Available online at www.ifejost.org

IFE JOURNAL OF SCIENCE AND TECHNOLOGY

Vol 6. No. 1 (2022) 17–35

Nutritional composition and functional properties of *ogi* powder made from quality protein maize (qpm), defatted soy and cinnamon

D. E. Enwerem and A. V. Ikujenlola

Department of Food Science & Technology, Obafemi Awolowo University, Ile-Ife, Nigeria

*Corresponding author: debbyfavours@gmail.com

Abstract

The study evaluated the nutritional and functional properties of powdered *ogi* made from QPM, defatted soy, and cinnamon and determined the impact of cinnamon inclusion on the nutritional and functional properties of the product. Six samples A (100:0:0), B (89:10:1), C (87:10:3), D (85:10:5), E (83:10:7) and F (80:10:10) of powdered *ogi* were formulated using different ratios of QPM, defatted soy, and cinnamon powder. Standard methods were used to analyze the samples for proximate composition, mineral, dietary fibre, functional, pasting, and sensory properties. The proximate analysis showed that the powdered *ogi* samples had a protein range of 7.33-8.93%, carbohydrate (73.07-74.55%), fat (2.30-2.45%), crude fibre (1.52-1.67%), ash (2.03-2.24%), and moisture (11.61-12.25%). The dietary fibre result showed a range of total dietary fibre (3.27-4.35), soluble dietary fibre (1.73-2.70), and insoluble dietary fibre (1.47-1.64). The mineral content of the *ogi* samples ranged from Na (0.10-0.13%), K (0.23-0.29%), Ca (0.11-0.14%), Mg (0.11-0.15%), and Zn (1.13-0.47%). The functional properties of the powdered *ogi* product in terms of oil absorption capacity ranged between 105.70-116.50, water absorption capacity (112.45-121.40), swelling capacity (13.28-16.46) and least gelation capacity of 0.51-0.53. The sensory acceptability level of the powdered *ogi* product reduced with increased level of cinnamon powder inclusion. The powdered *ogi* product exhibited good nutritional and functional properties that could serve as a good staple to combat protein energy malnutrition and other nutritional health issues.

Keywords: *Ogi*, QPM, Defatted Soy, Cinnamon, Proximate, Functional Properties, Antioxidant

Introduction

Ogi is a wet-milled, fermented cereal grain-based thin porridge that is smooth, free-flowing, and used as a primary diet for newborns during weaning, a breakfast item for both children and adults, and occasionally as recuperating diet for the sick (Nnanyelugo & Onofiok, 2014). It is a fermented, non-alcoholic West African grain gruel made from millet, sorghum, or maize. The cereals can also be mixed together to improve the gruel's nutritional value. In Nigeria, it is also referred to as "Eko," "Agidi," "Akamu," and "Koko" (Afolayan *et al*., 2010). *Ogi* can be eaten as a whole meal or combined with other foods such as cooked beans, fried bean cakes known as akara, moi-moi, fried plantains, and occasionally vegetable sauce. *Ogi* can be enhanced with additional enlivening substances such as milk, tea, sugar, and honey to increase its flavor and nutritional value. The main drawback of this cereal gruel is that it is heavy and low in nutrients due to the starchy nature of these foods' tendency to bind so much water (Mbaeyi-Nwaoha & Obetta, 2016). Additionally, o*gi* slurry is a high moisture food and this makes it susceptible to deterioration; however, by reducing moisture content through drying, *Ogi* powder will have a longer shelf life, be more convenient to use, and be easier to reconstitute (Mbaeyi-Nwaoha & Obetta, 2016).

Lysine is typically not found in high concentrations in the amino acid compositions of the proteins in cereal grains (Mbaeyi-Nwaoha & Obetta, 2016); but while there is a known lack of the sulfur-containing amino acids methionine and cysteine in legume protein, lysine is very abundant (Iqbal *et al.,* 2006). Legumes will fill in the nutritional gaps left by cereals when cereal and legumes are combined in food formulation, creating a complementary diet. Due to the nutrient deficits in regular maize, which is typically deficient in amino acids like lysine, methionine, and tryptophan, enhanced protein quality in maize has been bred. Quality protein maize (QPM) is an improved variety of maize with increased levels of tryptophan and lysine. It has greater nutritional and biological value and can be used in place of regular maize in terms of culture and kernel phenotype. Since maize is a key ingredient in the manufacture of *ogi*, using the QPM type would be preferable given its nutritional and biological benefits in the production of breakfast gruel. (Akinsola *et al*., 2021)

Malnutrition of proteins is widespread in both developing and impoverished nations. Since animal protein is out of the price range of the average person, plant-based foods serve as their main source of protein (Shiriki *et al.,* 2015). As a result, combining a grain with a legume will assist to increase the nutrient density and consumption of *Ogi*, which may lead to the prevention of malnutrition, especially among young children and newborns.

Leguminosae is the family of plants that includes soybean (Glycine max). Protein, lipids, and other nutrients can be found in soybeans in good amounts. Because soy delivers a "complete" protein profile, unlike some other legumes, soy protein products make excellent alternatives to animal products. Except for methionine, all of the essential amino acids that must be obtained through diet since the human body is unable to synthesis them are found in soybeans. Products containing soy protein can take the role of animal-based foods, which likewise provide complete proteins but frequently have higher fat content, particularly saturated fat (Chima *et al*., 2022). Despite having a significant quantitative contribution, carbohydrates are only moderate nutritional components. This is primarily due to the fact that soybeans are ingested for their higher protein and nutritional value rather than for their carbohydrate level to the human diets.

One of the domestic food technologies that has received the most attention for its potential to increase the nutritional value of plant foods is fermentation (Adebiyi *et al*., 2018). In a controlled environment, food samples from the cereal family, such as maize, sorghum, millet, and rice, can be fermented to increase their nutrient content, carbohydrate digestibility, and energy densities of gruels, increase the bioavailability of amino acids, and also lengthen their shelf life (WHO, 2008). In addition to fermentation's ability to preserve food, microbes are crucial in the manufacture of fermented foods because they enhance the physicochemical, sensory, and safety properties of the finished goods (Pérez-Díaz *et al*., 2017).

This study was motivated by the need for immediate and strategic improvement in the use of accessible local resources in the preparation of nutritious traditional breakfast meal. With the use of QPM, defatted soybean, and cinnamon, a functional *ogi* powder is intended to be produced. Soybeans and hybrid maize are both rich sources of high-quality amino acids, while cinnamon is a strong source of antioxidants. Functional "*ogi*" powder made from a high-protein blend of maize, soybeans, and cinnamon will aid in preventing, controlling, or treating some of these nutritionally associated health problems. Hence, this study investigated the chemical, functional, pasting, antioxidant, dietary fiber and sensory properties of *ogi* powder made from the blends of quality protein maize, defatted soybeans and cinnamon

Materials and Methods

The raw material used includes quality protein maize (QPM), defatted soybean and cinnamon. The QPM was purchased from the International Institute of Tropical Agriculture (IITA), Ibadan, defatted soy flour from Spectra Foods, Agege, Lagos, Nigeria and cinnamon quill was purchased at Oja-Oje market, Ede, Osun state, Nigeria and authenticated at the Herbarium unit of Department of Botany< Obafemi Awolowo University, Ile-Ife, Nigeria.

