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Utilization potential of quality protein maize in spiced ogi

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The high incidence of protein energy malnutrition among children under 5 years in Nigeria informed this study. Quality protein maize (QPM) produces more lysine and tryptophan than most modern varieties of maize. It has been reported to be economically superior to traditional maize. This research focuses on QPM ogi fortified with indigenous food spices in order to improve its health benefits and organoleptic properties. The yellow variety QPM ART98/SW1 was processed into ogi with inclusion of natural spices (garlic, ginger and clove) each at 1 and 3% concentration. Spiced ogi paste samples were assessed for proximate, minerals, functional and sensory properties on day zero (0). The other portions of the spiced ogi samples were stored for 15 days for microbial analysis and pH. For all parameters studied, plain QPM ogi served as control. Total viable count increased with days of storage in all the ogi samples but the least counts were recorded in QPM ogi spiced with 3% cloves. Crude protein was highest (6.21%) in QPM ogi spiced with 3% clove whereas the control contained 5.57%. The pH of all the ogi samples decreased with days of storage. The most abundant mineral in all the ogi samples is magnesium (mg) which ranges from 1213 to 1495 mg/kg. The result of functional properties shows that the ogi samples had good gelatinization properties. In conclusion, addition of spices improved the nutrient contents of ogi made from QPM. Quality protein maize ogi with 1% ginger was preferred to all the other spiced QPM samples in terms of sensory attributes. Shelf life of QPM ogi could be improved by fortifying with clove at a 3% level.

Key words: Quality protein maize, spices, ogi.

INTRODUCTION

Quality protein maize (QPM) contains almost twice as much usable protein as other maize grown in the tropics. It yields 10% more grain than traditional varieties of maize (Omolaran et al., 2014). In Central and South America, Africa and Asia, several hundred million people rely on maize as their principal daily food, for weaning babies and for feeding livestock (Hilary, 2014).

Nutritionally, QPM grains contain approximately 55 and 30% more tryptophan and lysine, respectively compared to normal maize varieties. This has been confirmed to be true even in QPM varieties developed in Institute of Agricultural Research and Training (IAR&T) Ibadan (Omolaran et al., 2014; Lawal et al., 2014). Lysine and tryptophan allow the body to manufacture complete proteins, thereby eliminating wet malnutrition. In addition, tryptophan can be converted in the body to niacin, which

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theoretically reduces the incidence of pellagra (Mamatha et al., 2017). Maize is known to be the primary provider of calories supplying 20% of the world's food calories (Olakojo et al., 2007). The development of high-protein foods of plant origin is essential in developing countries because of the high cost of animal protein. Consumption of such products may play a major role in combating malnutrition, which is a serious problem in developing countries (Aminigo and Akingbala, 2004).

Ogi is either consumed as porridge (pap) or as a gel-like product (agidi) by a very large number of Nigerians. Pap however is the most important traditional food for weaning infants and the major breakfast cereal for adults especially those low income earners that cannot afford imported baby foods (Ijabadeniyi, 2007; Eke-Ejiofor and Beleya, 2017). Ogi is a popular breakfast cereal gruel in West Africa with high acceptability, low cost and shelf life stability characteristics. Normal maize proteins have poor nutritional value for monogastric animals such as humans and pigs because of lesser content of essential amino acids such as lysine and tryptophan (Akande and Lamidi, 2006). Ogi made from QPM varieties do have a significant impact on the nutritional status of vulnerable groups (Lawal et al., 2014). Its fermentation involves lactic acid bacteria converting the carbohydrates in the cereals during ogi production to organic acids which contribute to softness in the product and the characteristic flavor and sour taste (Banigo and Muller, 1972). Conventionally, ogi (pap) is processed, prepared and consumed without addition of spices. In the recent time, local consumption pattern has moved towards the inclusion of different single or combined spices by the local processors with the view to improving the nutritional value and taste of the products. Spices are culinary herbs which have aromatic or pungent flavor. They are dried seeds, fruit, root or vegetable substances used in preparation of soups to enhance the flavor of such food (Farinde, 2015). Spices do not only excite taste, they are composed of high quality phytonutrients, essential oils, antioxidants, minerals and vitamins that are essential for overall health sustenance. Fortification of traditionally fermented food products is a vital process of increasing the concentration and bioavailability of the nutritional content of the edible part of the plant food especially cereals to the levels that consistently exceed the inherent content (John et al., 2017). Studies carried out to show the interrelationship between microorganisms found in Ogi and the nutritional benefits reveal that some of the microorganisms used in fermentations result in the addition of the nutritive value of ogi. There is an increase in the lysine content during fermentation (Odunfa et al., 1994). The isolated microorganisms that were characterized using conventional methods in fermenting varieties of maize ogi included fungi (molds and yeasts) and bacteria species such as *Lactobacillus* species and *Saccharomyces cerevisiae* that has played an important role during fermentation (Ijabadeniyi, 2007; Falana et al., 2011). Hence, this work focuses on the evaluation of microbiological, nutritional and sensory properties of QPM spiced product (ogi).

