

Biocontrol Efficacy of Ginger (*Zingiber officinale*) Fortification on the Nutrient and Aflatoxin Compositions of ‘Ogi’

Gbolagade S. Jonathan, Oluwatosin B. Ogunsanwo, Michael D. Asemoloye, Glory I. Baysah and Omolola O. Omotayo.

¹Mycology/Fungal Biotechnology Unit, Department of Botany, University of Ibadan, Ibadan, Oyo State, Nigeria.

²Department of Biology, Adventist University of West Africa, Liberia

Corresponding authors: M.D. Asemoloye (asemoloyemike@gmail.com; +2348064844977) and O.O. Ogunsanwo (+2348131205333; higherground015@gmail.com).

Abstract: ‘Ogi’ is a fermented maize product which is commonly used as weaning food for children in Nigeria. However, there is dearth of knowledge on the possible aflatoxin contamination of many of such indigenous maize products due to commonly associated fungi and possible control measures. This study was therefore conducted to investigate the fungal and aflatoxin composition of stored Ogi powder and the effect of ginger fortification in relation to the shelf life of the product. Ogi samples were prepared in the laboratory and fortified with different concentrations of ginger at 5 different batches namely: Control (unfortified Ogi), Treatment T₁ (97.5% Ogi+ 2.5% ginger), Treatment T₂ (95% Ogi + 5% ginger), Treatment T₃ (92.5% Ogi+7.5% ginger) and Treatment T₄ (90% Ogi+ 10% ginger). They were later dried into powder and stored for eight weeks. The nutrient and aflatoxin contents (AFB₁, AFB₂, AFG₁ and AFG₂) of the samples were analyzed before and after storage using Thin Layer Chromatography. Generally, the pH and the nutrient contents such as crude protein, crude fiber and crude fat of the samples reduced with the increased storage time but increased with the ginger concentrations. The treatments also improved the sensory attributes as T₂ was the most generally accepted sample after 8 week of storage. Result obtained also showed that different fungi are associated with the samples which increased with the storage time, the isolated aflatoxigenic fungi includes *Aspergillus niger*, *A. flavus*, *A. penicilloides*, *A. tamarii*, *A. fumigatus* and *A. ellipticus* while others belongs to *Fusarium*, *Penicillium*, *Saccharomyces*, *Rhizopus*, *Trichoderma* and *Alternaria* species. In addition, the control had the highest fungal load (5.33-12.00 cfu/mL) and aflatoxin contents but they were significantly reduced in T₁-T₄, respectively. The aflatoxin contents of the samples increased with the storage time but none was higher than the tolerance limit. Consumers are therefore encouraged to consider using ginger as additive in preparing Ogi especially at 5 % concentration to improve the taste and reduce the possible aflatoxin contamination.

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Key Words: Ogi powder; Ginger; Treatment; Aflatoxin; Tolerance limit; Sensory evaluation

Introduction

Ogi is a fermented starchy paste which is traditionally obtained by sub-merged fermentation of some cereals (Adegunwa et al., 2011; Adesokan et al., 2010; Adebunkunola et al., 2015; Bolaji et al., 2015; Awoyale et al., 2016). It is made from several cereal based feedstock such as maize (*Zea mays*), millet (*Pennisetum typhoides*), Sorghum (*Sorghum bicolor*) or Guinea corn (*Sorghum spacers*) as reported by (Ohenhen and Ikenemoh 2007; Osungbaro, 2009; Abioye and Aka, 2015; Adegbehingbe, 2013; Adegbehingbe, 2014). It is a popular cereal food in West Africa especially in Southern part of Nigeria where it serves as a staple food for many and commonly used as first native food given to babies at weaning, breakfast meal for adults and food of choice for the sick and the elderly ones. It also has its

application in traditional medicine (Ojokoh, 2009; Egwim et al., 2013; Adesokan et al., 2010; Chilaka et al., 2016). Ogi is very critical to the diet of rural communities in Southern Nigeria and with garri were the most frequently consumed fermented foods in that area (Aderiye and Laleye, 2003). In Oyo state, Nigeria for instance, out of the total food processing industries in the state, cereal grain processing industries using maize as their raw material to produce Ogi constitutes about 11.9% (Ajayi, 2004). In Nigeria, Ogi is prepared and consumed as Akamu, Akassan or Koko among the Yorubas, Ibos and Hausas, respectively (Egwim et al., 2013; Akinleye et al., 2014). However, it is called *Akosa* in Ghana (Adegbehingbe, 2013). Recently, there has been increase in the industrial production of this food in powdery form. Ogi powder is often packaged in sachets and sold for consumption. The

dried Ogi is expected have a stable shelf life compared to wet Ogi (Bolaji and Oyewo, 2017) but little have been done on the associated bio-deterioration fungi which are majorly responsible for the spoilage of this product and control measures for its possible aflatoxin contamination.

