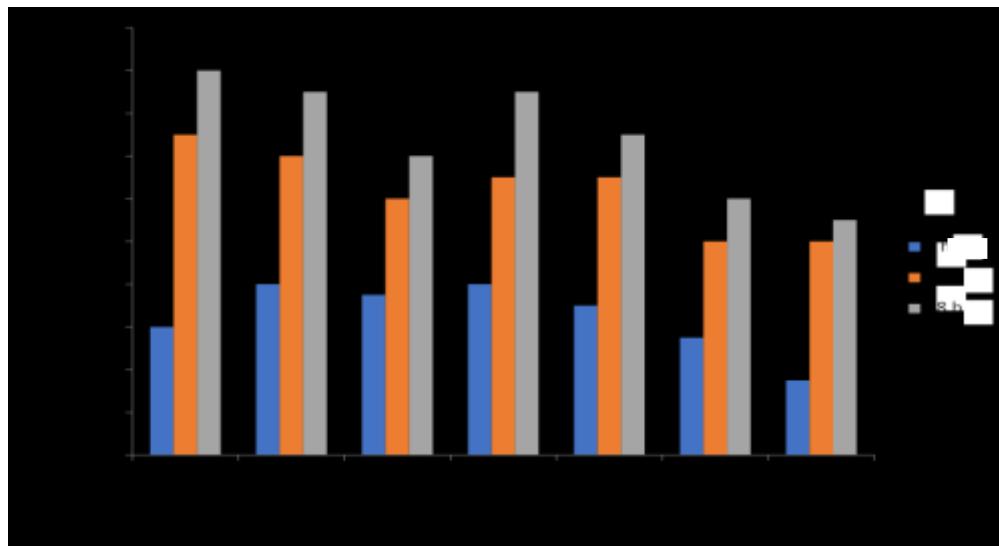
Sample	Fermentation time (hour)	LAB count (CFU/g)	Total bacterial count (CFU/g)	Fungi count (CFU/g)	Coliform count (CFU/g)
0CC	0	$9.8 \times 10^6$	$2.2 \times 10^5$	$6.0 \times 10^4$	$5.6 \times 10^5$
GN1	0	$7.6 \times 10^6$	$1.0 \times 10^5$	$4.0 \times 10^4$	$3.7 \times 10^5$
GN2	0	$7.3 \times 10^6$	$1.1 \times 10^5$	Nil	$5.3 \times 10^5$
GN3	0	$9.1 \times 10^6$	$1.3 \times 10^5$	$1.0 \times 10^4$	$2.3 \times 10^5$
TM1	0	$8.7 \times 10^6$	$2.4 \times 10^5$	$3.0 \times 10^4$	$4.3 \times 10^5$
TM2	0	$9.5 \times 10^6$	$2.0 \times 10^5$	$2.0 \times 10^4$	$4.2 \times 10^5$
TM3	0	$8.4 \times 10^6$	$1.0 \times 10^5$	$2.0 \times 10^4$	$2.6 \times 10^5$
0CC	24	$1.54 \times 10^6$	$1.1 \times 10^5$	$2.2 \times 10^5$	$2.8 \times 10^5$
GN1	24	$1.28 \times 10^6$	$4.0 \times 10^4$	$1.5 \times 10^5$	Nil
GN2	24	$8.6 \times 10^5$	$3.0 \times 10^4$	$2.0 \times 10^5$	$1.0 \times 10^4$
GN3	24	$8.9 \times 10^5$	$6.0 \times 10^4$	$1.8 \times 10^5$	Nil
TM1	24	$8.4 \times 10^5$	$4.0 \times 10^4$	$1.2 \times 10^5$	Non detectable
TM2	24	$7.6 \times 10^5$	$5.0 \times 10^4$	$2.3 \times 10^5$	$1.0 \times 10^4$
TM3	24	$8.0 \times 10^5$	$5.0 \times 10^4$	$1.7 \times 10^5$	Non detectable
0CC	48	$2.02 \times 10^6$	$8.0 \times 10^4$	$3.6 \times 10^5$	$2.1 \times 10^5$
GN1	48	$1.27 \times 10^6$	<10	$1.8 \times 10^5$	Nil
GN2	48	$1.23 \times 10^6$	$1.0 \times 10^4$	$2.1 \times 10^5$	Nil
GN3	48	$1.45 \times 10^6$	<10	$1.7 \times 10^5$	Nil
TM1	48	$1.37 \times 10^6$	<10	$2.0 \times 10^5$	Nil
TM2	48	$1.05 \times 10^6$	$2.0 \times 10^4$	$2.4 \times 10^5$	Nil
TM3	48	$1.20 \times 10^6$	<10	$2.0 \times 10^5$	Nil