Sample preparation

Preparation of fermented QPM Powder

The method described by Ajala and Taiwo (2018) was adopted for the production of fermented '*ogi*' from QPM. The QPM grains were cleaned, washed and steeped in clean warm water in a plastic bucket with a cover for 72 hr. After this, the water was removed and the maize wet-milled into slurry. Using a muslin cloth, the slurry was drained and dried at 60 ^{o}C for 24 hr. The dried fermented QPM *ogi* was milled and packaged in an air tight container after cooling. The flow chart for the preparation of the blends of *ogi* is shown in figure1.

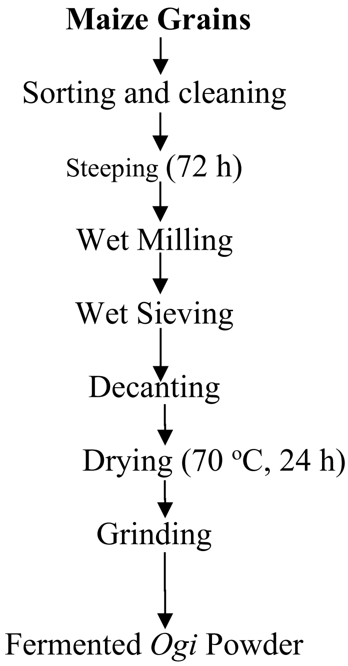

Figure 1: Flowchart for the production of *ogi* powder **(**Ajala and Taiwo, 2018)

Preparation of Cinnamon Powder

The cinnamon powder was produced by drying the cinnamon quill for 2 h, milled and then packaged into an air-tight high density polythene bags.

Formulation of ogi sample blends

The ratio used in the formulation of the different food blends of *ogi* is shown in Table 1 below

Table 1: Percentage (%) Ratios of Ingredients used for Different QPM *Ogi* Blends

Food samples	**Sample A**	**Sample B**	**Sample C**	**Sample D**	**Sample E**	**Sample F**
QPM *Ogi*	100	89	87	85	83	80
Defatted Soybean	0	10	10	10	10	10
Cinnamon	0	1	3	5	7	10
Total	**100**	**100**	**100**	**100**	**100**	**100**

Proximate composition analysis
The proximate composition of the *ogi* powder samples was assessed using the method of AOAC (2010), with each analysis carried out in triplicates.

Functional Properties
The following terms are used to describe different functional properties of evaluated bulk densities: loose bulk density (LBD), pack bulk density (PBD), oil absorption capacity (OAC), water absorption capacity (WAC), foaming capacity (FC), foaming stability (FC), swelling capacity (SC), emulsion capacity (EC), and emulsion stability (ES). Using common analytical techniques, dispersity (DI) and least gelation concentration (LGC) were examined on the composite flours.

Pasting properties
Using a Rapid Visco- Analyzer (RVA) and the program thermocline for Windows version 1.1, the pasting characteristics of the flour samples was determined.

Mineral determination

Ca, Mg and Zn contents of the powdered *ogi* samples were determined with Atomic Absorption Spectrophotometry while Na and K were determined with flame ionization procedure (AOAC, 2020).

Dietary fiber determination of food samples.
Total dietary fibre (TDF), soluble dietary fibre (SDF) and insoluble dietary fibre (IDF) contents of the samples were determined using AOAC (2010) method

pH
The sample's pH was determined in accordance with Pearson's (1976) guidelines. Using a digital pH meter (Hanna instrument, Woonsocket, RI, USA, Model HI 98127), the pH of a sample of 10 g of flour suspended in 50 mL of de-ionized water for 5 min was measured.

Sensory evaluation
Sensory evaluation was performed on the prepared diets and the control sample. Thirty (30) semi-trained panelists were served with coded prepared ogi samples reconstituted in hot water. Each member of the panel was given coded samples to evaluate for taste, aroma, colour, consistency, and overall acceptability using a 9-point Hedonic scale.

Statistical analysis of sample
Statistical Analysis of Variance (ANOVA) was performed on all collected data using the SPSS 20.0 version. The Duncan multiple test was used to compare the mean values in order

to identify any statistically significant differences between them at $P \leq 0.05$.

Results and Discussion

Proximate composition of samples

The result of proximate composition of fermented QPM breakfast meal is shown in table 2. Protein content ranged from 7.33% to 8.93%, fat (2.26% to 2.45%), fibre (1.52% to 1.67%), ash content (2.03% to 2.24%), moisture (11.61% to 12.25%) and carbohydrate (73.07% to 74.55%). sample C and D having the highest carbohydrate content and no significant difference at $P \leq 0.05$.

The result of the study shows that the inclusion of defatted soybean and cinnamon in the QPM-based breakfast meal has positive effects on its nutritional composition. The values obtained for protein in the QPM *ogi* and its blends ranges between 7.33 and 8.93 with sample B (89:10:1) having the highest protein value. This is consistent with previous studies that have reported that the addition of legumes to cereal-based meals could improve their protein quality (Oluwamukomi *et a*l., 2013; Akande *et al*., 2015) and these values were higher than the protein values reported for maize *ogi* complemented with soybean and sorghum malt (6.57-8.62) by Charles *et al.,* (2016).

The increase in fat content in sample B suggests that the addition of defatted soybean could also enhance the fat content of the meal. This is consistent with previous studies that have reported that soybean is a good source of fat (Akande *et al*., 2015).

The table of result shows that the fiber content in samples suggests that cinnamon could have a positive effect on the fiber content of the meal. Cinnamon has been reported to contain dietary fiber, which could contribute to the overall fiber content of the meal (Gruenwald *et al*., 2010).

Functional Properties of the QPM Ogi and its Blends

The functional properties of the QPM ogi is shown in Table 3. Oil Absorption Capacity (OAC) refers to the ability of the fermented *ogi* blend to absorb oil. Samples F and E had the highest OAC values, indicating that they had a higher ability to absorb oil compared to the other samples.

Water Absorption Capacity (WAC) refers to the ability of the fermented *ogi* blend to absorb water. Samples C and D had the highest WAC values, indicating that they had a higher ability to absorb water compared to the other samples.