Many fungi have been reported to cause spoilage of fermented foods especially during storage (Jonathan et al., 2011;2016a-c), various maize products have also been found to be susceptible to this fungal contamination when they are not properly kept (Bankole and Adebajo, 2003). Fungal spoilage of maize products have been shown to results in contaminations by different forms of fungal toxins called 'Mycotoxins' of which 'Aflatoxins' are well known (Jonathan et al., 2015). Aflatoxins are toxins which are produced by the fungi *Aspergillus flavus* and *A. parasiticus*, they are the most documented toxins in various foods in Nigeria. Concerns have been raised concerning the health effect of the aflatoxins and many researchers have advocated for biological control measures for managing or controlling aflotoxin contaminations in foods. Example of such intervention is the 'aflasafe' intervention by the International Institute of Tropical Agriculture (IITA) in Nigeria.

Ogi is an important food for many people in various parts of Nigeria and in some other West African countries. However, some of the challenges facing the production of Ogi are nutrient losses which occur at different stages of its production (Awoyale et al., 2016) as well as its contamination by fungi. Therefore, a food additive which can both add to its nutrient composition and at the same time prevent its microbial contamination is needed.

Just like other spices, ginger has been reported to have antimicrobial properties which make it a potent spice for preserving foods. The use of spices such as ginger has been seen as a better option for preserving foods compared to the use of many chemicals due to the fact that they are body friendly and improve food tastes as well as acceptability. Ginger is an herbaceous perennial plant which usually grows as pseudo stem; it belongs to the family Zingiberaceae in which turmeric, cardamom and galangal also belongs (An et al., 2016). Its antimicrobial properties have been well reported, and it is a well-known plant in Nigeria commonly used as spice. This research was therefore embarked upon to investigating the influence of ginger treatments on the fungal and aflatoxin composition of stored Ogi in relation to the shelf life and the nutrient composition of the product.

Materials and Methods

Collection of Samples

Maize samples were obtained from three different maize grain shops in Bodija market, Bodija, Ibadan, Oyo State (7°26'21"N, 3°54'46"E) while fresh tubers of ginger were bought from Oja Oba market, Oja Oba, Oyo State (7°22'01"N, 3°55'11"E). The samples were put into sterile polythene bags and taken to the laboratory for further studies.

Production and Fortification of Ogi with Ginger

Ogi was prepared using a modified traditional method as previously described by Odunfa and Adeyele (20). The maize samples were thoroughly washed in distilled water and soaked in a plastic container with cover. The water was decanted after two days of soaking and wet milled into slurry using a sterilized warring blender. This was followed by sieving the slurry using a muslin cloth.

Fresh tubers of ginger were thoroughly washed with sterile water and peeled with sharp knife. They were dried in the dehydrator (Andrew James dehydrator) at 55°C for 24 h. The dried ginger tuber was there after milled into fine powder with Excella grinder (Ziaur-Rehman et al., 2002). Different concentrations of the prepared powder ginger were added to the samples of Ogi filtrate to give rise to 5 treatments as follows:

Control = 100% Ogi + 0% ginger,
Treatment T₁ = 97.5% Ogi + 2.5% ginger,
Treatment T₂ = 95% Ogi and 5% ginger,
Treatment T₃ = 92.5% Ogi+ 7.5% ginger and
Treatment T₄= 90% Ogi + 10% ginger

The new formulations were later allowed to ferment for 2 days. The samples were later dried using the modified method of Akingbala *et al.* (2005) and Awoyale *et al.* (2015). After 2 days of fermentation ginger fortified Ogi samples were dried in hot air oven at 50°C for 48 h using small cans. The dried forms were milled using a sterile blender and sieved in order to obtain fine Ogi powder. After sieving, each samples of fortified Ogi powder were later carefully packaged in moisture proof air tight polythene container, labeled accordingly and stored at room temperature for 8 weeks.



Fig. 1: Flowchart for the production of Ginger Ogi powder

Isolation and Characterization of Associated Deteriorating Fungi

This was done by using serial dilution technique at dilution factor of 10^{-4} for plating. Each sample diluents was plated out in three replicates by spreading them in Petri dishes containing prepared PDA media of 18 ml each. Culture plates were incubated at 30 °C for 5 days and examined daily for fungal growth noted in each replicates. Fungal count (Colony Forming Unit) of Yeast-mould colonies were determined and expressed as colony forming unit per gram (CFU/g) (Egbuta et al., 2015) using the formula:

$$\text{CFU/g} = \text{Number of colonies} \times \text{reciprocal of the dilution factor/Plating volume (1 ml)}$$

Fungi isolates were characterized based on cultural and morphological features such as growth rate, colony texture, colour on PDA (Jonathan et al., 2013) Microscopic structures of the fungi isolates was observed under the light microscope by using slide culture prepared and incubated in moist chambers at 26 ± 2 °C for 4 days. Identification of each fungi isolates was done by using mycological keys and manuals were used for macro and microscopic features which include conidiophores, conidial shape and shape of vesicles (Diba et al., 2007).