METHODOLOGY

QPM yellow variety ART 98/SW1was processed into ogi paste (QPM ogi) with the addition of three different spices (clove, ginger and garlic) at 1 and 3% concentration. Microbiological properties were determined (total bacteria count, total fungi count and lactic acid bacteria count) and the shelf life of spiced QPM ogi paste were assessed over 15 days at room temperature. The nutritional properties of spiced QPM ogi was assessed (proximate analysis, minerals and functional properties) only at day 0. The ogi samples were also subjected to sensory evaluation. Data obtained from the analyses were subjected to analysis of variance (ANOVA) and means were separated by using Duncan Multiple Range Test at $p < 0.05$.

Source of material used

QPM variety ART 98/SW1 was obtained from the seed store of the Institute of Agricultural Research and Training, Ibadan. The spices were bought from Aleshinloye market in Ibadan, and processed in the IAR&T food processing laboratory.

Preparation of spices

Fresh ginger and garlic (500 g each) obtained were peeled, washed and mashed manually with a mortar. Cloves in its dry form were also ground to powdery form and they were separately kept in airtight containers. The spices were weighed, and added to the ogi paste mixed together at a 1 and 3% concentration.

Preparation of ogi with spices

QPM grains were sorted from the shaft and dirts. A 2 kg of maize grains were added to 5L of water and steeped for 3 days (72 h) at room temperature. The maize grains were then washed and was wet milled into paste using a local ATLAS grinder. Water was added and sieved with muslin cloth, the slurry was allowed to settle for one day, the supernatant was decanted and the ogi paste recovered. The solidified ogi paste was portioned into seven parts. One part served as control, which had no spice. The other six parts had 1 and 3% of ginger, garlic and cloves, respectively. A 500 g of ogi paste was added to 5 g of each spice at 1% concentration; also 500 g of ogi paste was added to 15 g of each spice at 3% concentration.

Preparation of pap from spiced ogi

Each sample of spiced ogi paste (30 g) was transferred into a bowl and evenly mixed with 15 ml of cold water to avoid lumps. Boiling water was then added with continuous stirring to gelatinize the ogi to make pap. This was repeated with all seven samples before it was served for sensory evaluation.

Microbial analysis

Microbial load of the spiced QPM ogi samples were determined using the method of Ntuli et al. (2013). Nutrient agar (NA- BIOTEC

Medical Market UK Limited, Stanmore, United KIngdom) was used for bacterial count, Potato Dextrose Agar (PDA- A Neogen Company, LAB M Limited, Heywood Lancashire, United Kingdom) was used for fungal count and Man-De Rosa and Sharp medium (MRS- A Neogen Company, Heywood, Lancashire, United Kingdom) was used for lactic acid bacterial counts, respectively. One litre of each of NA, PDA and MRS was prepared and boiled to dissolve the media, and autoclaved at 121°C for 15 min. One gram of each sample was weighed into a test tube containing 9 ml of sterile distilled water and serially diluted until a dilution factor of 10^{-5} was reached. One millilitre of the last dilution factor was seeded aseptically into sterile plates (streptomycin was added to PDA to inhibit bacterial growth). The media were poured individually in triplicates. After solidifying, the plates were incubated in an incubator at 37°C for 24 h for NA and MRS and 25°C for 3 to 5 days for PDA, all the plates were incubated invertedly (upside down). Isolation and identification of bacteria in the ogi samples were based on selective media (Ntuli et al., 2013), while fungi were isolated following the method of Alkenz et al. (2015).

Chemical analysis

Proximate and mineral composition

Proximate composition of the ogi samples was determined using the standard method of AOAC (2005). Each sample was analysed in triplicate for crude protein, crude fat, crude fibre, total ash, moisture and carbohydrate. Nitrogen was converted to crude protein by multiplying with a factor of 6.25. The carbohydrate content was calculated based on the difference.