Table 2: Proximate Composition of QPM *Ogi* and Its Blends

SAMPLE	PROTEIN	FAT	FIBRE	ASH	MOISTURE	CHO
A	8.72±0.07^{c}	2.37±0.02^{c}	1.67±0.02^{d}	2.24±0.02^{a}	11.80±0.02^{b}	73.18±0.03^{c}
B	8.93±0.05^{d}	2.45±0.02^{d}	1.61±0.02^{bc}	2.19±0.02^{a}	11.74±0.02^{b}	73.07±0.00^{c}
C	7.33±0.07^{a}	2.30±0.02^{ab}	1.55±0.01^{ab}	2.07±0.02^{c}	12.25±0.02^{a}	74.49±0.04^{a}
D	7.42±0.12^{a}	2.26±0.02^{a}	1.52±0.14^{a}	2.03±0.02^{d}	12.20±0.02^{a}	74.55±0.^{04a}
E	8.22±0.07^{b}	2.33±0.02^{ab}	1.65±0.02^{cd}	2.15±0.02^{b}	11.66±0.02^{c}	73.98±0.02^{b}
F	8.34±0.07^{b}	2.35±0.02^{bc}	1.63±0.10^{cd}	2.12±0.02^{b}	11.61±0.02^{d}	74.00±0.05^{b}

Quality protein maize (QPM), A=100% QPM (control), B=89% QPM, 10% defatted soybean and 1% cinnamon, C=87% QPM, 10% defatted soybean and 3% cinnamon, D =85% QPM, 10% defatted soybean and 5% cinnamon, E=83% QPM, 10% defatted soybean and 7% cinnamon, F=80% QPM, 10% defatted soybean and 10% cinnamon. Mean values with different superscripts in each column as significantly different at p≤0.05.

Table 3: Functional Property of QPM *Ogi* and Its Blends

Mean values with different superscripts in each column as significantly different at p≤0.05.

SAMPLE	SCg/g Mean SD	EC Mean SD	ES Mean! SD	DISPERSIBILITY Mean SD	LGC Mean SD	LBD (g/ml) Mean SD	PBD (g/ml) Mean SD	OAC (g/100g) Mean! SD	WAC Mean SD	FC Mean SD	FS Mean SD
A	16.40±0.02^{e}	31.04±0.01^{c}	19.39±0.02^{c}	84.81±0.02^{c}	8.49±0.02^{b}	0.52±0.00^{a}	0.61±0.00^{b}	112.85±0.07^{c}	115.70±0.14^{c}	19.68±0.01^{c}	11.04±0.00^{d}
B	16.46±0.01^{f}	31.14±0.01^{d}	19.46±0.02^{d}	84.87±0.02^{c}	8.56±0.02^{c}	0.52±0.00^{a}	0.61±0.00^{b}	113.40±0.14^{d}	116.20±0.14^{d}	19.80±0.01^{d}	11.12±0.02^{e}
C	13.28±0.00^{a}	25.68±0.01^{a}	12.90±0.02^{a}	81.04±0.01^{a}	6.93±0.02^{a}	0.51±0.00^{a}	0.59±0.00^{a}	105.70±0.14^{a}	121.40±0.14^{f}	17.90±0.02^{a}	9.03±0.01^{a}
D	13.39±0.02^{b}	25.80±0.02^{b}	13.04±0.01^{b}	81.13±0.01^{b}	6.90±0.02^{a}	0.51±0.00^{a}	0.60±0.00^{a}	106.35±0.07^{b}	120.80±0.14^{e}	17.97±0.00^{b}	9.14±0.01^{b}
E	15.88±0.01^{b}	33.28±0.00^{e}	20.13±0.01^{e}	87.92±0.02^{e}	9.15±0.02^{d}	0.53±0.00^{a}	0.63±0.00^{c}	115.75±0.07^{e}	111.85±4.87^{a}	21.17±0.01^{e}	10.50±0.02^{c}
F	15.80±0.02^{c}	33.38±0.01^{f}	20.20±0.02^{f}	88.08±0.01^{f}	9.23±0.02^{e}	0.53±0.00^{a}	0.63±0.00^{c}	116.50±0.14^{f}	112.45±0.21^{b}	21.29±0.02^{f}	10.54±0.02^{c}

A=100% Quality protein maize (QPM), B=89% Quality Protein Maize, 10% defatted soybean and 1% cinnamon, C=87% Quality Protein Maize, 10% defatted soybean and 3% cinnamon, D=85% Quality Protein Maize, 10% defatted soybean and 5% cinnamon, E=83% Quality Protein Maize, 10% defatted soybean and 7% cinnamon, F=80% Quality Protein Maize, 10% defatted soybean and 10% cinnamon.

Foaming Capacity (FC) refers to the ability of the fermented *ogi* blend to form a foam when agitated. Samples E and F had the highest FC values, indicating that they had a higher ability to form a foam compared to the other samples.

Foaming Stability (FS) refers to the ability of the fermented *ogi* blend to maintain its foaming capacity over time. Samples E and F had the highest FS values, indicating that they had a higher ability to maintain their foaming capacity over time compared to the other samples.

Swelling Capacity (SC) refers to the ability of the fermented *ogi* blend to swell when mixed with water. Samples A and B had the highest SC values, indicating that they had a higher ability to swell compared to the other samples.

Emulsion Capacity (EC) refers to the ability of the fermented *ogi* blend to form an emulsion with oil. Samples A and B had the highest EC values, indicating that they had a higher ability to form an emulsion with oil compared to the other samples.

Emulsion Stability (ES) refers to the ability of the fermented *ogi* blend to maintain its emulsifying capacity over time. Samples A and B had the highest ES values, indicating that they had a higher ability to maintain their emulsifying capacity over time compared to the other samples.

Dispersibility (DI) refers to the ability of the fermented *ogi* blend to disperse uniformly in water. Samples A and B had the highest DI values, indicating that they had a higher ability to disperse uniformly in water compared to the other samples.

Least Gelation Concentration (LGC) refers to the lowest concentration of the fermented *ogi* blend required to form a gel. It involves the swelling of starch granules on heating. Samples E and F had the lowest LGC values, indicating that they required a lower concentration to form a gel compared to the other samples.

The functional properties results shown in table 3 suggest that the addition of defatted soybean and cinnamon to quality protein maize in fermented *ogi* can have significant effects on their functional properties. Different combinations of these ingredients can lead to variations in the functional properties of the blends, which can impact their suitability for various food applications.

Fermentation improves the nutritional value of the cereal by breaking down complex carbohydrates and increasing the availability of vitamins and minerals. *Ogi* can be consumed as a porridge, but it is also used as a base for other foods and beverages.