Aflatoxin Extraction, Detection and Quantification

Extraction: 1g of sample was pipette into a 100ml conical flask. 2.5 ml of distilled and 25 ml of chloroform water were added. The flask was covered with a stopper and shake in a shaker for 30 minutes after which the solution obtained was filter using a

Whatman no.1 filter paper. 10 ml of each extract or filtrate was collected and evaporated to dryness to a volume of 5 ml on a hot water bath. Five ml extract were stored in dark bottles in a freezer for detection and quantification (AOAC 2006).

Detection of aflatoxin: 1ml chloroform and 0.2 ml of the reconstituted extract was spotted on a pre-coated 20 x 20 cm TLC plate along with aflatoxin standards of known concentration. The spotted TLC plate was developed in an equilibrated tank containing chloroform: acetone (9:1 v/v). The developed TLC plate was air-dried at ambient temperature (28 ± 2 °C) and aflatoxins were detected under UV light at wavelength of 360 nm. A colour change from blue to yellow upon exposure to aqueous sulphuric acid (50:50 v/v) confirmed the presence of Aflatoxin B₁. Aflatoxin B₂ was derived from Aflatoxin B₁ as dihydroderivative which experienced a colour change from pale blue to deep yellowish colour upon exposure to aqueous sulphuric acid (50:50) to confirm its presence. Aflatoxin G₁ fluoresced yellowish green upon exposure to UV light while Aflatoxin G₂ fluoresced pale yellowish green upon exposure to same UV light (AOAC 2006).

Quantification of aflatoxin: 0.5 µm thick preparative TLC plates was employed for the quantification of stored extract after aflatoxin extraction was applied to the plate as band rather than a spot to chromatograph, the maximum amount of sample at the same time. The preparative TLC plates were developed in an equilibrated tank as an aflatoxin extraction. When the solvent front had risen to about $\frac{3}{4}$ of the total length of the plate, the plate was taken out of the tank and examined under UV light. The area containing the toxin of interest was located and scrapped off, elute with chloroform and filter using Muslin cloth. The extract was evaporated to dryness over a hot water bath and reconstituted with 3ml chloroform. The 3 ml reconstituted solution and aflatoxin standard of 20 µg/ml concentration was used to read Absorbance or Optical Density on an ultraviolet Spectrophotometer (Cecil Instrument CE505) at a wavelength of 360 nm (AOAC 2006).

Aflatoxin concentration in µg/kg was calculated using the formula:

$$\text{Absorbance of sample} \times \text{conc. of standard} \times \text{dil. factor/Absorbance of standard}$$

Nutrient Analysis of the Samples

Crude Protein Determination: The crude protein in the samples was determined by the routine semi-micro Kjeldahl procedure. 0.5 g of each finely ground dried sample was weighed carefully into the Kjeldahl digestion tubes, 1 tablet of selenium catalyst

and 10ml of H₂SO₄ was added into the digestion preset at 500°C. The digestion was left for 4 h in a fume cupboard. The tube was placed in a distilling unit and 5ml of 40 % NaOH was added to it. The mixture was steam distilled for 2 min into a 50 ml flask containing 10 ml of 2 % Boric acid, mixed with indicator solution which was then titrated against 0.01N HCl until a wine colour was obtained. The quantification was done using AOAC procedure (AOAC 2005).

Crude Fat Determination: 250 cm³ clean boiling flask was dried in oven at 105-110 °C for about 30 min. It was later transferred into desiccators and allowed to cool. About 2 g of sample was weighed accurately into labeled thimbles. The correspondingly labeled cooled boiling flasks were weighed. The boiling flasks were filled with about 300 cm³ of petroleum ether (boiling point 40-60 °C). The extraction thimble was plugged with cotton wool. The soxhlet apparatus was assembled and allowed to reflux for about 6 hours. The thimble was removed with care and the petroleum ether was collected in the top of the container of the set-up and drained into a container for re-use. When the flask was almost free of petroleum ether it was removed and dried at 105°C-110°C for 1 h. It was later transferred into a desiccators from the oven and allowed to cool and weighed (AOAC 2005).

