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Nutritional Quality and Acceptability Evaluation of *Ogi* Flour Biofortified with Garlic and Ginger

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Abstract: *Ogi* an affordable complementary food is of paramount importance due to its popularity as diets of many native African populations. The study explored effects of biofortification with garlic and ginger on acceptability and nutritional quality of *ogi* flour prepared from sorghum and quality protein maize by natural fermentation technique. Pasting properties, bulk density, water absorption capacity, total reducing sugar and sensory characteristics were evaluated. Biofortified samples showed stable total reducing sugar content, increase in bulk density, decrease in water absorption capacity and peak time during storage. The pasting temperatures of biofortified *ogi* flour were below boiling temperature thus formed paste in hot water below the boiling point. *Ogi* (maize) with 2% garlic-2% ginger and *ogi* (sorghum) with 4% garlic-2% ginger were the most preferred with no significant difference ($p < 0.05$). Biofortification with garlic and ginger at 2 and 4% improved the quality attributes and acceptability of *ogi* flour. The study on biofortification of *ogi* with garlic and ginger is germane in formulation of nourishing weaning food that is light, less bulky for babies, nursing mothers and malnourished populations.

Key words: Biofortification, garlic, ginger, acceptability, nutritional, *ogi* flour.

1. Introduction

Maize is a major staple food consumed by societies with several food preferences and backgrounds in sub-Saharan Africa. It accounts for approximately one-fifth of the diets and source of protein consumed in West Africa [1]. Sorghum is ranked second after maize as most important cereal in Africa [2]. Quality protein maize (QPM) has higher amounts of protein (10.56%), fat (3.56 %) and ash (1.72%) more than regular maize (10.44, 2.66 and 1.28%, correspondingly) [3]. Sorghum is an important cereal grain food, grown globally and could be used as a substitute for conventional cereals due to its high bioactive compounds, minerals, dietary fiber, vitamin E and carotenoids content [4]. Sorghum is suitable as weaning food due to its protein digestibility that ranges from 36.4 to 74% upon wet cooking. *Ogi* cereal gruel is a staple food of several communities in Nigeria which can be produced from maize, sorghum and millet [5]. *Ogi* from locally available cereals remains the most important complementary foods in West African countries especially in Nigeria, Benin, Ghana and Senegal. It is easy-to-get and cheap when compared with canned baby food [6]. Garlic (*Allium sativum*) and ginger (*Zingiber officinale*) are rich in proteins, phosphorous, potassium, calcium, magnesium and carbohydrates [7]. Biofortified food crops involve combination of high yielding and high nutrient crop varieties. Commercial fortification is addition of essential nutrients at the time of food processing to increase the content of essential micronutrients in food [8]. Garlic has functional antimicrobial, anti-carcinogenic, antihypertensive effects, hepato and cardio protection properties. In spite of the various health benefits of garlic; overall consumption of raw garlic is declining because of its pungent smell and taste [9]. They are universally acceptable; relatively inexpensive and well tolerated by most people, making it an indispensable ingredient

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of food processing throughout the world [7]. *Ogi* has high moisture content, which predisposes it to spoilage hence reduction of moisture content by drying can elongate their shelf-life, makes it handier and allows reconstitution of the *ogi* powder with ease. The consistency and thickness of complementary food given to the children determines its acceptability. Hence, this study explored the influence of biofortification of garlic and ginger on the quality of *ogi* flour in terms of the bulk density, water absorption capacity, pasting properties and its overall acceptability during storage.

2. Material and Methods

2.1 Powdered Garlic and Ginger Preparation

Freshly harvested garlic bulbs and ginger rhizomes (white variety) were washed; skinned and weighed before drying using hot air oven (Gallenkamp, UK) at 65 °C for 12 h. It was then milled in a grinder (Marlex Appliances PVT, Mumbai, India), sieved (50 to 60 µm mesh size) and packaged [7].

2.2 Ogi Preparation Biofortified with Garlic and Ginger

White Quality protein maize (ART/98/SW06/OB/W) was obtained from the Institute of Agricultural Research and Training (I.A.R.T.), Ibadan, Nigeria. Sorghum (red variety) was purchased from a local market in Ile-Ife, Osun State, Nigeria. The grains were sorted, weighed (15 kg) each and steeped individually for 72 h. The grains were drained, wet-milled to smooth paste using an attrition mill without sieving. The smooth pastes (1 kg) were weighed into 8 portions and 500 mL of distilled water was added to each to form slurry. Garlic and ginger powder were added for biofortification and labeled as follows: A: control samples (without garlic/ginger); B: *Ogi* + 2% Garlic; C: *Ogi* + 4% Garlic; D: *Ogi* + 2% Ginger; E: *Ogi* + 4% Ginger; F: *Ogi* + 2% Garlic-2% Ginger; G: *Ogi* +2% Garlic-4% Ginger; H: *Ogi* + 4% Garlic-2% Ginger. The slurry was evenly homogenized and fermented for 24 h at ambient temperature (27 ± 2 °C). The fermented slurry was then decanted; pressed inside a muslin cloth bag to squeeze out excess water to form cake [10].