Cinnamon is a spice that is known for its various medicinal properties and has been reported to possess antioxidant and antimicrobial properties (Araújo *et al*., 2019; Ghasemi *et al*., 2019). The addition of cinnamon to *Ogi* blends may have contributed to the increased oil absorption capacity observed in this study. According to Adebiyi *et al*. (2020), cinnamon has high oil absorption capacity and can be used as a natural food ingredient for enhancing the oil binding capacity of food products. This finding is consistent with the trend observed in this study, where there was a steady increase in oil absorption capacity with increasing levels of cinnamon in the *ogi* blend.

In terms of foaming capacity and stability, all sample blends of *ogi* containing 10% defatted soybean and 1-10% cinnamon showed significantly higher values than sample A (100% quality protein maize) in this study. This could be attributed to the presence of soybean, which is known to improve the foam stability of food products (Giami and Ukwuru, 2016). Additionally, some studies have reported that cinnamon can improve the foaming properties of food products. Amagliani *et al*. (2021) has already reported that certain plant proteins including plants like soybean can positively affect foaming of any food medium. These findings suggest that the improved foaming properties of *ogi* blends in this study may be attributed to the combined effect of soybean and likely cinnamon.

Also, Table 3 shows that the blends with higher proportions of cinnamon (samples D, E, and F) exhibited higher values for LBD, PBD, and OAC. This could be due to the presence of polyphenols and other bioactive compounds in cinnamon, which have been reported to have antioxidative properties (Zhu *et al*., 2014). These results suggest that the addition of cinnamon to *ogi* blends could improve their nutritional and functional properties.

Mineral content of the QPM Ogi

Table 4 shows the results of the mineral content of the fermented QPM *ogi* samples in this study. There are significant differences between the samples. Sample F, which had the highest percentage of cinnamon, had the highest values for all minerals (Na, K, Ca, Mg, and Zn) at P≤0.05 compared to the other samples. This is consistent with previous studies that have reported the high mineral content of cinnamon, particularly in magnesium and calcium (Duguma *et al*., 2020).

Table 4: Mineral Content (mg/kg) for QPM *Ogi* and Its Blends

SAMPLE	NA	K	Ca	Mg	Zn
A	0.11±0.00 ^{c}	0.27±0.00 ^{b}	0.12±0.00 ^{b}	0.13±0.00 ^{b}	1.30±0.02 ^{c}
B	0.12±0.00 ^{d}	0.28±0.00^{c}	0.13±0.00 ^{c}	0.14±0.00 ^{c}	1.36±0.01 ^{d}
C	0.10±0.00 ^{a}	0.24±0.00 ^{a}	0.11±0.00 ^{a}	0.12±0.00 ^{a}	1.14±0.02 ^{a}
D	0.11±0.00 ^{b}	0.24±0.00 ^{a}	0.12±0.00 ^{ab}	0.12±0.00 ^{a}	1.19±0.03 ^{b}
E	0.13±0.00 ^{e}	0.28±0.00 ^{c}	0.14±0.00 ^{d}	0.15±0.00 ^{d}	1.47±0.01 ^{e}
F	0.13±0.00 ^{f}	0.30±0.00 ^{d}	0.15±0.00 ^{f}	0.16±0.00 ^{e}	1.43±0.01 ^{e}

Mean values with different superscripts in each column as significantly different at p≤0.05.
A=100% Quality protein maize (QPM), B=89% Quality Protein Maize, 10% defatted soybean and 1% cinnamon, C=87% Quality Protein Maize, 10% defatted soybean and 3% cinnamon, D=85% Quality Protein Maize, 10% defatted soybean and 5% cinnamon, E=83% Quality Protein Maize, 10% defatted soybean and 7% cinnamon, F=80% Quality Protein Maize, 10% defatted soybean and 10% cinnamon.

Furthermore, samples B, C, D, and E, which contained varying percentages of cinnamon, showed higher mineral content compared to sample A, which contained only QPM. This suggests that the addition of cinnamon and defatted soybean flour to QPM *ogi* could have increased its mineral content. Previous studies have also reported the potential positive effect of cinnamon on mineral content particularly calcium and magnesium (Ranasinghe *et al*., 2013).

The result of the study shows that the addition of cinnamon to QPM *ogi* can be an effective strategy for increasing its mineral content, particularly magnesium and calcium, which are important for bone health and overall well-being.

Antioxidative Properties of the QPM Ogi and Its Blends

The results of the antioxidative properties of the fermented QPM Ogi samples are shown in Table 5. The metal chelating activity, ferric reducing antioxidant power (FRAP), DPPH scavenging activity, and total phenolic content (TPC) of the QPM *ogi* and its blends are presented in the table.

Table 5: Antioxidative Properties of the QPM *Ogi* and Its Blends

Sample	Metal chelating (%)	FRAP (mMolFe^{2+})	DPPH (%)	Total Phenolic (µgGAE/g)
A	28.08±0.21^{a}	0.14±0.00^{b}	51.55±0.01^{d}	0.34±0.00^{c}
B	40.48±1.41^{c}	0.14b±0.00^{b}	45.08±0.03^{a}	0.21±0.01^{a}
C	42.42±0.32^{d}	0.15±0.00^{c}	45.21±0.05^{b}	0.22±0.00^{a}
D	46.73±0.81^{d}	0.13±0.00^{a}	65.81±0.03^{f}	0.62±0.00^{d}
E	38.07±1.61^{b}	0.15±0.00^{c}	51.32±0.04^{c}	0.32±0.01^{bc}
F	41.45±0.63^{cd}	0.13±0.00^{a}	57.59^{c}±0.04^{e}	0.31±0.01b

Mean values with different superscripts in each column as significantly different at p≤0.05.
A=100% Quality protein maize (QPM), B=89% Quality Protein Maize, 10% defatted soybean and 1% cinnamon, C=87% Quality Protein Maize, 10% defatted soybean and 3% cinnamon, D=85% Quality Protein Maize, 10% defatted soybean and 5% cinnamon, E=83% Quality Protein Maize, 10% defatted soybean and 7% cinnamon, F=80% Quality Protein Maize, 10% defatted soybean and 10% cinnamon.

Sample D (85% QPM, 10% defatted soybean and 5% cinnamon) had the highest metal chelating activity, which is an indication of its ability to bind to and remove metal ions. Sample D also had the highest DPPH scavenging activity, indicating its ability to neutralize free radicals and the highest TPC, indicating that it contained the highest concentration of phenolic compounds.

Sample A had the lowest antioxidant activity and TPC, indicating that addition of cinnamon to QPM and defatted soybean mixture increased the antioxidant properties of the *ogi* blends. In comparison with existing literature, the results of this study are consistent with previous studies that have reported the antioxidant properties of maize-based fermented products. The addition of soybean and cinnamon to the QPM resulted in an increase in antioxidant activity and TPC, which is consistent with the findings of previous studies. The results shows that the addition of cinnamon and defatted soybean to the QPM *ogi* has raised the breakfast meal to the status a functional food due to its high antioxidant properties.