%Fat = Weight of fat × 100 / Weight of sample

Dry Matter and Moisture Determination: Two grams of the sample were weighed into a previously weighed crucible (W₀). The crucible plus sample (W₁) taken was then transferred into the oven set at 100 °C to dry to a constant weight for 2 hours. At the end, the crucible plus sample was removed from the oven and transferred to desiccators, cooled for ten minutes and weighed (W₃) (AOAC 2005).

$$\% \text{ Dry Matter (DM)} = \frac{W_3 - W_0}{W_1 - W_0} \times 100$$

% Moisture = 100 - % DM.

Ash Determination: Two grams of the sample was weighed into a porcelain crucible. This was transferred into the muffle furnace set at 550°C and left for about 4 h. About this time it had turned to white ash. The crucible and its content were cooled to about 100°C in air, then room temperature in a desiccator and weighed (AOAC 2005).

Ash content = weight of ash × 100 / Original weight of sample

Fiber Determination: Two grams of the sample was weighed accurately into the fiber flask and 100ml of 0.255N H₂SO₄ was added. The mixture was heated

under reflux for 1 hour with the heating mantle. The hot mixture was filtered through a fiber sieve cloth. The residue was returned to the fiber flask to which 100ml of (0.313N NaOH) was added and heated under reflux for another 1 hour. The mixture was filtered through a fiber sieve cloth and 10 ml of acetone added. The residue was washed with about 50 ml hot water on the sieve cloth before it was finally transferred into the crucible. The crucible and the residue were oven-dried at 105°C overnight to drive off moisture. The oven-dried crucible containing the residue was cooled in desiccators and weighed to obtain the weight W₁. The crucible with weight W₁ was transferred to the muffle furnace for ashing at 550°C for 4 hours. The crucible containing white or grey ash was cooled in the desiccators and weight to obtain W₂. The difference W₁ - W₂ gives the weight of fiber (AOAC 2005).

$$\% \text{ Fiber} = \frac{W_1 - W_2}{\text{Weight of sample}} \times 100$$

Carbohydrate (CHO): The carbohydrate content was determined by using the formula: (Moisture content + Crude fat + Crude Protein + Crude Fiber + Ash) - 100 (AOAC 2005).

Preparation and Sensory Evaluation of Fortified Ogi Powder

Forty grams of each batches of Ogi were constituted in 50 ml of clean water and was introduced into 150 ml of boiling water to give 20 % (w/v) concentration. It was then heated for 1 minute and constantly stirred (Bristone et al., 2016). For the sensory evaluation, the samples at different storage time were given to different people and questionnaire was administered to them to measure the sensory value based on their responses. The values examined are the colour, taste, flavor and texture.

Statistical Analysis

Data generated were subjected to analysis of variance (ANOVA) using SAS 9.3 version, and means were separated by Duncan's multiple range tests at 5 % significance level.

Results

Effect of the Ginger Treatment on the Nutrient Content of Ogi after 8 Weeks of Storage:

Table 1: Effect of ginger treatments on nutritional composition of Ogi powder before and after storage

Sample	Storage (Weeks)	Moisture Content (%)	Crude Protein (%)	Crude Fat (%)	Crude Fiber (%)	Ash (%)	Carbohydrate (%)
Control	0	9.67±0.15 ^a	2.55±0.01 ^c	2.69±0.00 ^c	0.40±0.01 ^b	0.31±0.01 ^a	84.38±0.02 ^a
	8	8.49±0.01 ^b	3.47±0.03 ^a	3.70±0.01 ^a	0.41±0.01 ^b	0.29±0.05 ^b	83.64±0.05 ^c
T ₁	0	9.11±0.01 ^a	2.74±0.02 ^d	2.74±0.01 ^c	0.40±0.01 ^b	0.30±0.01 ^a	84.71±0.04 ^d
	8	7.57±0.15 ^d	3.53±0.10 ^a	3.70±0.01 ^a	0.43±0.01 ^{ab}	0.31±0.01 ^a	84.46±0.14 ^c
T ₂	0	8.80±0.01 ^c	2.82±0.01 ^b	2.75±0.01 ^c	0.41±0.01 ^b	0.31±0.01 ^a	84.91±0.10 ^c
	8	8.60±0.10 ^c	3.71±0.01 ^a	3.70±0.01 ^a	0.45±0.01 ^a	0.31±0.01 ^a	83.23±0.15 ^e
T ₃	0	8.40±0.10 ^c	2.79±0.01 ^c	3.03±0.01 ^b	0.41±0.01 ^b	0.33±0.01 ^a	85.04±0.16 ^e
	8	7.43±0.06 ^d	3.73±0.02 ^a	3.71±0.01 ^a	0.47±0.01 ^a	0.32±0.01 ^a	84.34±0.07 ^a
T ₄	0	8.65±0.06 ^b	3.02±0.01 ^b	3.08±0.01 ^b	0.43±0.01 ^{ab}	0.33±0.01 ^a	84.49±0.06 ^b
	8	8.50±0.01 ^b	3.81±0.01 ^a	3.71±0.01 ^a	0.48±0.01 ^a	0.33±0.02 ^a	83.17±0.04 ^f