2.3 Preparation of Biofortified Ogi Flour

Ogi flour was obtained by drying the *ogi* cake using cabinet dryer at 42 ± 2 °C for 48 h. The dried cake was dry milled to aperture of 50 µm. The flour was cooled to room temperature before packaging into polyethylene bag and sealed with an electric sealer. The packaged samples were stored at ambient temperature for 16 weeks during which samples were obtained for analysis.

2.4 Determination of Total Reducing Sugars

The total reducing sugar content was determined using the Dinitrosalicyclic acid (DNSA) reagent method as described by Adeniran and Abiose [11]. One (1) millilitre of ethanolic extract was dispensed into test tubes and 2 mL of DNSA was added. The mixture was boiled for 5 min then rapidly cooled under running water; 7 mL of distilled water was added. The absorbance of the mixture was read at 540 nm in a UV Spectrophotometer against reagent blank. Calibration curve was prepared with different concentrations of glucose.

2.5 Determination of Total Free Amino Acid

Ninhydrin colorimetric method as described by Omafuvbe [12] was used. To 1 mL of the aliquot in a properly labeled test tube, 0.5 mL of cyanide acetate buffer (pH 5.4) and 0.5 mL of 3.0% ninhydrin solution in 2-methoxyethanol were added. The tubes were heated in a boiling water bath for 15 min after which 10 mL of isopropyl-alcohol: water mixture (1:1) was added rapidly and the solution was cooled to room temperature. The optical density (OD) of the solution was read at 570 nm in a spectrophotometer (Model SP9, PyeUnican UK). The concentration of free amino acids in the sample was extrapolated from a standard curve of known concentrations of glycine.

2.6 Functional Properties Determination

Functional properties such as bulk density, water absorption capacity using [13] method and pasting properties of *ogi* flour with and without ginger and/or garlic were determined.

2.7 Bulk Density

Ogi flour samples (50 g) were weighed into a 100 mL measuring cylinder, empty and filled space of the measuring cylinders occupied by the sample was recorded. Cylinders were tapped until constant volume was attained. Bulk density (g/mL) was then calculated using the equation below with an average value of 10 measurements.

$$Bulk\ density\ = \frac{weight\ of\ flour\ (g)}{volume\ of\ flour(mL)}$$

2.8 Water Absorption Capacity (WAC)

The WAC of the *ogi* flour was determined at room temperature. *Ogi* flour (2 g) was weighed separately into a pre-weighed centrifuge tube and 20 mL of distilled water was dispensed into the sample. The contents were mixed for 30 s every 5 min using a glass rod. After 10 min, it was centrifuged at 1,788 rpm for 20 min. The supernatant was cautiously decanted, drained for 10 min and weighed. The water absorption capacity was expressed as percentage of the volume of water absorbed by the weight of the sample.

$$\text{WAC} = \frac{Volume\ \ of\ \ water\ \ absorbed\ \ (mL)}{weig\,ht\ of\ \ the\ sample\ \ (g)} \times 100(\%)$$

2.9 Determination of Pasting Properties

Pasting properties was determined using Rapid Visco Analyzer (RVA). *Ogi* flour (3 g) was weighed; 5 mL of distilled water was dispensed into test canister. The paddle was placed into the canister and the blade vigorously jogged through the slurry as the test proceeded and terminated automatically. The slurry was heated from 50 to 95 °C and cooled back to 50 °C within 12 min rotating the can at 160 rpm through constant stirring of the content by a plastic paddle. Peak viscosity, setback viscosity, final viscosity, pasting temperature, pasting time, trough and breakdown value was estimated [14].

2.10 Sensory Evaluation

The sensory evaluation of reconstituted *ogi* flour was carried out using 9-point Hedonic scale. Panelist used to evaluate the *ogi* porridge was semi-trained but comprised of those acquainted with *ogi* porridge quality. Selection was based on interest and availability. *Ogi* porridge was prepared by reconstituting 10 g *ogi* flour with 50 mL of portable water; boiling water was added until gelatinization occurs. It was randomly served hot in coded plates and was rated based on colour, appearance, aroma, texture, taste and overall acceptability, where 9 represented like extremely and 1 dislike extremely. The data obtained for all the parameters were reported as means of 15 judgments [15].

2.11 Statistical Analysis

The mean value and standard deviation for all *ogi* flour samples were calculated in each case as entire determinations carried out were carried out in triplicates. ANOVA was done and the separation of the mean values uses Duncan's Multiple Range Test at *p* for Social Scientists (SPSS) software, 16.0 version.