Stefanović *et al*. (2018) found that the antioxidant activity of fermented cereal-based was positively correlated with the phenolic content. This agrees with the finding on QPM *ogi.* The effect of the soybean added agrees with the submission of Tang *et al*. (2010) that reported antioxidant activity of soybean products which was ascribed to its isoflavones.

Antioxidant activity of cinnamon (*Cinnamomum zeylanicum*) extracts was reported on by Ranasinghe *et al*. (2012). The study links this activity to the presence of phenolic compounds. Inclusion of the cinnamon extract is some blends of QPM *ogi* explains its antioxidative property.

Anti-nutrient Properties of the QPM Ogi and Its blends

Table 6 shows the results of the antinutrient properties of the QPM *ogi* and its blends. Based on the results, sample A, E and F had a relatively high amount of tannin, phytate, and oxalate. However, samples B, C and D, which contained defatted soybean and cinnamon (10% and 1-5%) showed a significant reduction in the levels of these anti-nutrients.

Table 6: Anti-nutrient Properties of the QPM *Ogi* and Its Blends

Sample	Tannin (mg CAT/g)	Phytate (mg/100 g)	Oxalate (mg/100 g)
A	0.86±0.00[e]	0.16±0.00[d]	0.34±0.00[c]
B	0.80±0.00[a]	0.11±0.00[a]	0.22±0.05[a]
C	0.81±0.00[ab]	0.12±0.00[ab]	0.24±0.06[b]
D	0.81±0.00[b]	0..12±0.00[b]	0.25±0.04[b]
E	0.98±0.00[d]	0.17±0.00[d]	0.38±0.00[d]
F	1.03±0.00[c]	0.17±0.00[c]	0.38±0.00[d]

Mean values with different superscripts in each column as significantly different at p≤0.05.
A=100% Quality protein maize (QPM), B=89% Quality Protein Maize, 10% defatted soybean and 1% cinnamon, C=87% Quality Protein Maize, 10% defatted soybean and 3% cinnamon, D=85% Quality Protein Maize, 10% defatted soybean and 5% cinnamon, E=83% Quality Protein Maize, 10% defatted soybean and 7% cinnamon, F=80% Quality Protein Maize, 10% defatted soybean and 10% cinnamon.

Tannins are a type of polyphenolic compound that can bind to proteins and reduce their digestibility. According to a study by Egounlety and Aworh (2003), tannin levels in maize can range from 0.5 to 4.5%. They also found that fermenting maize for 24-72 hours can significantly reduce tannin levels.

Phytates are compounds found in plant-based foods that can bind to minerals such as iron, calcium, and zinc, making them less bioavailable to the body. According to a study by Mertz *et al.* (1984), the phytate content of maize can range from 0.27 to 0.53%, depending on the variety and growing conditions. They also found that fermentation can reduce phytate levels by up to 50%.

Oxalates are another anti-nutrient that can bind to minerals and reduce their absorption by the body. According to a study by Leenhardt *et al*. (2005), the oxalate content of maize can range from 23 to 94 mg/100g. They also found that soaking maize in water can reduce oxalate levels by up to 53%, and fermentation can reduce them even further, by up to 96%.

This study has revealed that addition of of defatted soybean and cinnamon to QPM significantly reduced the levels of anti-nutrients, thereby improving the bioavailability of nutrients in the diet.

Pasting Properties

Table 7 shows the pasting properties of the fermented QPM breakfast meal, as determined by analyzing the peak viscosity, trough viscosity, breakdown viscosity, final viscosity, setback viscosity, peak time, and pasting temperature. The results in the table indicate that the pasting properties of the samples vary significant. Sample A had the highest peak viscosity, which indicates high viscosity and good water-binding capacity. Sample E had the highest final viscosity, which indicates good stability and low tendency to retrograde.

Table 7: Pasting Properties of QPM *Ogi* and Its Blend

Sam Ples	Peak1	Trough 1	Breakdow n	Final Visc	Setback	Peak Time	Pasting Temp
A	106.42	37.17	69.25	69.58	32.42	4.13	79.10
B	98.58	41,58	57.00	75.92	34.33	4.27	79.95
C	87.17	42,83	44.33	77.67	34.83	4.33	79.90
D	74.83	40.42	34.42	73.92	33.50	4.47	80.70
E	109.00	55.08	53.92	104.25	49.17	4.33	79.05
F	100.42	39.75	60.67	70.33	30.58	4,20	79.90

Mean values with different superscripts in each column as significantly different at $p \leq 0.05$. A=100% Quality protein maize (QPM), B=89% Quality Protein Maize, 10% defatted soybean and 1% cinnamon, C=87% Quality Protein Maize, 10% defatted soybean and 3% cinnamon, D=85% Quality Protein Maize, 10% defatted soybean and 5% cinnamon, E=83% Quality Protein Maize, 10% defatted soybean and 7% cinnamon, F=80% Quality Protein Maize, 10% defatted soybean and 10% cinnamon.

These findings are in line with previous studies on the pasting properties of cereals and their products. A study by Ling *et al*. (2020) found that the pasting properties of rice flour were affected by the type and level of amylose and amylopectin, which are the major components of starch. Offia-Olua (2014) reported the dilution effect of walnut flour on the pasting properties of wheat flour which decreased with increased addition of walnut flour.

The pasting properties of the QPM *ogi* also deceased with increased addition of defatted soybean flour and cinnamon. They are important indicators of the quality of the reconstituted *ogi*. The peak viscosity indicates the maximum viscosity obtained during heating, which is related to the starch granule swelling and gelatinization. A higher peak viscosity is generally associated with better texture, smoothness, and mouthfeel of the reconstituted *ogi*. Trough viscosity and breakdown viscosity indicate the ability of the starch to maintain its structure during heating and cooling. A lower trough viscosity and higher breakdown viscosity are desirable because they indicate that the starch can withstand shear and heating stresses without breaking down too much (Önder Yildiz *et al*., 2013).

The final viscosity and setback viscosity indicate the ability of the starch to form a stable gel after cooling. A higher final viscosity and lower setback viscosity are desirable because they indicate a more stable and firm gel. Peak time and pasting temperature are also important. The pasting properties of the fermented QPM breakfast meal provide important information on the quality of the reconstituted *ogi*. A good quality *ogi* should have desirable pasting properties, which are indicated by a higher peak viscosity, lower trough viscosity, higher final viscosity, lower setback viscosity, and shorter peak time and pasting temperature because they determine the time and temperature required for the starch to gelatinize and form a stable gel.

