

## Microbiological, Physicochemical and Sensory Properties of Spiced Quality Protein Maize (QPM) Products

\*Ejigbo, E. A., Omenna, E. C. and Olanipekun O. T.

*Institute of Agricultural Research and Training, Obafemi Awolowo University,*

*P.M.B. 5029, Moor Plantation, Ibadan, Oyo State, Nigeria.*

*\*[creamlizzy@yahoo.com](mailto:creamlizzy@yahoo.com) +234803622247*

### Abstract

Malnutrition in developing countries is primarily a problem of protein deficiency. There thus the need to introduce foods that will combat this problem. Quality protein maize (QPM) is one of such foods as it contains more lysine and tryptophan than other varieties of maize. This work focuses on QPM food products fortified with locally available food spices (ginger, garlic and cloves) at 1% and 3% concentrations in order to improve the nutritional and organoleptic properties. Quality Protein Maize (ART98/SW1) grains were processed into spiced flour and cake. Proximate, functional, microbial and sensory analyses were carried out on the samples. Quality Protein Maize cake and flour spiced with 3% ginger (GIN3) were significantly higher ( $p > 0.5$ ) in crude protein. The control was significantly higher in moisture and carbohydrate content. Minerals like calcium, magnesium, iron and zinc were present in all the samples. The results showed that QPM flour fortified with 3% clove recorded the highest bulk density while that fortified with 1% clove recorded the highest swelling power. The total bacteria count ranged from  $0.1 \times 10^5 \text{ cfug}^{-1}$  to  $0.8 \times 10^5 \text{ cfug}^{-1}$  in the spiced QPM cake samples. In conclusion, spices improved the nutrient content of the flour and cake samples. Quality Protein Maize cake with 1% ginger was the most preferred of all the spiced QPM cake samples in terms of sensory attributes. The potentials of this research work are useful in the food industries, confectionaries and households.

**Key words:** Cake; Flour; Quality Protein maize and spices

### Introduction

In Africa, Asia Central and South America, several hundred million people rely on maize as their principal daily food, for weaning babies and for feeding livestock. Quality protein maize (QPM) contains nearly twice as much usable protein as other maize varieties grown in the tropics and yields 10% more grain than traditional varieties of maize (Jaliya, 2014). Quality protein maize produces 70-100% more of lysine and tryptophan than the most modern varieties of tropical maize (Jaliya, 2014). This has been confirmed in QPM varieties developed in the Institute of Agricultural Research and Training (IAR&T), Ibadan. Lysine and tryptophan allow the body to manufacture complete proteins thereby eliminating “wet” malnutrition (Mamatha

*et al.*, 2017). In addition, tryptophan can be converted in the body to niacin which theoretically reduces the incidence of pellagra (Abdulla, 2014). Diets high in maize produce a condition known as wet malnutrition (Mbuya *et al.*, 2010). A person suffering from wet malnutrition receives sufficient calories but insufficient protein. A chronic lack of protein in the diet leads to kwashiorkor. Thus, conventional maize is a poor source of protein unless consumed as part of a varied diet which in most cases is beyond the means of most people in the developing world.

Babies and adults consuming QPM are healthier and are at lower risk of malnutrition disorders such as marasmus and kwashiorkor (Alan and Michael, 2015).

Quality protein maize has been shown to offer 90% of the nutritional value of milk, the standard for adequate nutrition value. Globally, nearly 200 million children younger than five years are undernourished for protein; leading to a number of health problems including stunted growth, weakened resistance to infections and impaired intellectual development (Prasanna *et al.*, 2001). At a time when UNICEF reports that one million infants and small children are starving each month, the inclusion of QPM in daily rations can improve health and save lives (Bello *et al.*, 2011). At the global level, maize accounts for 15% of proteins and 20% of calories in world food diet (Nuss, 2010). Unfortunately, the amino acid profile of maize is poor as it is deficient in essential amino acids such as lysine, tryptophan and methionine due to a relatively higher proportion of prolamines in maize storage proteins which are essentially devoid of lysine and tryptophan (Mbuya *et al.*, 2010). Lysine, tryptophan and threonine are the limiting amino acids in human beings and non-ruminants. Maize is also an important component of livestock feed especially in developed nations where 78% of total maize production goes into livestock feed. In addition, pigs fed with QPM experience rapid weight gain and are ready for market sooner or can provide additional quality protein source for small farm families. Therefore breeding strategies aimed at improving the protein profile of maize will go a long way in reducing the prevalence and persistence of malnutrition in the developing world (Sofi *et al.*, 2009).