3. Results

Gradual decrease in total reducing sugar from 23.05-18.45 mg/mL (maize) and 22.46 to 18.80 mg/mL (sorghum) were observed in samples without garlic and ginger during 16 weeks of storage as presented in Figs. 1 and 2. It was observed that the total reducing sugar contents of flour samples containing 2% garlic gradually decreased from 22.32 to 20.77 mg/mL (maize) and from 22.50 to 21.53 mg/mL (sorghum) for the first 4 weeks and then became relatively stable till the end of storage. The total reducing sugar of *ogi*

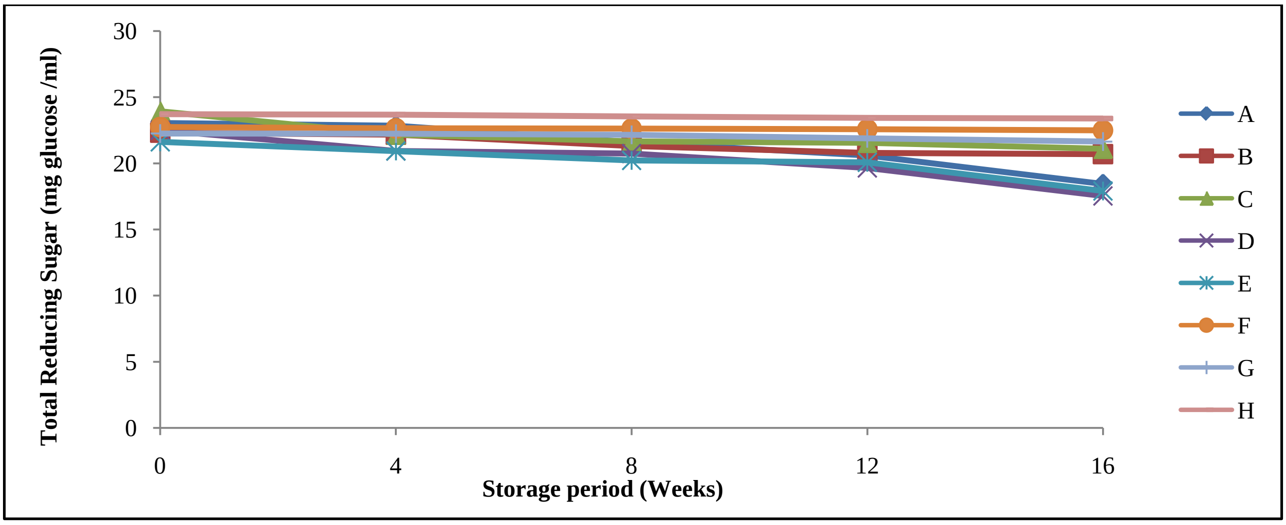

Fig. 1 Total reducing sugar of *Ogi* (maize) flour biofortified with garlic and ginger.
Sample codes: A: *Ogi*, B: *Ogi* + 2% Garlic, C: *Ogi* + 4% Garlic, D: *Ogi* + 2% Ginger, E: *Ogi* + 4% Ginger, F: *Ogi* + 2% Garlic-2% Ginger, G: *Ogi* + 2% Garlic-4% Ginger, H: *Ogi* + 4% Garlic-2% Ginger.