Mineral content of the ogi samples (Ca, Mg, Fe and Zn) were determined using the digestion method of AOAC (2005). Atomic absorption spectrophotometry (Accusys 211, Buck Scientific, USA) was used.

*Hydrogen ion concentration (*pH)

Hydrogen ion concentration or pH of each sample was measured with a standard pH meter (Mettler Toledo FG2/EL2 produced by Mettler – Toledo GmbH Analytical, CH-8603 Schwerzenbach, Switzerland) according to the method of Bolade et al. (2018). The pH was determined by dipping the electrode of the pH meter in the sample. The pH meter was calibrated using pH 4 and 7 buffers.

Functional properties

Water absorption capacity, swelling power and solubility power were determined following the methods described by Adepeju et al. (2014). Bulk density was determined following the method described by Bolaji et al. (2014).

Sensory evaluation

Freshly prepared spiced quality protein maize ogi (pap) samples were presented to a panel of 20 trained judges who are regular consumers of ogi. The panellists were given water for mouth rinsing after each tasting and they were asked to score the ogi samples for colour, appearance, flavour, texture, taste, and overall acceptability using a 9 point hedonic scale (where 9 = like extremely and 1= dislike extremely) (Farinde, 2015).

Statistical analysis

All determinations were measured in triplicate and the data obtained from the analyses were subjected to an analysis of variance (ANOVA). Means of values were separated using the Duncan Multiple Range Test. Significance was accepted at $p < 0.05$ (SAS, 1995).

RESULTS

Total bacteria count of spiced QPM ogi paste at day zero ranged from 0.4×10^5 to 2.2×10^5 cfug^{-1}, while at day fifteen, the total bacteria count ranged from 0.8×10^5 to 3.8×10^5 cfug^{-1}. Total bacterial count, in spiced QPM ogi increases gradually in growth as the number of days for storage increased (Figure 1). Control (Con) had the highest total bacterial count whereas ogi with 3% cloves (Clo3) recorded the lowest count. There was no fungal count on Days 0 and 5 during storage of spiced QPM ogi meanwhile scanty growth was recorded on day 10 (Figure 2). Lactic acid bacteria count increased with days of storage in all the ogi samples and the least counts were also recorded in QPM ogi spiced with 3% cloves (Figure 3).

The crude protein was highest (6.21%) in QPM ogi spiced with 3% cloves and QPM ogi without spice (control) had the lowest value (5.57). QPM ogi spiced with 3% garlic had the highest crude fat, crude fibre and ash contents. Moisture content ranged from 13.65 to 14.39% and carbohydrate ranged from 79.34 to 80.54% (Table 1). Plain QPM ogi (control) was significantly higher ($p < 0.05$) in calcium and iron when compared with all the other ogi samples. QPM ogi spiced with clove at 3% level recorded the highest zinc content (292 mg/kg) (Table 2).

The pH of all the ogi samples decreased with days of storage. In control (Con) the pH value is 3.5 at day 0, whereas at day 15 the value recorded 3.4. Also in Clo3 (3% cloves), the pH at day 0 is 3.7 and at day 15 of storage it is 3.5 (Table 3).

Bulk density was the highest in plain QPM ogi while Ogi spiced with garlic at 3% level recorded the highest water absorption capacity. Swelling power was the highest in QPM ogi spiced with 1% cloves, and solubility power ranged from 2.5 to 7.8% (Table 4). Plain QPM ogi was most accepted in all the sensory attributes tested (8.0) followed by QPM ogi spiced with ginger at 1% level, while the clove preparation had the lowest value (3.5) (Table 5).

DISCUSSION

Total bacterial count, in spiced QPM ogi increases gradually in growth as the number of days for storage increase, this agrees with the work of John et al. (2017) who reported that total bacteria count recorded for the untreated samples of ogi were found to be higher in ogi than the treated samples. He further explained that the higher microbial load in ogi may be due to accumulation of microorganisms in the water that was retained in the ogi. There was no fungal count on Days 0 and 5 during storage of spiced QPM ogi meanwhile scanty growth was