Dietary Fibre and pH of the QPM Ogi and its Blends

The results in Table 8 show the levels of dietary fibre and pH in the fermented QPM breakfast meal. TDF (Total Dietary Fibre) is the sum of both soluble and insoluble dietary fibre, while SDF (Soluble Dietary Fibre) and IDF (Insoluble Dietary Fibre) are the two main types of dietary fibre. The pH level indicates the acidity or alkalinity of the sample (Helmenstine, 2023).

Table 8: Dietary Fibre and pH of the Fermented QPM Breakfast Meal

Sample	TDF	SDF	IDF	pH
A	3.88 ± 0.01^{d}	2.19 ± 0.04^{c}	1.64 ± 0.02^{a}	6.21±0.00
B	4.35 ± 0.02^{a}	2.70 ± 0.03^{a}	1.58 ± 0.01^{b}	6.13±0.00
C	3.44 ± 0.01^{e}	1.91 ± 0.04^{d}	1.52 ± 0.01^{c}	6.68±0.00
D	3.27 ± 0.01^{f}	1.73 ± 0.03^{e}	1.47 ± 0.01^{d}	6.62±0.00
E	4.13 ± 0.02^{b}	2.42 ± 0.04^{b}	1.62 ± 0.01^{a}	6.34±0.00
F	4.08 ± 0.01^{c}	2.40 ± 0.06^{b}	1.60 ± 0.01^{ab}	6.29±0.00

Mean values with different superscripts in each column as significantly different at $p \leq 0.05$.
A=100% Quality protein maize (QPM), B=89% Quality Protein Maize, 10% defatted soybean and 1% cinnamon, C=87% Quality Protein Maize, 10% defatted soybean and 3% cinnamon, D=85% Quality Protein Maize, 10% defatted soybean and 5% cinnamon, E=83% Quality Protein Maize, 10% defatted soybean and 7% cinnamon, F=80% Quality Protein Maize, 10% defatted soybean and 10% cinnamon.

From the table, sample A had the highest IDF content (1.64 ± 0.02), while sample B had the highest SDF content (2.70 ± 0.03). Samples B, E and F had the highest TDF content (4.35 ± 0.02, 4.13 ± 0.02 and 4.08 ± 0.01, respectively). These are samples with defatted soy and cinnamon. The pH levels ranged from 6.13 to 6.68, with sample B having the highest pH level (6.68 ± 0.00).

Dietary fibre is important in the human diet as it has been associated with several health benefits, such as improving digestive health, reducing the risk of chronic diseases such as heart disease, diabetes, and some types of cancer, and aiding weight management. Soluble dietary fibre has been found to have a more pronounced effect on reducing cholesterol levels than insoluble dietary fibre (Ho *et al*., 2016).

The pH level of food also plays an important role in determining its quality, safety, and nutritional value. A neutral pH level is generally considered optimal for most foods. Acidic or alkaline conditions can affect the sensory properties, nutrient availability, and microbial safety of foods (Lund *et al*., 2020).

Based on the table showing the dietary fiber, the IDF (insoluble dietary fiber) content was higher than SDF (soluble dietary fiber) content in all the samples. This is consistent with findings from previous studies that have reported higher levels of IDF in fermented maize-based products compared to SDF (Hsu *et al*., 2004; Akinrele and Onimawo, 2005).

The pH values of the QPM *ogi* and the blends ranged from 6.13 to 6.68, indicating a slightly acidic pH. This finding is consistent with the results of other studies that have reported a pH range of 5.5 to 7.0 in fermented maize-based products (Steinkraus, 2002; Hsu *et al*., 2004).

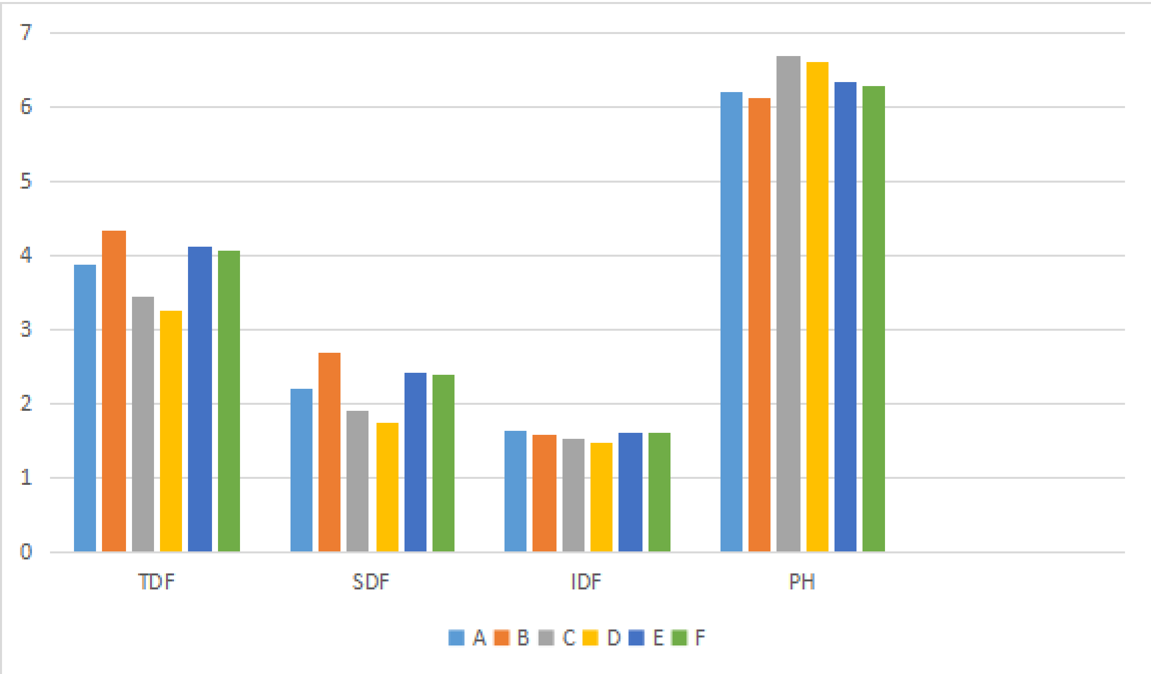

Figure 2: Dietary Fibre and pH of QPM *Ogi* and Its Blends

A=100% Quality protein maize (QPM), B=89% Quality Protein Maize, 10% defatted soybean and 1% cinnamon, C=87% Quality Protein Maize, 10% defatted soybean and 3% cinnamon, D=85% Quality Protein Maize, 10% defatted soybean and 5% cinnamon, E=83% Quality Protein Maize, 10% defatted soybean and 7% cinnamon, F=80% Quality Protein Maize, 10% defatted soybean and 10% cinnamon.