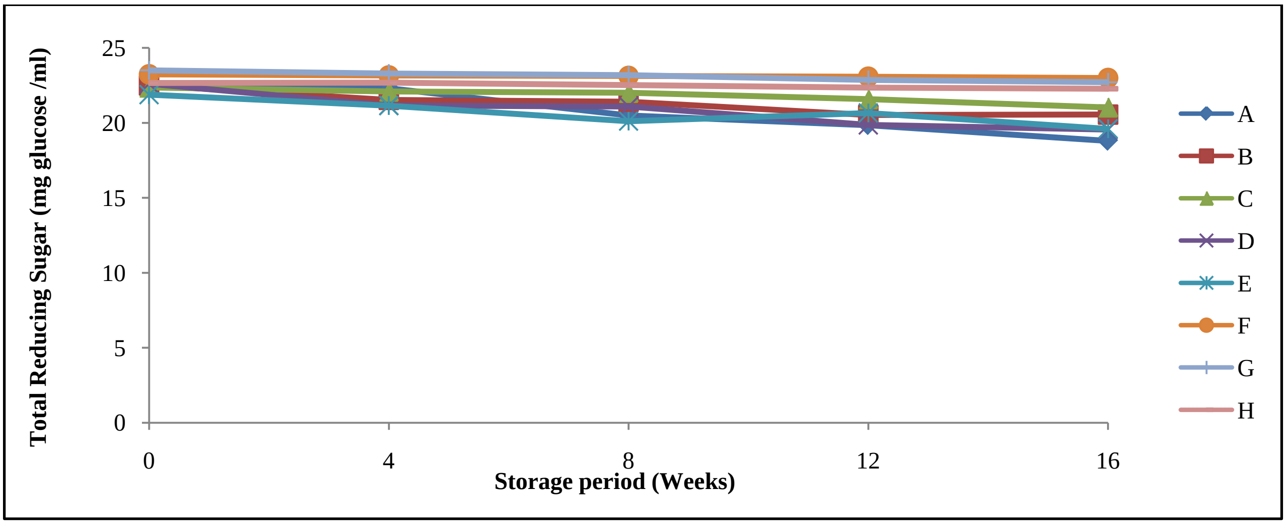

Fig. 2 Total reducing sugar of *Ogi* (sorghum) flour biofortified with garlic and ginger.
Sample codes: A: *Ogi*, B: *Ogi* + 2% Garlic, C: *Ogi* + 4% Garlic, D: *Ogi* + 2% Ginger, E: *Ogi* + 4% Ginger, F: *Ogi* +2% Garlic-2% Ginger, G: *Ogi* +2% Garlic-4% Ginger, H: *Ogi* +4% Garlic-2% Ginger.

flour (maize) with 4% garlic decreased from 23.94 to 21.66 mg/mL for 8 weeks and remained relatively stable till end of storage period. Relatively stable total reducing sugar content was observed in *ogi* flour (sorghum) with 4% garlic for 12 weeks followed by slight decrease for the remaining period of storage (20.66-19.60 mg/mL). The total reducing sugar contents of all *ogi* flour samples containing blends of 2% garlic-2% ginger, 2% garlic-4% ginger and 4% garlic-2% ginger were stable during storage. The total free amino acid of *ogi* flour without biofortification, samples biofortified with 2% garlic, 4% garlic; 2% garlic-2% ginger; 2% garlic-4% ginger and 4% garlic-2% ginger were stable throughout the 16 weeks of storage (Figs. 3 and 4). It was observed that *ogi* flour produced from sorghum without biofortification had the lowest total free amino acid content out of the samples throughout the period of storage. The bulk density of all *ogi* flour during storage ranged from 0.40 to 0.55 g/mL (maize) and 0.50 to 0.67 g/mL

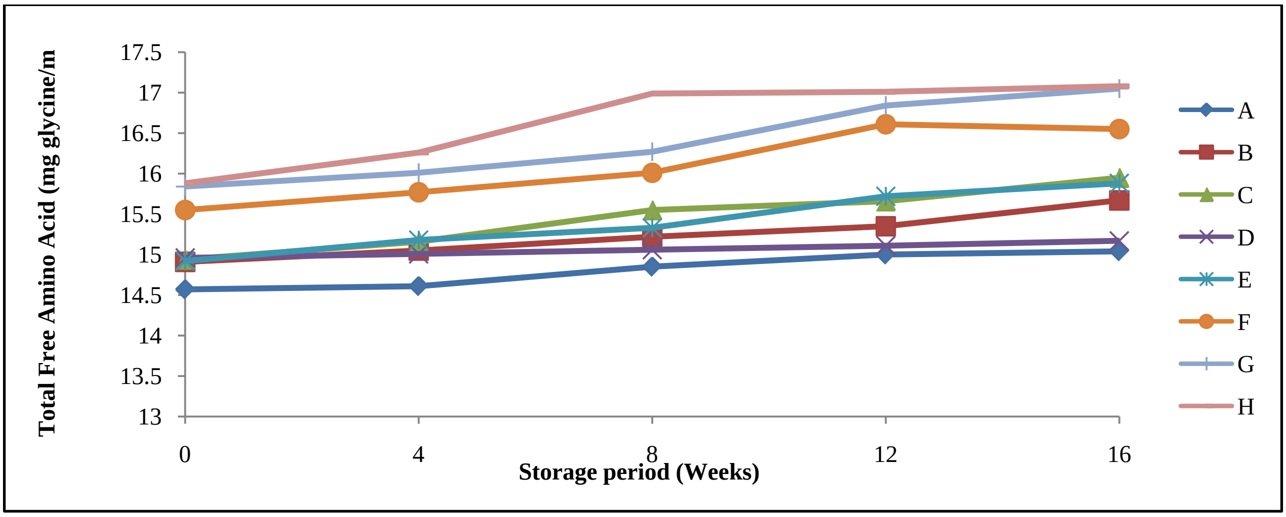

Fig. 3 Total free amino acid of *Ogi* (maize) flour biofortified with garlic and ginger.
Sample codes: A: *Ogi*, B: *Ogi* + 2% Garlic, C: *Ogi* + 4% Garlic, D: *Ogi* + 2% Ginger, E: *Ogi* + 4% Ginger, F: *Ogi* + 2% Garlic-2% Ginger, G: *Ogi* +2% Garlic-4% Ginger, H: *Ogi* + 4% Garlic-2% Ginger.