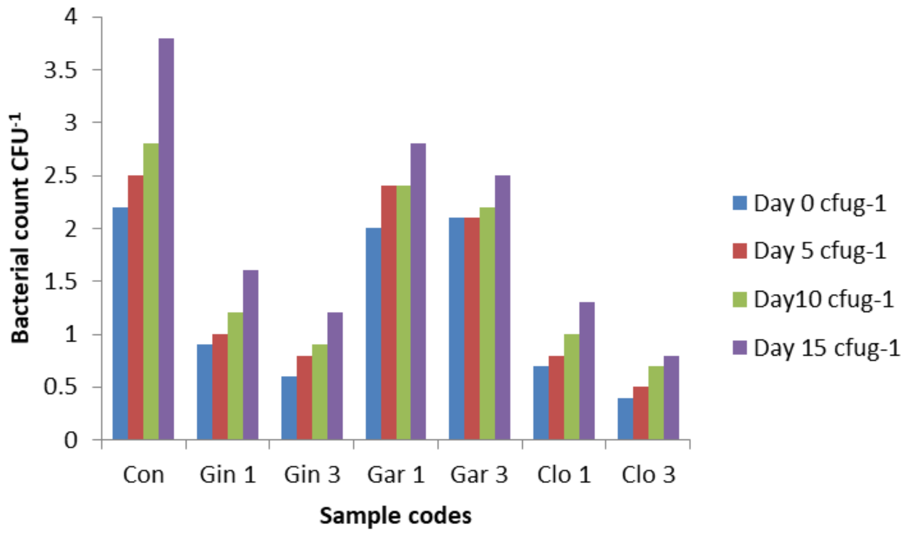

Figure 1. Total bacterial count of spiced QPM ogi paste.

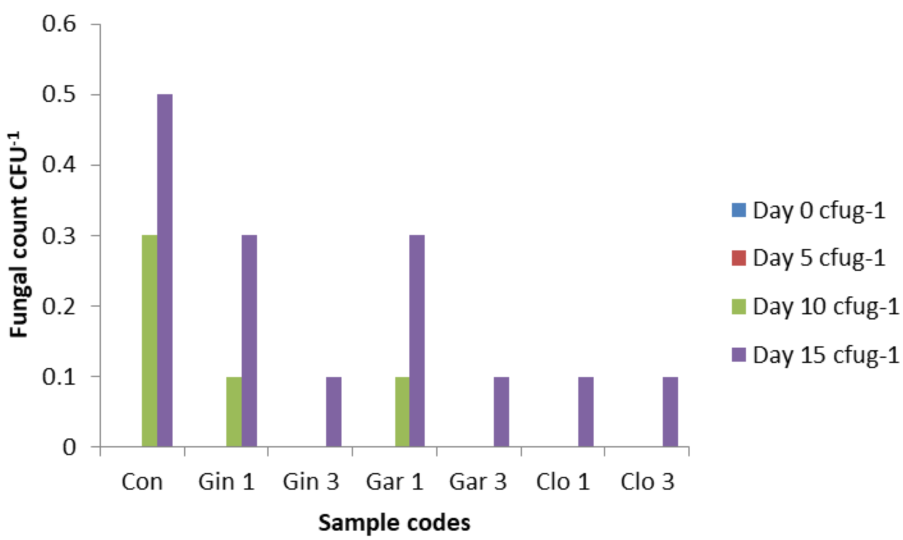

Figure 2. Total fungal count of spiced QPM ogi paste.

recorded on day 10. This is in agreement with the report of Omemu et al. (2007). He reported that moulds were not isolated until days 10 and 12 in the corn steep liquor and the ogi samples, respectively.

Lactic acid bacteria count increased with days of storage in all the ogi samples, and this agrees with the work of Adesokan et al. (2010). Many studies have reported that lactic acid bacteria (LAB) in the fermentation of ogi contribute to the flavor and aroma development of ogi and inhibit the growth of other organisms (Oyewole, 1997).

John et al. (2017) reported that the value of crude protein in spiced ogi was higher than the value of crude protein in the control which correlates with this study. The fortification of ogi with spices improved significantly ($p < 0.05$) the nutrient composition of ogi samples (protein). Spices are very important both as food and to contribute to the overall wellbeing of people. Ginger, garlic and clove contain high level of antioxidants which help in preventing cell damage caused by free radicals and also contain essential oils (Farinde, 2015). The QPM spiced ogi samples provide a good amount of calcium, magnesium, iron and zinc. Calcium helps bone to grow rapidly especially the growing children and to build strong bones. Magnesium helps to maintain normal nerve and muscle function and supports a healthy immune system (Soetan et al., 2010). QPM spiced ogi provides a good amount of iron needed in the production of haemoglobin