Key: 0CC (100% *ogi*); GN1 (95% *ogi* + 5% ginger); GN2 (90% *ogi* + 10% ginger); GN3 (85% *ogi* + 10% ginger); TM1(95% *ogi* + 5% turmeric); GN2 (90% *ogi* + 10% turmeric); GN3 (85% *ogi* + 10% turmeric)



**Fig. 2.** Effect of turmeric and ginger on the pH of *ogi* slurry

**Legend:** GN3: 85% *ogi* + 15% ginger; 0CC: 100% *ogi*; M1: 95% *ogi* + 5% turmeric; GN1: 95% *ogi* + 5% ginger; TM2: 90% *ogi* + 10% turmeric; GN2: 90% *ogi* + 10% ginger; TM3: 85% *ogi* + 15% turmeric



**Fig. 3.** Effect of turmeric and ginger on the TTA of *ogi* slurry

**Legend:** GN3: 85% *ogi* + 15% ginger; 0CC: 100% *ogi*; M1: 95% *ogi* + 5% turmeric; GN1: 95% *ogi* + 5% ginger; TM2: 90% *ogi* + 10% turmeric; GN2: 90% *ogi* + 10% ginger; TM3: 85% *ogi* + 15% turmeric

#### *Effect of turmeric and ginger on the proximate composition of ogi flour*

Table 2 shows the proximate composition of *ogi* flour spiced with turmeric and ginger at a different percentage. Moisture content of the samples ranged from 7.12 to 8.12% with the sample TM3 (85% *ogi* + 15% turmeric) having the highest moisture content. Farinde (2015) reported that moisture content of 8.25% for the sieved plain *ogi* sample. The moisture content of all the samples was relatively low, hence an indication of a better shelf-life and storability of

the product. There was a significant difference ( $p<0.05$ ) in the moisture content of the spiced *ogi* samples. Ash content of the samples increased with an increase in the percentage of each spice that was added and ranged from 0.64 to 1.21% with the sample TM3 (85% *ogi* + 15% turmeric) having the highest value. Since the ash content is a measure of the total amount of minerals present within a food sample, an increase in its level during microbial fermentation could be a result of the incomplete utilization of minerals by fermenting organisms during their metabolism. Crude fat content ranged

from 3.64% (0CC) to 5.92% with the sample TM3 having the highest value. The protein content of the *ogi* samples ranged from 5.58 to 11.89% and showed a significant increase with the addition of a certain percentage of spices. The reason for the increase in the protein content could be a result of the metabolic activities of the microorganisms which resulted in the release of extracellular enzymes into the samples, as reported by other studies carried out by Oboh and

Akindahunsi (2003). This showed an improvement in the nutritional quality of the spiced *ogi* flour samples. The total carbohydrate content of the *ogi* samples ranged from 73.04% to 81.92% with the sample 0CC having the highest. The carbohydrate content is in agreement with that reported by Farinde (2015). All the proximate parameters determined showed significant ( $p<0.05$ ) differences in all the samples.