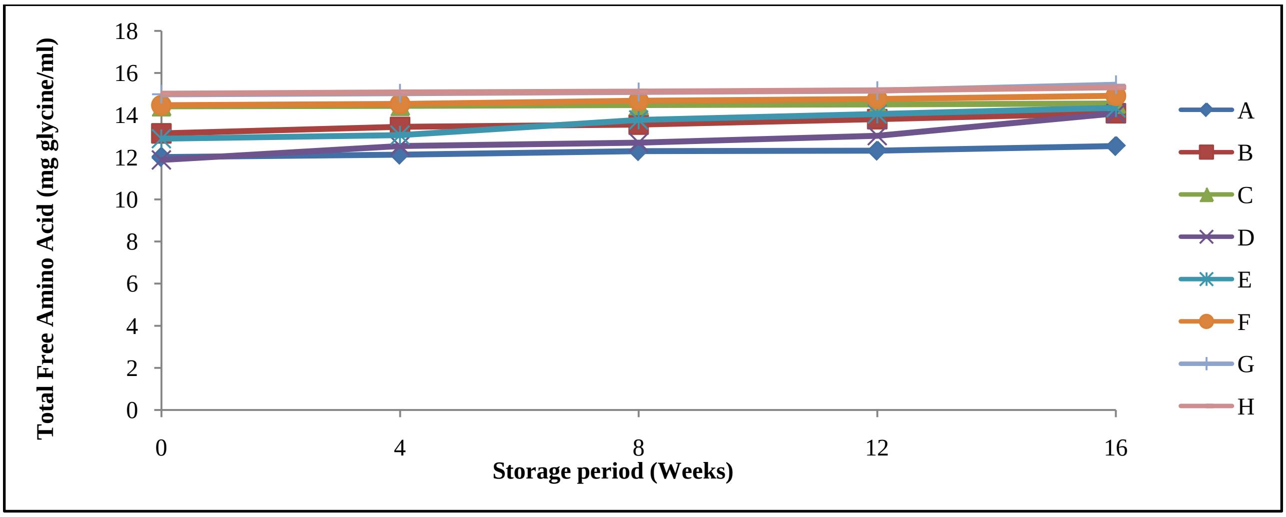

Fig. 4 Total free amino acid of *Ogi* (sorghum) flour biofortified with garlic and ginger.
Sample codes: A: *Ogi*, B: *Ogi* + 2% Garlic, C: *Ogi* + 4% Garlic, D: *Ogi* + 2% Ginger, E: *Ogi* + 4% Ginger, F: *Ogi* + 2% Garlic-2% Ginger, G: *Ogi* +2% Garlic-4% Ginger, H: *Ogi* + 4% Garlic-2% Ginger.

(sorghum) as presented in Table 1. It was observed that the bulk density of *ogi* flour produced from maize (0.50 g/mL) was lower than sorghum's (0.63 g/mL). The water absorption capacity (WAC) of all *ogi* flour samples ranged from 101.00 to 160.00% (maize) and 104.00 to 150.00% (sorghum). Biofortification of *ogi* flour with 2% garlic and 2% ginger singly increased the WAC (Table 1). However, decrease in water absorption capacity was observed in biofortified samples with 4% garlic, 4% ginger singly and samples containing combinations of garlic-ginger at different concentrations. The peak viscosity of *ogi* (maize) ranged from 119.67 to 222.08 RVU and 161.17 to 301.08 RVU for *ogi* (sorghum) as presented in Tables 2 and 3.

Increase in the peak viscosity of most biofortified *ogi* flour may be due to availability of more starch granules with a high swelling capacity resulting in higher peak viscosity [16]. The addition of garlic-ginger to *ogi* flour increased the setback values (ability for formation of semi-solid gel/paste) which ranged from 55.58 to 92.58 RVU for *ogi* (maize) and

Table 1 Bulk density and water absorption capacities of *Ogi* flour biofortified with garlic and ginger.

Sample/weeks	Bulk density (g/mL)		Water absorption capacity (%)	
	Maize	Sorghum	Maize	Sorghum
A0	0.50 ± 0.01^{b}	0.63 ± 0.02^{b}	140.00 ± 0.02	130.00 ± 0.06
16	0.49 ± 0.02^{b}	0.60 ± 0.03^{c}	101.00 ± 0.05	105.00 ± 0.01
B0	0.49 ± 0.02^{b}	0.61 ± 0.01^{c}	150.00 ± 0.05	140.00 ± 0.02
16	0.48 ± 0.02^{b}	0.60 ± 0.03^{c}	145.00 ± 0.01	132.00 ± 0.05
C0	0.48 ± 0.01^{b}	0.60 ± 0.04^{c}	130.00 ± 0.08	120.00 ± 0.04
16	0.48 ± 0.05^{b}	0.60 ± 0.01^{c}	127.00 ± 0.02	115.00 ± 0.09
D0	0.55 ± 0.01^{a}	0.67 ± 0.02^{a}	160.00 ± 0.03	150.00 ± 0.01
16	0.51 ± 0.01^{b}	0.66 ± 0.01^{a}	156.00 ± 0.01	149.00 ± 0.08
E0	0.52 ± 0.03^{a}	0.65 ± 0.03^{a}	120.00 ± 0.02	125.00 ± 0.02
16	0.49 ± 0.01^{b}	0.63 ± 0.01^{b}	117.00 ± 0.03	120.00 ± 0.03
F0	0.43 ± 0.02^{c}	0.54 ± 0.02^{d}	130.00 ± 0.02	120.00 ± 0.07
16	0.43 ± 0.05^{c}	0.54 ± 0.01^{d}	124.00 ± 0.03	118.00 ± 0.05
G0	0.42 ± 0.01^{c}	0.51 ± 0.03^{e}	130.00 ± 0.05	120.00 ± 0.02
16	0.42 ± 0.04^{c}	0.51 ± 0.01^{e}	129.00 ± 0.02	117.00 ± 0.05
H0	0.40 ± 0.02^{c}	0.50 ± 0.01^{e}	130.00 ± 0.07	110.00 ± 0.05
16	0.40 ± 0.05^{c}	0.50 ± 0.01^{e}	123.00 ± 0.07	104.00 ± 0.02