Several efforts have been made to improve the keeping quality of food with spices (Gottardi *et al.*, 2016). Spices have always been valued for their ability to add

flavour, colour and aroma to dishes. Spices have also been regarded as an important means of food preservation. In some cultures their medicinal and antiseptic characteristics are revered (Abdullahi, 2011). Spices may be derived from many parts of the plant like bark, buds, flowers, fruits, leaves, rhizomes, roots, seeds, stigmas and styles or the entire plant tops. Spices are often dried and used in a processed but complete state (Mahbukar *et al.*, 2012). Spices have been used since ancient times, and their role in food preservation have been studied *in vitro* and *in vivo* (Gottardi *et al.*, 2016). Spices have exhibited numerous health benefits in preventing and treating a wide variety of diseases and medical conditions such as cancer, aging, metabolic, neurological, cardiovascular, and inflammatory diseases (Gottardi *et al.*, 2016). Numerous articles published in the last few decades have described the antimicrobial activities of spices *in vitro*. Extracts of entire plants or parts of them obtained with diverse solvents (such as ethanol, methanol, ethyl acetate and water) have been tested against microbes (Gottardi *et al.*, 2016). Their essential oils or active compounds, alone or in combination, were also used to test for their activity against different microbes (Rasheeha *et al.*, 2013; Liu *et al.*, 2017). The study evaluated the microbiological, physicochemical and sensory properties of spiced quality protein maize (QPM) products.

## **Materials and Methods**

### **Source of material**

Quality protein maize of variety ART 98/SW1 was obtained from the Seed Store of the Institute of Agricultural Research and Training (IAR&T), Ibadan. The spices

(ginger, garlic and cloves) and wheat flour were bought from Aleshinloye Market in Ibadan and processed at IAR&T Food Processing Laboratory.

### **Preparation of Quality Protein Maize flour**

The quality protein maize obtained was sorted manually to remove chaff and stones. The clean maize was ground into flour of particle size  $>300\mu\text{m}$  with the aid of a mechanical grinding machine.

### **Preparation of spices**

Fresh ginger was peeled, washed and mashed with a mortar and pestle. The garlic was prepared the same way. The cloves were ground into a powder form. The spices were then weighed, mixed and added to the maize flour at 1% and 3% concentrations.

### **Preparation of spiced QPM cake**

Two kilogrammes of margarine and one kilogramme of sugar were creamed until smooth and fluffy using a Maxchef professional mixer. Eight eggs were lightly beaten and added to the creamed mixture. Two hundred and fifty grammes (250g) of the mixture was added to each flour sample. Two spoons of baking powder, 3 tablespoons of vanilla extract and 1 tablespoon of nutmeg were added to each sample. The flour and the ingredients were mixed thoroughly. Three hundred and fifty millilitres of diluted milk was added to each sample and mixed until a good batter consistency was obtained. The cake pans (two inches) were greased with margarine, dusted with some flour and filled up to two-third full with the samples. The samples were baked at  $150^{\circ}\text{C}$  in a pre-heated oven for 20 minutes (Onuegbu *et al.*, 2013).

### **Chemical analysis**

Proximate composition of the QPM flour and cake samples were determined using the methods of AOAC (2000). Nitrogen-free extract content was determined by subtracting the sum of the percentages of protein, fat, fibre and ash from 100%. Mineral composition of the samples were also determined using the methods of AOAC (2000).

### **Determination of crude protein**

Ten millilitres of concentrated sulphuric acid ( $\text{H}_2\text{SO}_4$ ) was added to 0.5g of dried sample. This was digested till the mixture became clear. The digest was cooled and washed with distilled water into a standard 100ml volumetric flask. The digest was distilled into 4% boric acid solution which was then titrated against standard 0.1N hydrochloric acid (HCl) solution till the appearance of a pink colour.

$$\% \text{ Crude Protein} = 6.25 * x \% \text{N}$$

**Determination of crude fat:** Crude fat was determined by ether extract method using soxhlet apparatus. One gramme of moisture-free sample was wrapped in filter paper, placed in a fat-free thimble and then introduced into the extraction tube. Weighed, cleaned and dried the receiving beaker was filled with petroleum ether and fitted onto the apparatus. Water and heater were turned on to start extraction. After 4 siphonings, ether was allowed to evaporate and the beaker was disconnected before last siphoning. The extract was transferred into clean glass dish with ether washing and evaporated ether on water bath. Then placed the dish in an oven at  $105^{\circ}\text{C}$  for 2 hrs and cooled it in a desiccator. The percent crude fat was determined by using the following

formula:

$$\% \text{Crude Fat} = \frac{\text{Wt. of ether extract} \times 100}{\text{Wt. of sample}}$$

**Determination of crude fibre:** A moisture-free and ether-extracted sample of crude fibre was first digested with dilute  $\text{H}_2\text{SO}_4$  and then with dilute KOH solutions. The undigested residue was ignited and loss in weight was recorded as crude fibre. 0.153g sample ( $W_1$ ) was weighed and transferred to porous crucible. One hundred and fifty millilitre (150ml) of preheated  $\text{H}_2\text{SO}_4$  solution was added and some drops of foaming suppresser to each column.