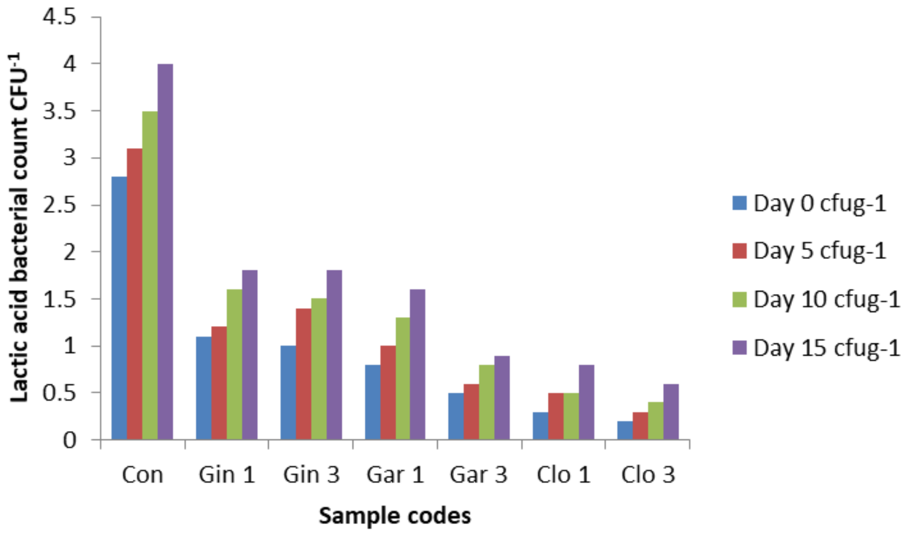

Figure 3. Total lactic acid bacterial count of spiced QPM ogi paste.

Table 1. Proximate composition of spiced QPM ogi.

Sample code	Crude protein (%)	Crude fat (%)	Crude fibre (%)	Total ash (%)	Moisture content (%)	Carbohydrate (%)
Con	5.57^{g}	0.66^{a}	0.18^{g}	0.79^{g}	14.28^{c}	79.34^{g}
Gin 3	5.89^{e}	0.48^{e}	0.23^{c}	0.82^{f}	13.76^{f}	80.54^{a}
Gin 1	5.68^{f}	0.55^{c}	0.21^{e}	0.85^{e}	14.33^{b}	80.04^{b}
Gar 3	6.03^{c}	0.62^{b}	0.26^{a}	0.96^{a}	13.81^{e}	79.64^{e}
Gar 1	5.97^{d}	0.43^{g}	0.22^{d}	0.88^{c}	13.65^{g}	79.97^{c}
Clo 3	6.21^{a}	0.52^{d}	0.20^{f}	0.93^{b}	14.39^{a}	79.38^{f}
Clo 1	6.11^{b}	0.45^{f}	0.24^{b}	0.86^{d}	13.82^{d}	79.79^{d}

Means in the same column followed by the same letter are not significantly different from each other at $p < 0.05$. Con- QPM ogi without spices Gin 1- QPM ogi spiced with ginger at 1%; Gin 3- QPM ogi spiced with ginger at 3%; Gar 1- QPM ogi spiced with garlic at 1%; Gar 3-QPM ogi spiced with garlic at 3%; Clo 1- QPM ogi spiced with clove at 1%; Clo 3- QPM ogi spiced with clove at 3%.

Table 2. Mineral composition of spiced QPM ogi.

Sample code	Ca (mg/kg)	Mg (mg/kg)	Fe (mg/kg)	Zn (mg/kg)
Con	576^{a}	1442^{c}	611^{a}	109^{b}
Gin 3	401^{c}	1315^{e}	168^{g}	18^{f}
Gin 1	275^{d}	1495^{a}	401^{b}	76^{c}
Gar 3	411^{b}	1465^{b}	302^{d}	34^{e}
Gar 1	63^{g}	1365^{d}	196^{f}	17^{g}
Clo 3	94^{e}	1213^{g}	374^{c}	292^{a}
Clo 1	70^{f}	1215^{f}	255^{e}	39^{d}

Means in the same column followed by the same letter are not significantly different from each other at $p < 0.05$

which carries oxygen in the blood (Ojo and Enujiugha, 2016). Zinc helps with hormone production and proper growth and repair (Soetan et al., 2010).