Sample codes: A: *Ogi*, B: *Ogi* + 2% Garlic, C: *Ogi* + 4% Garlic, D: *Ogi* + 2% Ginger, E: *Ogi* + 4% Ginger, F: *Ogi* + 2% Garlic-2% Ginger, G: *Ogi* + 2% Garlic-4% Ginger, H: *Ogi* + 4% Garlic-2% Ginger.

Table 2 Pasting properties of *Ogi* flour (maize) biofortified with garlic and ginger.

Sample	Peak viscosity	Trough viscosity	Breakdown viscosity	Final viscosity	Setback	Peak time	Pasting temperature
A	157.33 ± 0.01^{bc}	90.08 ± 0.02^{c}	67.25 ± 0.01^{c}	123.58 ± 0.03^{d}	33.50 ± 0.01^{d}	5.68 ± 0.02^{ab}	83.35 ± 0.01^{a}
B	221.42 ± 0.02^{a}	157.00 ± 0.01^{a}	64.42 ± 0.03^{c}	237.08 ± 0.01^{a}	80.08 ± 0.02^{ab}	6.35 ± 0.01^{a}	82.25 ± 0.01^{a}
C	222.08 ± 0.01^{a}	140.42 ± 0.03^{ab}	81.67 ± 0.01^{b}	233.00 ± 0.02^{a}	92.58 ± 0.01^{a}	6.45 ± 0.03^{a}	82.59 ± 0.02^{a}
D	213.83 ± 0.03^{ab}	107.08 ± 0.01^{b}	106.75 ± 0.02^{a}	196.67 ± 0.01^{b}	89.58 ± 0.03^{a}	5.25 ± 0.01^{b}	81.47 ± 0.03^{ab}
E	119.67 ± 0.01^{d}	70.92 ± 0.02^{d}	48.75 ± 0.01^{d}	126.50 ± 0.02^{d}	55.58 ± 0.01^{c}	5.78 ± 0.02^{ab}	81.45 ± 0.01^{ab}
F	133.50 ± 0.02^{c}	85.08 ± 0.01^{c}	48.42 ± 0.03^{d}	145.25 ± 0.01^{c}	60.17 ± 0.02^{b}	5.58 ± 0.01^{ab}	82.35 ± 0.02^{a}
G	169.42 ± 0.03^{b}	109.08 ± 0.02^{b}	60.34 ± 0.01^{c}	230.57 ± 0.03^{a}	61.15 ± 0.01^{b}	5.25 ± 0.02^{b}	83.65 ± 0.01^{a}
H	194.25 ± 0.01^{ab}	148.75 ± 0.01^{ab}	45.50 ± 0.02^{d}	237.58 ± 0.01^{a}	88.83 ± 0.02^{a}	6.33 ± 0.01^{a}	82.47 ± 0.02^{a}

Values are means (n = 3) ± standard deviation. Means followed by different superscripts are significantly different ($p < 0.05$) along column according to Duncan multiple range test. Sample codes: A: *Ogi*, B: *Ogi* + 2% Garlic, C: *Ogi* + 4% Garlic, D: *Ogi* + 2% Ginger, E: *Ogi* + 4% Ginger, F: *Ogi* + 2% Garlic-2% Ginger, G: *Ogi* +2% Garlic-4% Ginger, H: *Ogi* +4% Garlic-2% Ginger.

Table 3 Pastingproperties of Ogiflour (sorghum) biofortified with garlic and ginger.