The same procedure was used for alkali digestion by using KOH instead of  $\text{H}_2\text{SO}_4$ . Samples were dried in an oven at  $150^\circ\text{C}$  for 1 h. The samples were allowed to cool in a desiccator and weighed ( $W_1$ ). Sample was kept in a crucible in muffle furnace at  $55^\circ\text{C}$  for 3-4 hrs. Cooled the samples in desiccator and weighed again ( $W_2$ ). Calculations were done by using the formula:

$$\% \text{Crude Fiber} = \frac{W_1 - W_2 \times 100}{W_0}$$

**Determination of ash:** Clean empty crucibles were placed in a muffle furnace at  $450^\circ\text{C}$  for one hour to drive off all moisture. The crucibles were then cooled in a desiccator and weighed ( $W_1$ ). One gramme of each sample was weighed into the crucibles ( $W_2$ ), placed in the muffle furnace and ashed at  $450^\circ\text{C}$  for 2-4 hrs. The appearance of grey ash indicate complete oxidation of all organic matter in the sample. After ashing, the furnace was switched off and the crucibles were cooled and weighed ( $W_3$ ). Percentage ash was calculated using the following formula:

$$\% \text{Ash} = \frac{\text{Difference in Wt. of Ash} \times 100}{\text{Wt. of sample}}$$

**Determination of moisture:** Moisture was determined by oven drying method. Two grammes of sample was accurately weighed into clean, dried crucible ( $W_1$ ). The crucible was allowed in an oven at  $105^\circ\text{C}$  for 12 hours until a constant weight was obtained. The crucible was thereafter placed in the desiccator for 30 minutes to cool. After cooling, it was weighed again ( $W_2$ ). The percent moisture was calculated using following formula:

Where

$$\% \text{Moisture} = \frac{W_1 - W_2 \times 100}{\text{Wt. of sample}}$$

$W_1$  = Initial weight of crucible + Sample

$W_2$  = Final weight of crucible + Sample

**Determination of nitrogen free extract:** Nitrogen Free Extract (NFE) was calculated by subtracting the percentages of moisture, crude protein, crude fat, crude fibre and ash from 100%.

$\text{NFE} = (100 - \% \text{ moisture} + \% \text{ crude protein} + \% \text{ crude fat} + \% \text{ crude fiber} + \% \text{ ash})$ .

**Determination of Minerals [Iron (Fe), Zinc (Zn), Calcium (Ca) and Magnesium (Mg)] by Atomic Absorption Spectrometry**

**Principle:** One gramme of each sample was weighed into the digestion flask. Ten millilitres of 2:1 by volume of nitric-perchloric acid was added to the samples and digested until dense white fumes appeared for one and half hours. The digest was allowed to cool and some quantity of distilled water was added to the digest. The

solution was then filtered into a 50ml volumetric flask and diluted to volume. Digests from the above were later determined on the atomic absorption spectrophotometer (AAS) for each of the minerals stated above at their individual wavelengths.

The physical properties i.e. the height, colour and texture of the cake samples were determined by the methods of Akubor and Ishiwu (2013).

### Functional Properties

The functional properties of spiced QPM flour samples were determined following the methods of Oluwole *et al.* (2016).

### Water absorption capacity

Fifteen millilitres of distilled water was added to 1g of the sample in a washed 25ml centrifuge tube. The tube was agitated on a vortex mixer for 2 minutes. It was centrifuged at 400 revolutions per minute (rpm) for 20 minutes. The supernatant was decanted and discarded. The adhering drops of water were removed and the tube was reweighed.

### Calculation:

$$WAC = \frac{\text{wt of tube + sediment} - \text{weight of empty tube}}{\text{Wt of sample}}$$

### Swelling power and solubility power

One gramme of sample was weighed into a conical flask and hydrated with 15 millilitres of distilled water. The mixture was shaken for 5 minutes with a mechanical shaker at low speed. It was heated for 40 minutes at 80°C with constant stirring in a water bath. The content was then transferred into a clean, dry and pre-weighed centrifuge tube. 7.5 millilitres of distilled water of was added and

centrifuged at 2200 rpm for 20 minutes. The supernatant was decanted into a pre-weighed can and dried at 100°C to a constant weight. The sediment was weighed in the centrifuge tube.

### Calculation:

$$\text{Swelling power} = \frac{\text{weight of the mass of sediment}}{\text{Weight of dry matter in the gel}}$$

$$\text{Solubility} = \frac{\text{weight of starch}}{100}$$

### Bulk density

One gramme of the sample was weighed into a 25ml measuring cylinder. The sample was packed by gently tapping the cylinder on the bench top 10 times from a height of 5cm, volume of the sample was recorded.