The pH of all the ogi samples decreased with days of storage, this might be as a result of lactic acid production by fermentative organisms responsible for the fermentation of ogi. This observation is in agreement with the previous report of Adesokan et al. (2010) and Okwute and Olafiaji (2013). The decrease in bulk density may help in reduction of transportation and packaging cost

Table 3. pH of Spiced QPM Ogi.

Sample code	Day 0	Day 5	Day 10	Day 15
Con	3.5^{d}	3.5^{b}	3.4^{b}	3.4^{b}
Gin 1	3.6^{c}	3.4^{c}	3.4^{b}	3.3^{c}
Gin 3	3.5^{d}	3.4^{c}	3.4^{b}	3.3^{c}
Gar 3	3.6^{c}	3.4^{c}	3.4^{b}	3.3^{c}
Gar 1	3.8^{a}	3.4^{c}	3.4^{b}	3.3^{c}
Clo 1	3.7^{b}	3.5^{b}	3.4^{b}	3.4^{b}
Clo 3	3.7^{b}	3.6^{a}	3.5^{a}	3.5^{a}

Means in the same column followed by the same letter are not significantly different from each other at $p < 0.05$

Table 4. Functional properties of spiced QPM ogi.

Sample code	Bulk density (g/cm^3)	Water absorption capacity (gs^{-1})	Swelling power (%)	Solubility power (%)
Con	0.8^{a}	2.3^{b}	7.7^{c}	4.7^{bc}
Gin 1	0.6^{b}	2.3^{b}	7.8^{c}	6.1^{ab}
Gin 3	0.7^{ab}	1.3^{c}	7.6^{c}	4.2^{c}
Gar 3	0.7^{ab}	4.5^{a}	7^{cd}	2.5^{d}
Gar 1	0.7^{ab}	2.3^{b}	9.6^{b}	7.8^{a}
Clo 1	0.6^{b}	2.3^{b}	11.9^{a}	5.4^{b}
Clo 3	0.6^{b}	2.1^{bc}	6.3^{d}	4.4^{c}

Means in the same column followed by the same letter are not significantly different from each other at $p < 0.05$

Table 5. Sensory analysis of spiced QPM ogi.

Sample code	Colour	Appearance	Flavour	Texture	Taste	Overall acceptability
Con	8.0^{a}	7.8^{a}	7.5^{a}	7.4^{a}	8.4^{a}	8.0^{a}
Gin 1	7.3^{c}	6.5^{c}	5.9^{d}	5.8^{d}	6.2^{b}	7.1^{b}
Gin3	7.4^{b}	7.6^{b}	6.9^{b}	6.6^{b}	6.2^{b}	6.8^{c}
Gar 1	7.3^{c}	6.3^{d}	6.5^{c}	6.3^{c}	5.3^{c}	6.0^{d}
Gar 3	4.5^{e}	6.3^{d}	4.5^{e}	6.3^{c}	3.8^{d}	5.6^{e}
Clo 1	4.5^{e}	5.2^{e}	3.4^{g}	3.8^{f}	3.0^{e}	3.5^{g}
Clo 3	4.6^{d}	5.2^{e}	4.0^{f}	4.0^{e}	2.8^{f}	3.8^{f}

Means in the same column followed by the same letter are not significantly different from each other at $p < 0.05$.

that is the packaging will be economical (Bolaji et al., 2014; Ojo and Enujiugha, 2016). Water absorption capacity is desirable for the improvement of mouthfeel and viscosity reduction in food products (Ojo and Enujiugha, 2016). Swelling power reflects the extents of the association forces within the granules. Higher solubility in any sample implies that it is lesser in leaching than other sample, hence the higher the solubility, the more ogi reconstitute well in water (Bolaji et al., 2014). From time immemorial, spices have been employed for their aromatic, medicinal and flavouring characteristics. Apart from these characteristics, it also acts as an antimicrobial agent in foods. The study of Adesokan et al. (2010) and Okwute and Olafiaji (2013) agrees with this report which reveals that incorporation of spices into ogi led to an improved sensory attributes and a reduction in microbial load during storage and hence an improved shelf life.

Conclusion

Addition of spices improved the nutrient content of ogi made from QPM. QPM ogi with 1% ginger was preferred to all the other spiced QPM samples in terms of sensory attributes. Spices had a significant reduction effect on the microbial count of the ogi samples. Shelf life of QPM ogi could be improved by fortification with cloves at 3% level.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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