Values are means of three replicates, values with the same letter in a column are not significantly different from each other at $p > 0.05$

The nutrient composition of the Ogi samples is presented in Table 1, the crude protein, crude fat, crude fiber and ash content of all the treatments increased with the levels of ginger concentrations before storage, except the moisture and carbohydrate contents. The control had a significant lower content of crude protein, crude fat, crude fiber and ash contents compared to the ginger treated samples ($p < 0.05$) as the T₄ (90% Ogi and 10% ginger) had the highest nutrient composition. The moisture and carbohydrate contents however varied with the concentrations of ginger. At the end of storage period (week 8) the crude protein, crude fat and crude fiber contents of all the samples decreased with the increased storage period (Table 1) but there was improvement in the treated samples. The moisture content and carbohydrate content slightly increased, while the ash content relatively remained unchanged.

However, the crude protein, crude fat and crude fiber of all the batches of Ogi powder still maintained the increment with the increased in the level of ginger concentration despite their decrease during the storage period.

Effect of Ginger Treatments on the Fungi Associated with Ogi: The fungal count in all the samples reduced with the increased in the concentration of ginger during the period of storage as shown in Table 2. Generally, there was significant difference between the control and treated samples at week 0 and week 8 of storage, the fungal count for example ranged from 5.33 cfu/mL and 12.00 cfu/ml in control at week 0 and 8 respectively while T₄ had 1.00 and 5.67 cfu/mL in at week 0 and 8 respectively (Table 2).

Table 2: Effect of ginger on the fungal count of the samples of Ogi powder during storage

Sample	Week 0	Week 2	Week 4	Week 6	Week 8
Control	5.33±4.62 ^c	8.33±3.51 ^c	11.00±2.00 ^c	13.67±6.35 ^e	12.00±0.00 ^c
T ₁	3.00±0.00 ^{ab}	5.00±1.41 ^b	7.00±6.00 ^e	8.67±1.53 ^b	7.67±4.16 ^b
T ₂	2.00±0.00 ^{ab}	4.00±5.00 ^b	6.67±7.64 ^{ab}	7.33±2.08 ^b	6.00±0.00 ^b
T ₃	1.00±11.02 ^{ab}	3.0±18.03 ^a	5.33±4.62 ^a	4.67±9.02 ^d	6.33±4.16 ^b
T ₄	1.00±0.00 ^{ab}	3.33±0.58 ^a	3.00±5.20 ^d	3.67±2.08 ^d	5.67±2.89 ^b

Values are means of three replicates, values with the same letter in a column are not significantly different from each other at $p > 0.05$

Effect of Ginger Treatments on the pH of Ogi:

The samples pH increased with the increase in the concentration of ginger. The control had the lowest pH

values while T₄ had the highest pH (Table 3). The pH however decreased with the increased storage period.

Table 3: Effect of ginger on changes in pH during the storage of samples of fortified Ogi powder

Sample	Week 0	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
Control	5.04±0.01 ^f	4.96±0.01 ^h	4.87±0.01 ^h	4.73±0.01 ⁱ	4.67±0.01 ^h	4.59±0.02	4.53±0.01 ^c	4.47±0.02 ^e	4.36±0.02 ^f
T ₁	5.11±0.01 ^c	5.06±0.01 ^f	4.97±0.01 ^f	4.90±0.01 ^f	4.83±0.02 ^f	4.78±0.01 ^c	4.67±0.01 ^d	4.60±0.02 ^e	4.51±0.01 ^e
T ₂	5.26±0.01 ^d	5.19±0.02 ^d	5.13±0.02 ^d	5.06±0.01 ^d	5.00±0.01 ^d	4.94±0.02 ^b	4.88±0.01 ^b	4.84±0.02 ^c	4.78±0.02 ^c
T ₃	5.52±0.02 ^b	5.43±0.01 ^b	5.38±0.01 ^b	5.32±0.01 ^b	5.26±0.01 ^b	5.21±0.02 ^a	5.14±0.02 ^a	5.02±0.01 ^b	4.85±0.16 ^b
T ₄	5.65±0.01 ^a	5.51±0.01 ^a	5.44±0.01 ^a	5.38±0.01 ^a	5.30±0.01 ^a	5.22±0.01 ^a	5.15±0.01 ^a	5.09±0.01 ^a	5.01±0.01 ^a

Values are means of three replicates, values with the same letter in a column are not significantly different from each other at $p > 0.05$