### Calculation:

$$\text{Bulk density (g/cm}^3\text{)} = \frac{\text{weight of sample}}{\text{Volume of sample after tapping}}$$

### Microbial Analysis

Microbial load of the QPM flour and cake samples were determined using the methods of Ntuli *et al.* (2013). Nutrient agar (NA), Potato Dextrose agar (PDA) and Man-De Rosa and Sharp medium (MRS) were used for the bacteria count, fungi count and lactic acid bacteria count respectively. Commercially prepared agar (NA, PDA and MRS) was weighed on an analytical metler balance into a clean dry one litre conical flask. One litre of each of NA, PDA and MRS was prepared and boiled to dissolve the media before autoclaving at 121°C for 15 minutes. After autoclaving, the media were allowed to cool to 45°C to maintain the media in a molten state. One gramme of each sample was weighed into a test tube containing 9mls 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 then poured individually and were in triplicates. After solidifying, the plates were incubated in an incubator at  $37^{\circ}\text{C}$  for 24 hours for NA and MRS and  $25^{\circ}\text{C}$  for 3-5 days for PDA. All the plates were incubated invertedly and scored for incidence. Isolation and identification of bacteria in the flour and cake samples were based on selective media (Ntuli *et al.*, 2013), while fungi were isolated following the methods of Alkenz *et al.* (2015).

### **Sensory evaluation**

Freshly prepared spiced quality protein maize and wheat cake samples were presented to 15 untrained members of a panel of judges who are regular cake consumers. The panelists were given water for mouth rinsing after each tasting and they were told to score the cake samples for colour, appearance, flavour, mouthfeel, aftertaste and overall acceptability using a 9 point hedonic scale where 9 = like extremely and 1 = dislike extremely (Juyun, 2011).

### **Statistical analysis**

Data obtained from the analyses were subjected to analysis of variance (ANOVA) and means were separated using the Duncan Multiple Range Test. Significance was accepted at  $p < 0.05$

### **Results and Discussion**

The physical properties of the spiced cake samples are shown in Table 1. Cake made from QPM flour with 1 % and 3 % clove

inclusion were brown in colour and rough in texture while the rest of the cake samples were golden brown in colour and slightly rough in texture with the exception of the wheat flour cake which had a cream colour was creamy and fine texture.

The result of the proximate composition of the spiced QPM flour is shown in Table 2. Crude protein of QPM flour spiced with 3% ginger was significantly higher at  $p < 0.05$  (5.35%) than that of QPM flour without spice (4.28%). Some authors have reported an increase in the crude protein content of foods spiced with ginger. Fasasi and Alokun (2013) reported that addition of ginger resulted in a significant increase in the protein content of kokoro. Olayiwola *et al.* (2017) reported that the crude protein content of ogi fortified with 10% ginger was significantly higher than the one without ginger. These results are closely related to this present study which showed that ordinary QPM flour had the least percentage crude protein among all the samples. The percentage crude protein of QPM cake spiced with 3% ginger (GIN 3) was significantly higher at  $p < 0.05$  while QPM cake without spice (CON) was significantly lower in protein content compared with the other samples. The values ranged from 6.74 in CON to 8.67 in GIN3 (Table 3). This agrees with the report of Otunola *et al.* (2010) that spices are rich in protein content due to the presence of active proteinous metabolites, therefore these spices could serve as supplements since they are usually combined in human main dishes. Fat content in QPM flour ranged from 0.56% in GAR 1 to 0.96% in CLO3. Fat content in QPM cake was significantly higher in GIN 1 followed by GIN 3 while control recorded the least value of 13.28%. Fat provides a source of stored energy, dietary fat in human

**Table 1: Physical Properties of Spiced QPM Cake Samples**

Codes	Height	Colour	Texture
W.C	1.5 cm	Creamy-brown	Fine texture
CON	1.5 cm	Golden-brown	Slightly rough
GIN 1	1.5 cm	Golden-brown	Slightly rough
GIN 3	1.5 cm	Golden-brown	Slightly rough
GAR 1	1.5 cm	Golden-brown	Slightly rough
GAR 3	1.5 cm	Golden-brown	Slightly rough
CLO 1	1.5 cm	Brown	Rough
CLO 3	1.5 cm	Rusty-brown	Rough

## Key

W.C- Wheat cake without spices

CON- QPM cake without spices

GIN 1- QPM cake spiced with ginger at 1%

GIN 3- QPM cake spiced with ginger at 3%

GAR 1- QPM cake spiced with garlic at 1%

GAR 3-QPM cake spiced with garlic at 3%

CLO 1- QPM cake spiced with clove at 1% a

CLO 3- QPM cake spiced with clove at 3%.