Sample	Peak viscosity	Trough viscosity	Breakdown viscosity	Final viscosity	Setback	Peak time	Pasting temperature
A	191.17 ± 0.01^{d}	156.00 ± 0.03^{c}	35.17 ± 0.02^{d}	224.33 ± 0.01^{bc}	68.33 ± 0.03^{c}	6.25 ± 0.02^{a}	82.58 ± 0.01^{a}
B	301.08 ± 0.03^{a}	240.33 ± 0.01^{a}	60.75 ± 0.02^{c}	413.83 ± 0.03^{a}	73.50 ± 0.01^{c}	5.19 ± 0.01^{c}	81.47 ± 0.02^{a}
C	278.67 ± 0.02^{ab}	199.83 ± 0.01^{b}	78.84 ± 0.01^{b}	391.58 ± 0.02^{a}	91.75 ± 0.02^{ab}	5.38 ± 0.03^{b}	83.65 ± 0.01^{a}
D	251.83 ± 0.01^{b}	220.08 ± 0.02^{ab}	31.75 ± 0.03^{e}	309.25 ± 0.01^{ab}	80.17 ± 0.03^{b}	5.44 ± 0.01^{b}	82.58 ± 0.03^{a}
E	161.17 ± 0.02^{e}	123.25 ± 0.01^{d}	37.92 ± 0.01^{d}	247.33 ± 0.02^{b}	104.08 ± 0.01^{a}	6.35 ± 0.02^{a}	81.47 ± 0.01^{a}
F	197.33 ± 0.01^{d}	158.92 ± 0.03^{c}	38.45 ± 0.02^{d}	249.25 ± 0.01^{b}	98.33 ± 0.02^{a}	5.85 ± 0.01^{ab}	82.58 ± 0.02^{a}
G	197.33 ± 0.03^{d}	124.17 ± 0.01^{d}	38.42 ± 0.03^{d}	157.92 ± 0.03^{d}	90.33 ± 0.01^{ab}	5.19 ± 0.03^{c}	83.66 ± 0.01^{a}
H	235.88 ± 0.01^{c}	108.58 ± 0.02^{e}	127.30 ± 0.01^{a}	183.42 ± 0.01^{c}	74.84 ± 0.02^{c}	5.25 ± 0.01^{c}	80.47 ± 0.03^{a}

Values are means (n = 3) ± standard deviation. Means followed by different superscripts are significantly different ($p < 0.05$) along column according to Duncan multiple range test. Sample codes: A: *Ogi*, B: *Ogi* + 2% Garlic, C: *Ogi* + 4% Garlic, D: *Ogi* + 2% Ginger, E: *Ogi* + 4% Ginger, F: *Ogi* + 2% Garlic-2% Ginger, G: *Ogi* + 2% Garlic-4% Ginger, H: *Ogi* +4% Garlic-2% Ginger.

Table 4 Sensory evaluation of *Ogi* flour (maize) biofortified with garlic and ginger.

Samples	Attributes					
	Colour	Appearance	Aroma	Taste	Texture	Overall acceptability
A	6.72 ± 0.01^b	7.50 ± 0.05^a	6.35 ± 0.02^a	6.45 ± 0.01^a	6.01 ± 0.03^c	6.77 ± 0.04^a
B	6.61 ± 0.02^b	6.55 ± 0.03^c	5.51 ± 0.01^c	5.02 ± 0.03^c	6.25 ± 0.01^b	5.86 ± 0.02^b
C	7.31 ± 0.01^a	7.11 ± 0.02^b	5.54 ± 0.03^c	4.89 ± 0.05^c	6.48 ± 0.02^a	6.07 ± 0.01^b
D	6.25 ± 0.03^c	6.53 ± 0.01^c	6.21 ± 0.04^a	5.05 ± 0.02^c	6.35 ± 0.03^a	6.02 ± 0.05^b
E	5.05 ± 0.01^e	5.02 ± 0.03^f	4.77 ± 0.01^d	4.83 ± 0.04^c	4.61 ± 0.01^d	4.88 ± 0.01^d
F	6.27 ± 0.04^c	6.19 ± 0.01^d	6.05 ± 0.02^b	6.25 ± 0.01^a	6.39 ± 0.05^a	6.74 ± 0.03^a
G	5.81 ± 0.02^d	6.01 ± 0.04^e	6.28 ± 0.01^a	6.08 ± 0.03^b	6.15 ± 0.01^b	5.72 ± 0.02^c
H	7.54 ± 0.05^a	7.34 ± 0.01^a	6.02 ± 0.03^b	4.96 ± 0.02^c	5.09 ± 0.04^d	4.51 ± 0.01^d

Values are means (n = 15) ± standard deviation. Means followed by different superscripts are significantly different ($p < 0.05$) along column according to Duncan multiple range test. Sample codes: A: *Ogi*, B: *Ogi* + 2% Garlic, C: *Ogi* + 4% Garlic, D: *Ogi* + 2% Ginger, E: *Ogi* + 4% Ginger, F: *Ogi* + 2% Garlic-2% Ginger, G: *Ogi* + 2% Garlic-4% Ginger, H: *Ogi* +4% Garlic-2% Ginger.

Table 5 Sensory evaluation of *Ogi* flour (sorghum) biofortified with garlic and ginger.