**Table 2.** Effect of turmeric and ginger on the proximate composition of *ogi* flour

Sample	Moisture (%)	Ash(%)	Crude fat (%)	Crude (%)	protein	Crude (%)	fibre	Carbohydrate (%)
0CC	7.74 <sup>c</sup>	0.64 <sup>a</sup>	3.64 <sup>a</sup>	5.58 <sup>a</sup>	0.84 <sup>a</sup>	81.92 <sup>f</sup>		
GN1	7.81 <sup>d</sup>	0.67 <sup>a</sup>	3.97 <sup>b</sup>	6.69 <sup>b</sup>	1.12 <sup>b</sup>	80.84 <sup>e</sup>		
GN2	7.50 <sup>b</sup>	0.75 <sup>b</sup>	4.27 <sup>c</sup>	8.79 <sup>c</sup>	1.55 <sup>c</sup>	78.68 <sup>d</sup>		
GN3	7.12 <sup>a</sup>	0.97 <sup>d</sup>	4.31 <sup>d</sup>	8.88 <sup>d</sup>	1.97 <sup>e</sup>	78.72 <sup>d</sup>		
TM1	8.07 <sup>f</sup>	0.92 <sup>c</sup>	4.93 <sup>e</sup>	9.69 <sup>e</sup>	1.83 <sup>d</sup>	75.94 <sup>c</sup>		
TM2	8.02 <sup>e</sup>	1.09 <sup>e</sup>	5.26 <sup>f</sup>	10.27 <sup>f</sup>	2.05 <sup>e</sup>	75.37 <sup>b</sup>		
TM3	8.12 <sup>g</sup>	1.21 <sup>f</sup>	5.92 <sup>g</sup>	11.89 <sup>g</sup>	2.78 <sup>f</sup>	73.04 <sup>a</sup>		

Values with difference superscript on the same column are significantly different ( $p<0.05$ )

**Legend:** 0CC: 100% *ogi*; TM1: 95% *ogi* +5% turmeric; GN1: 95% *ogi* + 5% ginger; TM2: 90% *ogi* + 10% turmeric; GN2: 90% *ogi* + 10% ginger; TM3: 85% *ogi* +15% turmeric; GN3: 85% *ogi* + 15% ginger

**Table 3.** Effect of turmeric and ginger on the vitamin profile of *Ogi* flour

Sample code	Vitamin B2 ( $\mu$ g/100g)	Vitamin B6 (mg/100g)	Vitamin C (mg/100g)	Vitamin D ( $\mu$ g/100g)
0CC	42.78 <sup>a</sup>	1.11 <sup>a</sup>	9.60 <sup>d</sup>	8.94 <sup>a</sup>
GN1	53.16 <sup>b</sup>	1.21 <sup>b</sup>	11.89 <sup>e</sup>	11.67 <sup>b</sup>
GN2	56.79 <sup>c</sup>	1.30 <sup>c</sup>	13.28 <sup>f</sup>	13.90 <sup>c</sup>
GN3	57.23 <sup>d</sup>	1.37 <sup>d</sup>	13.60 <sup>g</sup>	14.04 <sup>d</sup>
TM1	121.88 <sup>e</sup>	2.33 <sup>e</sup>	5.38 <sup>a</sup>	26.78 <sup>e</sup>
TM2	134.18 <sup>f</sup>	2.41 <sup>f</sup>	6.48 <sup>b</sup>	28.18 <sup>f</sup>
TM3	135.33 <sup>g</sup>	2.52 <sup>g</sup>	6.79 <sup>c</sup>	29.03 <sup>g</sup>

Values with different superscripts in the same column are significantly different ( $p<0.05$ )

**Legend:** 0CC: 100% *ogi*; TM1: 95% *ogi* +5% turmeric; GN1: 95% *ogi* + 5% ginger; TM2: 90% *ogi* + 10% turmeric; GN2: 90% *ogi* + 10% ginger; TM3: 85% *ogi* +15% turmeric; GN3: 85% *ogi* + 15% ginger

#### Effect of turmeric and ginger on the vitamin content of *Ogi* flour

The vitamin content of *ogi* flour spiced with turmeric and ginger at different percentages is shown in Table 3. Vitamin B<sub>2</sub> (riboflavin) content ( $\mu$ g/100 g) ranged between 42.78 to 134.33 with a significant difference ( $p<0.05$ ) between the samples. The highest value of 134.33  $\mu$ g/100 g recorded in the sample TM3 could be due to the high percentage of turmeric in the *ogi* sample. This is because turmeric is rich in vitamin B<sub>2</sub>. Riboflavin is water-soluble vitamin that is flushed out of the body daily, so it must be restored each day by eating foods that are rich in the nutrient. Riboflavin is a part of the coenzymes, flavin mononucleotide (FMN), and flavin adenine dinucleotide (FAD), needed for oxidation/reduction

reactions, including those involved in energy production (Agunbiade et al., 2013). Vitamin B<sub>6</sub> (pyridoxine) content (mg/100 g) ranged from 1.13 to 2.52. It varied significantly ( $p<0.05$ ) among the samples with sample 0CC (100% *ogi*) having the lowest value. Maize contained trace amounts of vitamins, especially the B-vitamins. The spiced *ogi* flour samples were observed to have higher vitamin B contents. The B vitamins are the most prevalent in turmeric, with vitamin B6 having the highest content. Vitamin B<sub>6</sub> is a water-soluble vitamin that the body needs for several functions. It's significant to protein, fat and carbohydrate metabolism and the creation of red blood cells and neurotransmitters. Recommended daily allowance for an adult is 1.7 mg, and for children is 0.5 mg. Vitamin C contents (mg/100 g) of spiced *ogi* flour sample ranged between 5.38 to