Sensory Evaluation of the fermented Ogi and the Blends

The sensory evaluation results is shown in table 9.Sample A, which contains 100% quality protein maize, had the highest overall acceptability score. This is consistent with existing literature which suggests that the quality of the raw materials used in producing *Ogi* has a significant impact on its sensory properties (Nwosu *et al*., 2019; Eneche *et al*., 2021). Sample F, which contains (80% QPM, 10% defatted soy,10% cinnamon) had the highest score in taste indicating that the addition of these ingredients may improve the sensory properties of the o*gi* especially cinnamon which has a sweet smell and taste.

Table 9: Sensory Characteristics of QPM *Ogi* and Its Blends

SAMPLE	Taste	Flavour	Colour	Texture	Consistency	Overall Acceptability
A	8.13±0.74[b]	7.86±1.30[a]	7.86±1.30[a]	7.93±0.88[a]	7.73±1.22[a]	8.73±0.45[a]
B	7.33±0.48[c]	7.20±1.01[b]	6.33±1.04[b]	6.46±0.99[b]	6.66±0.89[a]	7.40±0.50[b]
C	6.46±0.74[e]	6.33±0.81[c]	5.93±0.79[b]	6.00±1.13[b]	6.86±0.91[a]	7.20±0.94[b]
D	7.53±1.45[d]	7.53±1.12[b]	6.80±1.52[b]	6.93±1.70[a]	7.20±1.26[a]	7.80±0.86[b]
E	7.00±1.84[d]	6.60±0.73[c]	6.33±1.34[b]	6.40±1.29[b]	7.06±1.27[a]	7.33±1.17[b]
F	8.46±0.74[a]	8.13±0.99[a]	8.33±0.81[a]	8.06±1.03[a]	7.80±1.37[a]	8.53±0.63[a]

Mean values with different superscripts in each column as significantly different at $p \leq 0.05$.
A=100% Quality protein maize (QPM), B=89% Quality Protein Maize, 10% defatted soybean and 1% cinnamon, C=87% Quality Protein Maize, 10% defatted soybean and 3% cinnamon, D=85% Quality Protein Maize, 10% defatted soybean and 5% cinnamon, E=83% Quality Protein Maize, 10% defatted soybean and 7% cinnamon, F=80% Quality Protein Maize, 10% defatted soybean and 10% cinnamon.

However, the addition of cinnamon to the *ogi* (at a lower quantity) in samples B, C, D and E did not have a significant effect on their taste and flavour scores. But the addition of soybean and cinnamon (samples B, C, D, E, and F) had a significant effect on the colour of the *ogi*, with lower scores observed for these samples.

Texture and consistency scores were highest for sample A and lowest for sample C. This is consistent with the fact that the addition of soybean and cinnamon can affect the texture and consistency of *ogi* (Eneche *et al*., 2021).

This study suggest that fermenting maize can significantly reduce the levels of anti-nutrients such as tannins, phytates, and oxalates, which can improve the nutritional quality and bioavailability of the fermented QPM breakfast meal. .Also, the results generally suggest that the addition of soybean and cinnamon to *ogi* made from quality protein maize can affect the sensory properties of the *Ogi*, depending on the level of substitution. The QPM *ogi* and its blends are a good source of dietary fiber which could be beneficial for human health. The variation in the levels of dietary fiber between the samples could be due to the different ingredients used in their preparation, and this could be further explored in future studies. Further studies are recommended to optimize the levels of these ingredients to achieve the desired sensory properties while maintaining the nutritional quality of the *ogi*.

Conclusion

This study highlights the potential benefits of fermenting Quality Protein Maize and complementing it a legume and natural spice to improve the nutritional value of a product that could serve as breakfast meal. Fermentation reduced the levels of anti-nutrients and increased the bioavailability of important minerals. The addition of soybean and cinnamon to *ogi* made from Quality Protein Maize also significantly reduced the levels of anti-nutrients such as tannins, phytates, and oxalates and improved the nutritional quality and bioavailability of minerals in the QPM *ogi* and the blends. The sample with 80, 10 and 10% of QPM, defatted soymeal flour and cinnamon, respectively had the preferred sensory characteristics. The sample could be used to combat protein energy malnutrition and by virtue of its high fibre content could also raise the QPM *ogi* to the status of a functional food.

References

Adebiyi, J. A., Obadina, A. O., Adebo, O. A. and Kayitesi, E. (2018). Fermented and malted millet products in Africa: Expedition from traditional/ethnic foods to industrial value-added products. *Critical Reviews in Food Science and Nutrition*, *58*(3): 463-474.

Afolayan, M.O, Afolayan, M., and Abuah, J.N. (2010). An investigation into sorghum-based *ogi* (*Ogi Baba*) storage characteristics. *Advanced Journal of Food Science and Technology*, 2(1): 72-78.

Ajala A.S, Taiwo T. F. (2018). Study on supplementation of ‘ogi’ with oyster mushroom flour (*Pleurotus ostreatus*). *Journal of Nutritional Health and Food Engineering*, 8(3): 287-291.

Akande, K. E., Olagunju, A. I., Adegbola, J. A., Adegunwa, M. O. and Adegbite, O. A. (2015). Proximate and mineral composition of maize-soybean-crayfish blends. *African Journal of Food Science,* 9(10): 499-503.

Akinrele, I. A. and Onimawo, I. A. (2005). Chemical composition and sensory quality of ogi fortified with cowpea flour. *World Journal of Agricultural Sciences*, 1(1): 65-68.

Akinsola O.T., Alamu, E. O., Otegbayo, B. O., Menkir, A. and Maziya-Dixon, B. (2021) Nutritional properties of ogi powder and sensory perception of *ogi* porridge made from synthetic provitamin: A maize genotype. *Frontier Nutrition*, 8: 685004. doi: 10.3389.

Amagliani, L. Silva, J.V.C. Saffon, M. Dombrowski, J. (2021). On the foaming properties of plant proteins: Current status and future opportunities. *Trends in Food Science & Technology,*118 (A): 261-272.

Awuchi, C.G., Igwe, V. S. and Echeta, C.K. (2019). The functional properties of foods and flours. *International Journal of Advanced Academic Research: Sciences, Technology and Engineering*, 5(11) 139-160

AOAC (2010) Official Methods of Analysis. 18th Edition, Association of Official Analytical Chemists International, Benjamin Franklin Station, Washington DC.

Balet, S., Guelpa, A. and Manley, M. (2019). Rapid Visco Analyser (RVA) as a tool for measuring starch-related physiochemical properties in cereals-A review. *Food Analytical Methods,* 12: 2344-2360.

Charles B., Evaristus O.C., Mamudu H.B., Ladi H.K. (2016). Production of powdered maize ogi (indigenous complementary food) flour complemented with soybean and sorghum malt. *Mayfed Journal of Agricultural Science,* 3: 1-14.