Samples	Attributes					
	Colour	Appearance	Aroma	Taste	Texture	Overall acceptability
A	6.74 ± 0.02^b	6.55 ± 0.01^b	6.69 ± 0.03^a	6.28 ± 0.01^a	6.92 ± 0.04^a	7.05 ± 0.01^a
B	6.95 ± 0.01^a	6.55 ± 0.03^b	6.51 ± 0.02^b	5.88 ± 0.04^b	6.31 ± 0.02^b	6.48 ± 0.03^c
C	7.05 ± 0.01^a	6.55 ± 0.02^b	5.32 ± 0.01^d	5.51 ± 0.03^d	5.71 ± 0.01^d	5.73 ± 0.01^d
D	6.41 ± 0.03^c	6.55 ± 0.01^b	6.65 ± 0.02^a	5.48 ± 0.05^d	6.05 ± 0.03^c	6.44 ± 0.02^c
E	6.33 ± 0.01^c	5.82 ± 0.04^c	6.59 ± 0.01^b	6.12 ± 0.02^b	5.95 ± 0.01^c	6.46 ± 0.03^c
F	6.55 ± 0.02^c	7.01 ± 0.01^a	5.54 ± 0.03^c	6.02 ± 0.01^b	6.02 ± 0.02^c	6.73 ± 0.04^b
G	6.48 ± 0.04^c	6.45 ± 0.01^b	6.41 ± 0.03^b	5.73 ± 0.01^c	5.68 ± 0.01^c	6.11 ± 0.02^d
H	6.99 ± 0.01^a	6.95 ± 0.03^a	6.66 ± 0.01^a	6.16 ± 0.02^a	7.01 ± 0.04^a	6.99 ± 0.01^a

Values are means (n = 15) ± standard deviation. Means followed by different superscripts are significantly different ($p < 0.05$) along column according to Duncan multiple range test. Sample codes: A: *Ogi*, B: *Ogi* + 2% Garlic, C: *Ogi* + 4% Garlic, D: *Ogi* + 2% Ginger, E: *Ogi* + 4% Ginger, F: *Ogi* + 2% Garlic-2% Ginger, G: *Ogi* + 2% Garlic-4% Ginger, H: *Ogi* + 4% Garlic-2% Ginger.

ogi (sorghum) 68.33 to 104.08 RVU. The pasting temperature was between 81.45 and 83.65 °C for *ogi* (maize) and 80.47 to 83.66 °C for *ogi* (sorghum). Biofortification with garlic improved the colour while ginger enhanced the aroma of *ogi* samples. Garlic-ginger samples were more preferred in terms of appearances and texture of *ogi* flour (Tables 4 and 5).

4. Discussion

Reducing sugar content in *ogi* has been reported as good attribute because methods of preparing weaning foods involve heat-processing [17]. Biofortification with garlic and ginger increased the total free amino acid *ogi* flour samples containing 2% garlic, 4% garlic; blends of 2% garlic-2% ginger; 2% garlic-4% ginger and 4% garlic-2% ginger increased throughout the 16 weeks of storage. Similar observations have been reported during storage of cereal product [18]. Biofortification of *ogi* flour with garlic and garlic-ginger reduced the bulk density and was stable during storage. Samples of lower density are required for infants to allow them swallow with ease without choking. The low bulk density value corresponds to increase in compactness of flour particles; thereby increasing available energy content from *ogi* flour [19]. The reduction in water absorption observed in biofortified *ogi* flour with garlic and garlic-ginger is advantageous in formulation of healthy weaning foods that are low viscous and less bulky. The variance observed in WAC of flour samples may be due to molecular structure, particle size, and amylose/amylopectin ratio [20]. The pasting temperature of all biofortified the samples was lower than 100 °C as a result all samples formed paste in hot water below boiling point. The difference in the pasting characteristics of maize and sorghum flour could be attributed to their grain components [21]. *Ogi* (maize) with 2% garlic-2% ginger and *ogi* (sorghum) with 4% garlic-2% ginger were the most preferred in term of appearance, colour, aroma, taste, texture and overall acceptability out of all biofortified samples with no significant difference compared with control. Least preference observed for samples containing 4% garlic may be due to the strong flavour of garlic [22].

5. Conclusions

Results from this study showed that biofortification of *ogi* flour produced from maize or sorghum with garlic, ginger and garlic-ginger at 2 and 4% increased the guaranteed derivable nutrients and calories due to decrease in visousity and the bulkiness of the *ogi* flour. Their integration also improved its acceptability, as there was no significant difference ($p > 0.05$) in the overall acceptability between most preferred biofortified and the non-biofortified samples. Hence, these products are highly recommended as nourishing food for weaning, nursing mothers and malnourished population.

Conflict of Interest Statement

Authors declared no conflicting interests.

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Authors' Contributions

AFO and SHA conceptualized and designed the study; AFO performed the experiments, analyzed and interpreted the data. SOG analysed the pasting properties of the samples, SHA supervised and proof read the manuscript, and AFO was a major contributor in writing the manuscript. All authors read and approved the final manuscript.

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