13.60. The samples were significantly different from each other in terms of their vitamin C content. Highest value was recorded in the sample GN3 (85% *ogi* + 15% ginger), while the lowest value was recorded in sample TM1 (95% *ogi* + 5% turmeric). Vitamin C is a water-soluble vitamin and a natural antioxidant, which helps the body develop immunity against infectious agents, and remove harmful free oxygen radicals. It has healing properties, aids in collagen formation, and also aid the absorption of other nutrients (Agunbiade *et al.*, 2013). Vitamin D contents ( $\mu\text{g}/100\text{ g}$ ) of the samples ranged from 8.94 in the sample 0CC to 29 in sample TM3. Vitamin D value increased significantly ( $p<0.05$ ) with an increase in the percentage of each spice. Generally, the values recorded on the nutritional contents of the sample 0CC (100% *ogi*) were low. This could be attributed to the low values of vitamins in maize, which is the raw material for the *ogi* flour in this study.

#### *Effect of turmeric and ginger on the anti-nutritional contents of *ogi* flour*

Results of anti-nutritional content of *ogi* samples containing different percentages of spices are presented in Table 4. The tannin content of all the *ogi* flour samples was generally very low, ranging from 0.0013 to 0.0053%. The lowest value of 0.0013% was recorded in the sample 0CC, while the highest value of 0.0053% was recorded in the sample TM3. This indicated that there are high levels of anti-nutrients in turmeric and ginger. The results of the anti-nutrients were far lower than the lethal dose of 0.7–0.9% (Pikuda and Ilelaboye, 2013). Tannins are naturally occurring plant polyphenols. Their main characteristic is to bind and precipitate protein interfering with its digestion and absorption. Phytate contents ranged between 0.0025 and 0.0087%, with the sample 0CC having the lowest value and the sample TM3 having the highest value. This may be a result of the high level of anti-nutrients present in the spices. Phytates are known to form complexes with iron, zinc, calcium and magnesium, making them less available and thus inadequate in food samples, especially for children. It is known that 10–50 mg of phytate per 100 g will not cause a negative effect on the absorption of zinc and iron (Pikuda and Ilelaboye, 2013). Trypsin inhibitor contents (mg /100 g) ranged from 2.40 to 8.29. The results of each anti-nutrient varied significantly ( $p<0.05$ ). In all the anti-nutritional contents, the lowest values were obtained in the sample 0CC (100%) and the highest values

obtained in the sample TM3 (85% *ogi* + 15% turmeric). The results of each anti-nutrient increased with an increase in the percentage of spices (turmeric and ginger). This indicated that there are high levels of anti-nutrients in turmeric and ginger. Although the anti-nutrient contents of all the spiced *ogi* flour samples were below the lethal doses in humans.

**Table 4.** Effect of turmeric and ginger on the anti-nutritional contents of *ogi* flour

Sample code	Tannin (%)	Phytate (%)	Trypsin inhibitor (mg/100g)
0CC	0.0013 <sup>a</sup>	0.0025 <sup>a</sup>	2.4033 <sup>a</sup>
GN1	0.0019 <sup>b</sup>	0.0032 <sup>b</sup>	2.8867 <sup>b</sup>
GN2	0.0026 <sup>c</sup>	0.0043 <sup>c</sup>	3.0400 <sup>c</sup>
GN3	0.0031 <sup>d</sup>	0.0053 <sup>d</sup>	3.7833 <sup>d</sup>
TM1	0.0043 <sup>e</sup>	0.0070 <sup>e</sup>	4.1800 <sup>e</sup>
TM2	0.0049 <sup>f</sup>	0.0075 <sup>f</sup>	4.2467 <sup>f</sup>
TM3	0.0053 <sup>g</sup>	0.0087 <sup>g</sup>	5.2100 <sup>g</sup>