Chima, J. U., David-Abraham, F. M. and Okpala, L. C. (2022). Micronutrient and amino acid *(Dioscorea bulbifera)* and germinated black turtle bean (*Phaseolus vulgaris*). *JSFA* profile of breakfast cereal flakes from germinated brown rice (*Oryza sativa*), aerial yam. *Reports*, *2*(9): 430-441.

Duguma, B., Feyissa, T. and Taddese, B. (2020). Proximate composition and mineral content of Ethiopian cinnamon (*Cinnamomum cassia*) bark powder. *Journal of Food Science & Nutrition,* 8(1): 534-541.

Egounlety, M. and Aworh, O. C., (2003). Effect of soaking, dehulling, cooking and fermentation with *Rhizopus oligosporus* on the oligosaccharides, trypsin inhibitor, phytic acid and tannins of soybean (*Glycine max* Merr.), cowpea (*Vigna unguiculata* L. Walp) and groundbean (*Macrotyloma geocarpa* Harms). *Journal of Food Engineering*, 56 (2-3): 249-254.

Eneche, E. H., Ariahu, C. C. and Okafor, D. C. (2021). Sensory and physicochemical characteristics of *ogi* produced from blends of maize and cowpea flour. Heliyon, 7(7)

Gruenwald, J., Freder, J., and Armbruester, N. (2010). Cinnamon and health. *Critical Reviews in Food Science and Nutrition*, 50(9): 822-834.

Ho, H. V., Sievenpiper, J. L., Zurbau, A., Blanco Mejia, S., Jovanovski, E., Au-Yeung, F., Jenkins, A. L. and Vuksan, V. (2016). The effect of oat β-glucan on LDL-cholesterol, non-HDL-cholesterol and apoB for CVD risk reduction: a systematic review and meta-analysis of randomised-controlled trials. *The British Journal of Nutrition*, 116(8): 1369–1382.

Hsu, H. W., Vavak, D. L. and Satterlee, L. D. (2004). *Miller's Review of Critical Nutritional Factors in the Production of Fermented Foods*. CRC Press, Boca Raton.

Lee, M. S., Kim, C. T., Kim, I. H. and Kim, Y. (2020). Effect of cinnamon extract and identification of its bioactive compounds on postprandial plasma glucose, insulin, antioxidant, and lipidomic profiles in healthy adults. *Nutrients,* 12(7): 1978.

Leenhardt, F., Levrat-Verny, M. A., Chanliaud, E., and Rem´ esy, C. (2005). Moderate decrease of pH by sourdough fermentation is sufficient to reduce phytate content of whole wheat flour through endogenous phytase activity. *Journal of Agriculture and Food Chemistry,* 53: 98-102

Li, J, Yang, X., Swallah, M.S., Fu, H., Ji, L., Meng, X., Yu, H. and Lyu, B. (2022). Soy protein isolate: an overview on foaming properties and air–liquid interface *International Journal of Food Science and Technology*, 57: 188-200.

Lund, P.A., De Biase D., Liran, O., Scheler, O., Mira, N.P., Cetecioglu, Z., Fernández, E.N., Bover-Cid, S., Hall, R., Sauer, M. and O'Byrne, C. (2020). Understanding how microorganisms respond to acid pH is central to their control and successful exploitation. *Frontier Microbiology*, 11: 556140.

Mbaeyi-Nwaoha I.E, Uchendu N.O. (2016). Production and evaluation of breakfast cereals from blends of acha and fermented soybean paste (okara). *Journal of Food Science and Technology 53(1):50-70.*

Moskowitz, H.*R. (1988). Applied Sensory Analysis of Foods. Volume 1, CRC, Boca Raton*

Nnanyelugo D.O, and Onofiok N.O. (2014). Weaning Foods in West Africa: Nutritional problems and possible solutions. *Occasional Paper of the Department of Home Science and Nutrition, University of Nigeria, Nsukka*, *Nigeria*.

Nwosu, J. N., Agiriga, A. N. and Igwe, C. U. (2019). Physico-chemical and sensory evaluation of fermented maize meal (*ogi*) enriched with crayfish and fluted pumpkin leaves. *Journal of Food Quality*, 2019: 1-9.

Offia-Olua, B.I. (2014). Chemical, functional and pasting properties of wheat (*Triticum* spp) –walnut (*Jurglans regia*). *Food and Nutrition Sciences*, 2014, 5: 1591-1604

Oluwamukomi, M. O., Bankole, M. O. and Oladunmoye, O. O. (2013). Chemical and sensory properties of complementary foods fortified with fermented and germinated cowpea flours. *Journal of Food and Nutrition Sciences*, 4(10): 89-95.

Önder Yildiz, Bayram Yurt, Ayhan Baştürk, Ömer Said Toker, Mustafa Tahsin Yilmaz, Safa Karaman, Orhan Dağlıoğlu, (2013). Pasting properties, texture profile and stress–relaxation behavior of wheat starch/dietary fiber systems. *Food Research International*, 53(1): 278-290.

Pérez-Díaz, I.M., Altuntas, E.G., Juneja, V.K. (2017). Microbial fermentation in food preservation. In: Juneja, V., Dwivedi, H., Sofos, J. (eds.) *Microbial Control and Food Preservation. Food Microbiology and Food Safety*. Springer, New York, NY.

Ranasinghe, P., Pigera, S., Premakumara, G. S., Galappaththy, P., Constantine, G. R., &

Katulanda, P. (2013). Medicinal properties of 'true'cinnamon (*Cinnamomum zeylanicum*): a systematic review. *BMC Complementary and Alternative Medicine*, 13(1): 1-12.

Shiriki, D., Igyor, M. A. and Gernah, D. I. (2015). Nutritional evaluation of complementary food formulations from maize, soybean and peanut fortified with Moringa oleifera leaf powder. *Food and nutrition sciences*, *6*(05): 494-500.

Steinkraus, K. H. (2002). Fermentations in world food processing. *Comprehensive Reviews in Food Science and Food Safety*, 1(1): 23-32.

Tan, S., Prasad, K. and Ismail, A. (2010). Antioxidant capacity, phenolics and isoflavones in soybean by-products. *Food Chemistry*, 123: 583-589.

WHO (1998). Complementary feeding of young children in developing countries. A review of current scientific knowledge. *WHO Programme of Nutrition*, Geneva. pp: 133-134.

Zeng, Z., Wang, X., Wang, Y., Chen, L. and Luo, H. (2021). Effect of fermentation on dietary fibre content and antioxidant capacity of corn bran. *Food Science and Nutrition*, 9(1): 434-441.

Zhu, F., Asada, T., Sato, A., Ogasawara, Y., Wu, X. and Miyake, M. (2014). Polyphenols in cinnamon (*Cinnamomum zeylanicum*) bark extract and their antioxidant activity. *Journal of Agricultural and Food Chemistry*, 62(29): 6141-6149.