**Table 2: Proximate Composition of Spiced QPM Flour**

Sample code	Crude protein %	Crude fat %	Crude fibre %	Total ash %	Moisture content %	N.F.E %
CON A	4.28 <sup>h</sup>	0.65 <sup>d</sup>	0.34 <sup>c</sup>	0.62 <sup>f</sup>	7.38 <sup>f</sup>	79.83 <sup>a</sup>
CON B	5.23 <sup>b</sup>	0.74 <sup>c</sup>	0.39 <sup>bc</sup>	0.54 <sup>h</sup>	8.31 <sup>a</sup>	79.34 <sup>d</sup>
CLO 1	4.76 <sup>g</sup>	0.89 <sup>b</sup>	0.42 <sup>ab</sup>	0.76 <sup>c</sup>	7.56 <sup>d</sup>	78.84 <sup>f</sup>
CLO 3	4.89 <sup>f</sup>	0.96 <sup>a</sup>	0.45 <sup>a</sup>	0.59 <sup>g</sup>	7.61 <sup>c</sup>	79.30 <sup>e</sup>
GIN 1	5.11 <sup>d</sup>	0.58 <sup>g</sup>	0.37 <sup>bc</sup>	0.81 <sup>b</sup>	7.44 <sup>e</sup>	79.48 <sup>c</sup>
GIN 3	5.35 <sup>a</sup>	0.63 <sup>e</sup>	0.32 <sup>c</sup>	0.85 <sup>a</sup>	7.38 <sup>f</sup>	78.46 <sup>g</sup>
GAR 1	4.97 <sup>c</sup>	0.56 <sup>h</sup>	0.43 <sup>ab</sup>	0.66 <sup>e</sup>	8.25 <sup>b</sup>	79.56 <sup>b</sup>
GAR 3	5.18 <sup>c</sup>	0.61 <sup>f</sup>	0.4 <sup>a</sup>	0.72 <sup>d</sup>	7.35 <sup>g</sup>	78.84 <sup>f</sup>

Means followed by the same superscript in a column are not significantly different ( $p < 0.05$ )

## Key

CON A- QPM flour without spices

CON B- Wheat flour without spices

GIN 1- QPM flour spiced with ginger at 1%

GIN 3- QPM flour spiced with ginger at 3%

GAR 1- QPM flour spiced with garlic at 1%

GAR 3-QPM flour spiced with garlic at 3%

CLO 1- QPM flour spiced with clove at 1%

CLO 3- QPM flour spiced with clove at 3%.

**Table 3: Proximate Composition of Spiced QPM Cake**

Sample code	Crude protein %	Crude fat %	Crude fibre %	Total ash %	Moisture content %	N.F.E %
CON	6.74 <sup>h</sup>	13.28 <sup>h</sup>	0.26 <sup>f</sup>	2.28 <sup>f</sup>	13.46 <sup>a</sup>	70.06 <sup>b</sup>
W.C	7.89 <sup>g</sup>	15.11 <sup>g</sup>	0.38 <sup>a</sup>	2.34 <sup>e</sup>	12.04 <sup>f</sup>	81.08 <sup>a</sup>
CLO 1	8.26 <sup>e</sup>	16.03 <sup>d</sup>	0.34 <sup>bc</sup>	2.17 <sup>h</sup>	12.67 <sup>c</sup>	65.64 <sup>d</sup>
CLO 3	8.37 <sup>d</sup>	16.11 <sup>c</sup>	0.29 <sup>e</sup>	2.39 <sup>c</sup>	12.49 <sup>e</sup>	65.23 <sup>f</sup>
GAR 1	8.11 <sup>f</sup>	15.84 <sup>f</sup>	0.27 <sup>e</sup>	2.44 <sup>a</sup>	12.53 <sup>d</sup>	65.90 <sup>c</sup>
GAR 3	8.49 <sup>c</sup>	15.97 <sup>c</sup>	0.36 <sup>b</sup>	2.25 <sup>g</sup>	12.76 <sup>b</sup>	65.55 <sup>e</sup>
GIN 1	8.58 <sup>b</sup>	16.21 <sup>a</sup>	0.33 <sup>c</sup>	2.36 <sup>d</sup>	12.55 <sup>d</sup>	64.27 <sup>h</sup>
GIN 3	8.67 <sup>a</sup>	16.18 <sup>b</sup>	0.31 <sup>d</sup>	2.41 <sup>b</sup>	12.69 <sup>c</sup>	65.08 <sup>g</sup>

Means followed by the same superscript in a column are not significantly different ( $p < 0.05$ )

**Key**

W.C- Wheat cake without spices

CON- QPM cake without spices

GIN 1- QPM cake spiced with ginger at 1%

GIN 3- QPM cake spiced with ginger at 3%

GAR 1- QPM cake spiced with garlic at 1%

GAR 3-QPM cake spiced with garlic at 3%

CLO 1- QPM cake spiced with clove at 1% a

CLO 3- QPM cake spiced with clove at 3%.