Values with different superscripts in the same column are significantly different ( $p<0.05$ )

**Legend:** 0CC: 100% *ogi*; TM1: 95% *ogi* +5% turmeric; GN1: 95% *ogi* + 5% ginger; TM2: 90% *ogi* + 10% turmeric; GN2: 90% *ogi* + 10% ginger; TM3: 85% *ogi* +15% turmeric; GN3: 85% *ogi* + 15% ginger

#### *Mean score of the sensory evaluation of spiced *ogi* flour*

The result of the sensory evaluation for colour, taste, aroma, mouthfeel, and overall acceptability of spiced *ogi* is shown in Table 5. Sample TM1 (95% *ogi* + 5% turmeric) was the preferred in terms of colour with the highest hedonic score of 7.50 when compared with the lowest hedonic score of 5.33 for sample TM3(85% *ogi* + 15% turmeric), which differed significantly ( $p<0.05$ ) from other samples. Sample GN1 (95% *ogi* + 5% ginger) was most preferred in terms of taste, aroma mouthfeel and overall acceptability, while sample TM3 was the least preferred in all the attributes. There was a significant difference ( $p<0.05$ ) among the samples with respect to overall acceptability, except sample 0CC and GN1 which did not vary significantly. Preference in colour for the sample TM1 could be due to a moderate percentage (5%) of turmeric in the *ogi* flour. Probably, higher percentage of turmeric and ginger in the samples TM2, TM3, GN2 and GN3 reduced their preference with respect to colour, taste and aroma, which affected the overall acceptability of the samples because the colour and taste were altered as the percentage of spices increased in the *ogi* sample.

**Table 5.** Mean score of sensory evaluation of spiced *ogi* flour

Sample code	Colour	Taste	Aroma	Mouthfeel	Overall acceptability
OCC	7.00 <sup>b</sup>	7.70 <sup>c</sup>	6.80 <sup>c</sup>	7.00 <sup>cd</sup>	7.78 <sup>f</sup>
GN1	6.67 <sup>ab</sup>	7.60 <sup>c</sup>	7.50 <sup>d</sup>	7.50 <sup>d</sup>	8.11 <sup>f</sup>
GN2	7.30 <sup>b</sup>	6.67 <sup>b</sup>	6.70 <sup>c</sup>	6.60 <sup>c</sup>	7.44 <sup>e</sup>
GN3	7.43 <sup>b</sup>	5.50 <sup>a</sup>	6.20 <sup>abc</sup>	5.50 <sup>ab</sup>	6.89 <sup>d</sup>
TM1	7.50 <sup>b</sup>	6.40 <sup>b</sup>	6.40 <sup>bc</sup>	5.90 <sup>b</sup>	6.56 <sup>c</sup>
TM2	6.00 <sup>ab</sup>	5.50 <sup>a</sup>	6.00 <sup>ab</sup>	5.40 <sup>ab</sup>	5.78 <sup>b</sup>
TM3	5.33 <sup>a</sup>	5.30 <sup>a</sup>	5.60 <sup>a</sup>	5.20 <sup>a</sup>	5.33 <sup>a</sup>

Values with different superscripts in the same column are significantly different (p<0.05)

**Legend:** OCC: 100% *ogi*; TM1: 95% *ogi* +5% turmeric; GN1: 95% *ogi* + 5% ginger; TM2: 90% *ogi* + 10% turmeric; GN2: 90% *ogi* + 10% ginger; TM3: 85% *ogi* +15% turmeric; GN3: 85% *ogi* + 15% ginger

## Conclusions

It can be concluded that the addition of spices (turmeric and ginger) to *ogi* flour improved significantly the nutrient contents of the samples with respect to the proximate, vitamin and mineral content values that increased with an increase in percentage with the addition of spices. Microbial analysis of the spiced *ogi* samples showed lower bacteria and fungal counts during the 8 weeks of storage stability test. The use of turmeric and ginger in *ogi* fermentation reduced microbial contamination and therefore contributed to its health benefits.

Sensory evaluation showed that *ogi* spiced with 5% turmeric and 5% ginger had the highest acceptability, with respect to colour and taste respectively, while the colour and taste of *ogi* with the higher percentages of turmeric and ginger were not acceptable.

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