Effect of Ginger Treatments on the fungi and Aflatoxin content of Ogi: The most frequently isolated fungi from the samples belong to seven fungal genera namely *Aspergillus*, *Fusarium*, *Penicillium*,

Saccharomyces, *Rhizopus*, *Trichoderma* and *Alternaria*. They were identified as *Aspergillus niger*, *A. flavus*, *A. penicilloides*, *A. tamarii*, *A. fumigatus*, *A. ellipticus*, *Penicillium notatum*, *Penicillium sp.*

Saccharomyces cerevisiae, *Mucor* sp. *Rhizopus nigricans*, *Trichoderma hamatum*, *Alternaria alternata*, *Fusarium* sp. of which the aflatoxigenic ones are shown in Fig. 1. There was a very low level of aflatoxin in all the samples at week 0 of storage but

the aflatoxin contents increased with the storage time but varied with the increased concentrations of ginger. However, control had the highest content of aflatoxin after week 8 of storage (Table 4).

Table 4: Aflatoxin concentration in samples of Ogi powder before and after storage

Sample	Storage (Weeks)	Aflatoxin B ₁	Aflatoxin B ₂	Aflatoxin G ₁	Aflatoxin G ₂	Total Aflatoxins
Control	0	0.010±0.000 ^c	0.020±0.001 ^c	0.001±0.000 ^b	0.001±0.000 ^b	0.032 ^d
	8	0.160±0.000 ^j	0.180±0.000 ^k	0.007±0.001 ^b	0.044±0.057 ^b	0.391 ^b
T ₁	0	0.020±0.000 ^{b-e}	0.027±0.006 ^{bc}	0.001±0.000 ^b	0.001±0.000 ^b	0.049 ^c
	8	0.120±0.000 ^{ij}	0.140±0.000 ^{jk}	0.010±0.000 ^b	0.013±0.000 ^b	0.283 ^b
T ₂	0	0.017±0.006 ^{cde}	0.027±0.006 ^{bc}	0.001±0.000 ^b	0.001±0.000 ^b	0.046 ^c
	8	0.123±0.006 ^{hij}	0.147±0.006 ^{ij}	0.043±0.058 ^b	0.014±0.000 ^b	0.327 ^b
T ₃	0	0.020±0.000 ^{b-e}	0.037±0.006 ^b	0.001±0.000 ^b	0.001±0.000 ^b	0.059 ^b
	8	0.140±0.000 ^{d-h}	0.153±0.006 ^{ghi}	0.009±0.001 ^b	0.012±0.000 ^b	0.314 ^b
T ₄	0	0.010±0.000 ^c	0.027±0.006 ^{bc}	0.001±0.000 ^b	0.001±0.000 ^b	0.039 ^d
	8	0.157±0.006 ^{bcd}	0.167±0.006 ^{ef}	0.010±0.001 ^b	0.012±0.001 ^b	0.346 ^b

Values are means of three replicates, values with the same letter in a column are not significantly different from each other at $p>0.05$

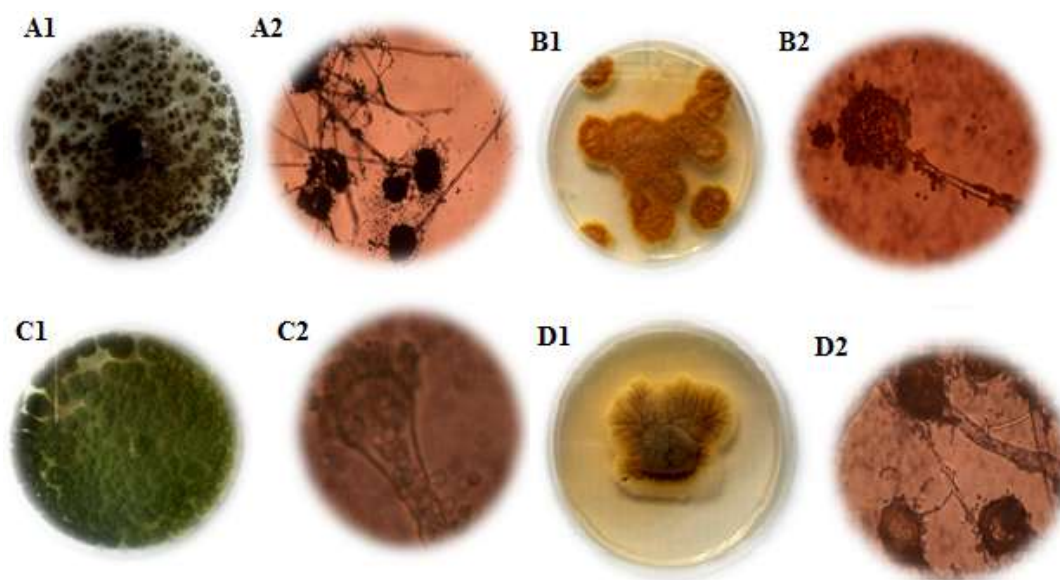


Fig 2: Selected aflatoxigenic fungal strains isolated from the Ogi samples.