**Table 4: Sensory Evaluation of Spiced QPM Cake**

Sample code	Colour	Appearance	Flavour	Texture	Taste	Overall acceptability
W.C	7.4 <sup>a</sup>	7.1 <sup>a</sup>	7.2 <sup>a</sup>	7.2 <sup>a</sup>	7.9 <sup>a</sup>	8.1 <sup>a</sup>
CON	5.5 <sup>g</sup>	5.5 <sup>f</sup>	4.7 <sup>e</sup>	4.6 <sup>e</sup>	4.4 <sup>e</sup>	4.5 <sup>f</sup>
GIN 1	5.9 <sup>e</sup>	6.3 <sup>c</sup>	6.3 <sup>c</sup>	5.5 <sup>b</sup>	5.0 <sup>c</sup>	5.7 <sup>b</sup>
GIN 3	6.2 <sup>d</sup>	5.9 <sup>d</sup>	6.5 <sup>b</sup>	5.0 <sup>c</sup>	4.5 <sup>e</sup>	5.5 <sup>c</sup>
GAR1	6.4 <sup>c</sup>	6.6 <sup>b</sup>	5.3 <sup>d</sup>	4.7 <sup>d</sup>	4.7 <sup>d</sup>	5.3 <sup>d</sup>
GAR3	6.5 <sup>b</sup>	6.4 <sup>c</sup>	5.4 <sup>d</sup>	4.6 <sup>e</sup>	4.7 <sup>d</sup>	4.9 <sup>e</sup>
CLO 1	5.9 <sup>e</sup>	5.8 <sup>d</sup>	6.2 <sup>c</sup>	5.6 <sup>b</sup>	5.7 <sup>b</sup>	5.6 <sup>b</sup>
CLO 3	5.7 <sup>f</sup>	5.6 <sup>e</sup>	4.5 <sup>f</sup>	4.7 <sup>d</sup>	4.3 <sup>f</sup>	4.5 <sup>f</sup>

Means followed by the same superscript in a column are not significantly different ( $p < 0.05$ )

**Key**

W.C- Wheat cake without spices

CON- QPM cake without spices

GIN 1- QPM cake spiced with ginger at 1%

GIN 3- QPM cake spiced with ginger at 3%

GAR 1- QPM cake spiced with garlic at 1%

GAR 3-QPM cake spiced with garlic at 3%

CLO 1- QPM cake spiced with clove at 1% a

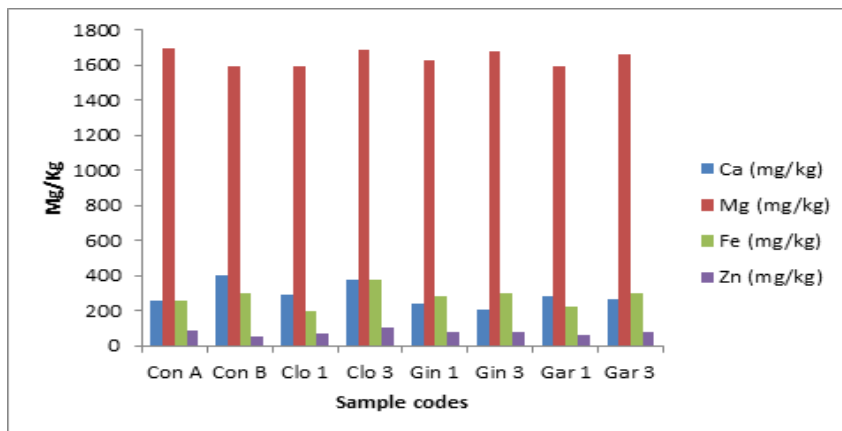
CLO 3- QPM cake spiced with clove at 3%.

nutrition is important particularly in the synthesis of the essential fatty acids, linoleic and linolenic acids and of the fat soluble vitamins. Insufficient fat intake or absence of certain fatty acids contributes to a variety of physiological symptoms (Newman, 1993) including: reduced growth, poor food conversion, increased metabolic rate and liver deficiencies. There was no significant difference ( $p < 0.05$ ) in the crude fibre of QPM flour without spice (CON A) and QPM flour with ginger at 3% (Table 2). Percentage crude fibre was significantly higher at  $p < 0.05$  in wheat cake (WC) while QPM cake without spice was significantly lower (0.26%) in crude fibre. The report of Anderson *et al.* (2009) stated that dietary fiber intake provides many health benefits that reduce the risk in developing diseases like coronary heart disease, hypertension, diabetes, obesity, and certain gastrointestinal disorders. Furthermore, it lowers blood pressure, improves blood glucose control in diabetes, aids in weight loss, and appears to improve immune function. Dietary fiber supplements have the potential to play an adjunctive role in offering the health benefits provided by high-fiber foods. Percentage total ash ranged from 0.54% to 0.85% in the flour samples. Ash content of food is a direct measure of the total mineral content in a food sample (Olanipekun *et al.*, 2015). The percentage total ash was significantly higher in QPM cake spiced with garlic at 1% level when compared with all other cake samples (Table 3), the presence of ash here indicate the presence of minerals in the cake samples. Moisture content in QPM flour ranged from 7.35% to 8.31%. The lower moisture content is important as it enables long storage by minimizing fungal contamination and

spoilage of the maize flour (Sule *et al.*, 2014). Moisture content of QPM cake without spice was significantly higher (13.46%) compared with other cake samples. Carbohydrate ranged from 78.46% to 79.83% in the flour samples. These values are in accordance with the previous work of Begun *et al.* (2013). The highest carbohydrate was recorded in WC followed by QPM cake without spice and QPM cake with 1% ginger recorded the least value. Carbohydrates are good sources of energy and that a high concentration of it is desirable in breakfast meal (David *et al.*, 2015).

For mineral composition of spiced QPM flour, calcium ranged from 211mg/kg to 402 mg/kg, magnesium ranged from 1597mg/kg to 1698mg/kg. There was no significant difference between QPM flour spiced with 1% clove, 1% garlic and wheat flour. Iron ranged from 201mg/kg to 375mg/kg, QPM flour with clove at 3% recorded the highest value for iron whereas, there is no significant difference between QPM flour with garlic at 3% (GAR 3) and wheat flour (CON B). Zinc ranged from 50mg/kg to 104mg/kg, QPM flour spiced with 3% clove recorded the highest value for Zn (figure 1). Sule *et al.* (2014) reported that maize flour samples contain different minerals but calcium, iron and zinc had lower percentage compared to magnesium which correlates with this study.

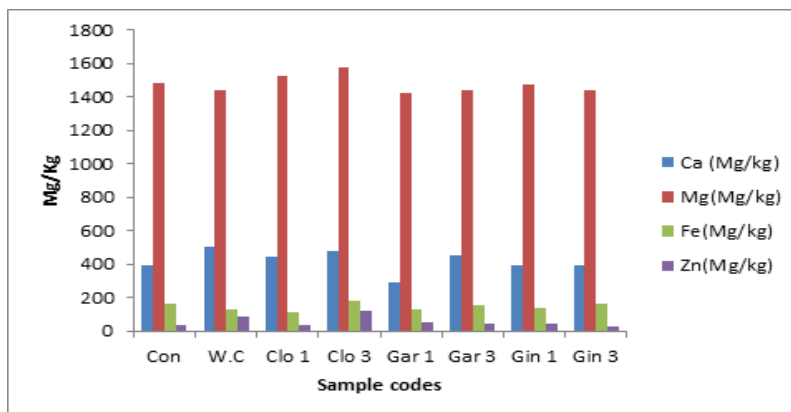
Cake with 3% clove inclusion (CLO3) recorded the highest magnesium (1576mg/kg), iron (185 mg/kg) and zinc (123 mg/kg) respectively (Figure 2). Wheat cake recorded the highest value for calcium (502mg/kg), followed by cake with 3% clove inclusion (483mg/kg) among other cake samples. Minerals are essential constituents of skeletal structures such as



**Figure 1: Mineral Composition of Spiced QPM Flour**

**Key**

- CON A- QPM flour without spices
- CON B- Wheat flour without spices
- GIN 1- QPM flour spiced with ginger at 1%
- GIN 3- QPM flour spiced with ginger at 3%
- GAR 1- QPM flour spiced with garlic at 1%
- GAR 3- QPM flour spiced with garlic at 3%
- CLO 1- QPM flour spiced with clove at 1%
- CLO 3- QPM flour spiced with clove at 3%.



**Figure 2: Mineral Composition of Spiced QPM Cake**

**Key**

- W.C- Wheat cake without spices
- CON- QPM cake without spices
- GIN 1- QPM cake spiced with ginger at 1%
- GIN 3- QPM cake spiced with ginger at 3%
- GAR 1- QPM cake spiced with garlic at 1%
- GAR 3- QPM cake spiced with garlic at 3%
- CLO 1- QPM cake spiced with clove at 1% a
- CLO 3- QPM cake spiced with clove at 3%.

bones and teeth, minerals help the body to grow, develop and stay healthy, the body uses minerals to perform many different functions (Ogunola *et al.*, 2010). Soetan *et al.* (2010) reported that simple or conditioned deficiencies of mineral elements have profound effects on metabolism and tissue structure. The result on the functional properties of the spiced QPM flour is shown in Figure 3. QPM flour with the addition of 3% clove (clo3) recorded the highest bulk density ( $0.80\text{g/cm}^3$ ) among all the samples while wheat flour (CONB) recorded the least ( $0.6\text{g/cm}^3$ ). There was no significant difference among the rest of the flour samples (figure 3). The bulk density is influenced by particle size and the density of the flour and is important in determining the packaging requirement (Abiose and Ikujenlola, 2014). The swelling power is an indication of presence of amylase which influences the quantity of amylase and amylopectin present in the maize meal. Swelling power is also related to the water absorption index of the starch based flour during heating (Abiose and Ikujenlola, 2014).