A = *Aspergillus niger* (A1: The plate view, A2: Microscopic view); B = *Aspergillus tamari* (B1: The plate view, B2: Microscopic view); C = *A. flavus* (C1: The plate view, C2: Microscopic view); D = *A. fumigatus* (D1: The plate view, D2: Microscopic view)

Effect of Ginger Treatments on the Sensory Value (Taste) of Ogi:

The sensory evaluation of the samples showed that ginger had significant effect on the colour, taste, flavour and texture of the Ogi samples (Table 5). T₁ was the most preferred of the entire fresh samples (week 0) in terms of colour, taste and texture while T₄

was the most preferred in terms of flavour. After storage however, T₂ was the most preferred in terms of colour, flavour and texture while T₃ was the most preferred in terms of taste. The overall acceptability of all the samples shows that T₁ was least accepted sample while T₂ was the most preferred in terms of overall acceptability.

Table 7: Sensory evaluation of Ogi powder before storage

Sample	Storage (Weeks)	Colour	Taste	Flavour	Texture	Overall Acceptability
Control	0	6.20±2.10 ^a	4.70±2.06 ^a	4.80±2.25 ^a	4.90±2.08 ^a	5.10±2.42 ^{ab}
	8	5.80±1.99 ^a	4.30±2.31 ^a	4.80±2.10 ^a	4.30±2.26 ^a	5.00±2.21 ^a
T ₁	0	6.50±1.84 ^a	6.00±2.36 ^a	6.10±2.47 ^a	6.20±1.99 ^a	6.80±2.20 ^a
	8	6.00±2.21 ^a	4.70±2.31 ^a	4.70±2.11 ^a	4.30±2.31 ^a	4.90±2.23 ^a
T ₂	0	6.20±1.23 ^a	5.90±1.73 ^a	6.30±1.42 ^a	6.10±1.29 ^a	6.20±1.40 ^{ab}
	8	6.40±1.43 ^a	5.70±1.06 ^a	6.00±1.15 ^a	5.20±1.69 ^a	5.90±0.99 ^a
T ₃	0	4.90±1.73 ^a	5.00±2.16 ^a	4.80±2.25 ^a	5.00±1.63 ^a	4.60±2.12 ^b
	8	5.90±2.02 ^a	5.80±1.87 ^a	5.40±1.65 ^a	4.80±2.04 ^a	5.50±1.84 ^a
T ₄	0	5.40±1.35 ^a	5.60±1.65 ^a	5.50±1.65 ^a	5.60±1.58 ^a	4.90±2.02 ^{ab}
	8	6.00±2.49 ^a	5.00±2.58 ^a	5.40±2.27 ^a	5.00±2.21 ^a	5.20±2.20 ^a

Values are means of three replicates, values with the same letter in a column are not significantly different from each other at $p>0.05$.

Discussion

Ogi is an important food for many people in various parts of Nigeria and in some other West African countries. However, some of the challenges facing the production of Ogi are nutrient losses which occur at different stages of its production (Awoyale et al., 2016) as well as its contamination by fungi. This study revealed that ginger enhances the nutritional composition of Ogi and increased its nutrient composition. Furthermore, it was observed in this study that the storage time significantly reduced the nutrient content of the Ogi samples between week 0 and week 8; this could be as a result of deteriorating activities of the associated fungi in the Ogi powder.

The nutritional composition of fermented stored flour has been reported to reduce with increase in the length of storage as a result of fungi (Jonathan et al. 2017). Jonathan et al. (2013) observed decrease in the nutritional composition of 'garri ijebu' (a fermented flour) with increase in the length of storage period. Fungi as saprophytic organisms usually act on food as substrate and deteriorate them in order to absorb nutrients from them (Jonathan et al. 2013). Fungal occurrence in dry store foods may be due to their capacity to adapt and survive in dry conditions. Spore production by thermo-tolerant spore producing fungi makes it possible for them to survive in dry conditions due to the resistance of their spores (Amusa et al., 2005) for example, *Aspergillus penicilloides* have been reported to have the ability to grow in a dry environment (Dijksterhuis et al., 2013). In this study, fungal representative from seven genera *Aspergillus*, *Fusarium*, *Penicillium*, *Saccharomyces*, *Rhizopus*, *Trichoderma* and *Alternaria* were isolated from Ogi powder even after the storage period most of which have been earlier identified from Ogi samples (Ajima et al., 2011; Amusa et al., 2005).

Ginger has earlier been reported to contain high fiber, protein, ash, fat and carbohydrate (Agu et al., 2016), this was further proven by that ginger and clove can improve the nutritional composition of sieved

plain Ogi such as ash, protein, fiber, fat and carbohydrate (Farinde, 2015). The fungal load in all the fortified Ogi samples were controlled effectively by various concentrations of ginger, fungal activities was still able to reduce the nutritional composition of the untreated stored Ogi (Control). This finding affirms the earlier recommendation made on the need for the addition of spices to processed Ogi in order to inhibit any microbial growth (Ajima et al., 2011). Increase in the level of ginger concentrations in treated samples reduced the fungal occurrence and enhanced the nutrient, improvement was also observed in the pH ranges of most of the samples. The pH of the control however was observed to fall within the tolerable limit for the growth of fungi during storage. The pH has been discovered to be one of the major factors for the survival of fungi in most food product especially in fermented foods. Fungi, especially moulds have the capacity to flourish in any substrate with low water activity and at pH below 5 while some conidial fungi grows at pH 2 and most fungi are little affected over a broad range, usually 3-8 (Pitt and Hocking, 2009; Okwute and Olafiji, 2014).

Reduction in fungal count and the aflatoxin content in the ginger treated Ogi powder during and after the storage period agrees with the fact that ginger possess antifungal properties. It is observed in this study that the increase in ginger concentrations reduced the fungal growth in all the treated samples. Ginger is an important spice that has been used for several purposes owing to its aroma, medicinal and flavouring characteristics (Adesokan et al., 2010). It is also known to contain several pungent and antioxidant compounds such as gingerol, zingerone, gingerol, zingerone, gingerdiol, shogaol etc most of which possess antimicrobial activity against food spoiling organisms (Ayodele et al., 2009; Zadeh and Kor, 2014). Antifungal effect of ginger may be as a result of availability of different secondary metabolites which inhibit the mycelia growth, spore germination or sporulation, each of these groups presented variable

mechanisms of action (Castillo et al., 2012). In a similar report, effect of ginger powder on the microbial load of *Ayib* (an Ethiopian cottage cheese) a fermented product supplemented with different concentrations of ginger powder (0, 1, 3 and 5 %) effectively reduced the microbial load in ten days (Regu et al., 2016). The aflatoxin content of Ogi samples in this study was within the tolerance limit, however the concentrations was observed to increase with storage time and this is a reflective of increase in the incidence of aflatoxigenic fungi with storage time. One of the most widely known aflatoxigenic fungi that affect various food products during storage is *Aspergillus flavus* which is the main fungi that produces aflatoxins in stored food products (Sule et al., 2015). Aflatoxins are highly stable, as they could still be detected even after the producing fungi has died or replaced by other fungi due to ecological succession (Pitt, 2009; Umesh, 2009).

Spices such as ginger have been severally used as to improve the taste and flavour of many foods and food products in many parts of the world. Apart from the fact that spices excites taste, they are also composed of high quality phytonutrients, essential oils, antioxidants, minerals and vitamins that are essential for overall health sustenance (Famurewa et al., 2011). Ginger is a widely used spice in Nigeria that serves as a food additive and preservative. Ginger rhizome is typically consumed as a fresh paste, dried powder, slices preserved in syrup or candy or for flavoring tea (Famurewa et al., 2011). Sample T₁ was the best samples in terms of general acceptability before the storage but later rated the least after storage while sample T₂ was rated the best in all parameters after storage. It can therefore be deduced that storage conditions coupled with fungal activities can influenced changes in the organoleptic properties. Notably, the decrease in pH, nutrient and aflatoxin contents in the samples based on ginger treatments a well as the improvement in the organoleptic acceptability (sensory evaluation) of the samples could be considered as the major factors while ginger treatments can be encouraged as supplement for Ogi powder.

Conclusion

This study revealed that Ogi samples contains some levels of aflatoxins due to associated fungi strains and this tend to increase with the storage time while its nutrient content decreased however, treatment of Ogi powder with ginger reduced the aflatoxin concentration, improved the nutrient content and general acceptability of the product even after 8 weeks of storage.

Ginger is recommended for Ogi fortification against fungi, aflatoxins and general acceptability of

the populace. A concentration of 5 % ginger is preferably recommended.

Corresponding authors:

Asemoloye, M. D. (asemoloyemike@gmail.com; +2348064844977) and Ogusanwo, O. O. (higherground015@gmail.com; +2348131205333) Mycology/Biotechnology Unit, Department of Botany, University of Ibadan, Ibadan, Nigeria

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