Water absorption capacity was the same for Spiced QPM flour with 1% ginger, 3% clove, 1% clove and plain QPM flour (CON A). Swelling power of QPM flour with 1% clove was significantly higher among the spiced QPM samples (9.1%) while spiced QPM with 3% clove was significantly lower (5.2%). Solubility power was significantly higher at  $p < 0.05$  in QPM flour with 3% clove among other flour samples (figure 3). Maize has high value for solubility index, increase in temperature cause an increase in the movement of the flour molecules, thereby allowing samples to be dispersed in the solvent. The value of

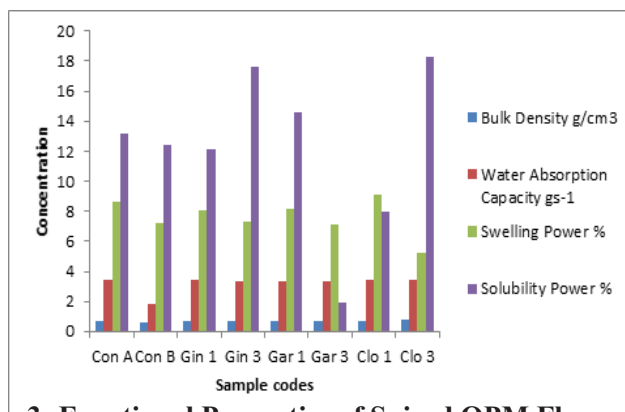
solubility index increased in direct proportion to increase in temperature (Oluwole *et al.*, 2016).

The result of the microbial count in the flour samples are shown in figure 4. Total bacterial count of spiced QPM flour at day zero ranged from  $0.2 \times 10^5 \text{cfug}^{-1}$  to  $1.5 \times 10^5 \text{cfug}^{-1}$  (Figure 4). Total bacterial count from maize flour could be due to microorganisms already present on the grain or from the milling machine used (Ntuli *et al.*, 2013). Total bacteria count of spiced QPM cake ranged from  $0.1 \times 10^5 \text{cfug}^{-1}$  to  $0.8 \times 10^5 \text{cfug}^{-1}$ . The highest total bacteria count was recorded in the control (CON) while QPM cake with 3 % clove recorded the least total viable count (Figure 5).

The result of sensory evaluation of spiced QPM cake samples is shown in Table 4. The overall acceptability of spiced QPM cake ranged from 4.5 to 8.1. There was no significant difference in the overall acceptability of plain QPM cake (control) and cake from QPM plus 3 % clove inclusion (Table 4). Cake made from 100% wheat flour (WC) was the most preferred by the sensory panelists followed by cake from QPM plus ginger 1% (Table 4). Lenchi *et al.* (2016) reported that maize could be used as an alternative source to wheat and that 100% maize flour and 100% wheat flour were acceptable for the sensory analysis in the production of snacks.

### Conclusion

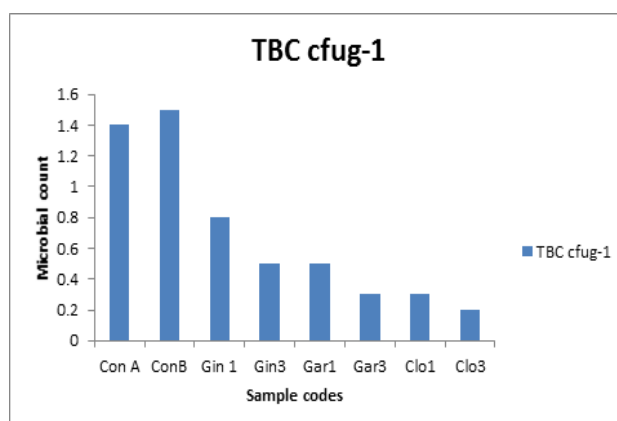
Spiced QPM cake and flour recorded higher crude protein content when compared with the QPM cake sample without spice (CON A) and plain QPM flour. Quality protein maize cake with 1% ginger was preferred to all the other spiced QPM samples in terms of sensory attributes. Highest total microbial count was recorded in the plain samples



**Figure 3: Functional Properties of Spiced QPM Flour**

**Key**

- CON A- QPM flour without spices
- CON B- Wheat flour without spices
- GIN 1- QPM flour spiced with ginger at 1%
- GIN 3- QPM flour spiced with ginger at 3%
- GAR 1- QPM flour spiced with garlic at 1%
- GAR 3- QPM flour spiced with garlic at 3%
- CLO 1- QPM flour spiced with clove at 1%
- CLO 3- QPM flour spiced with clove at 3%.

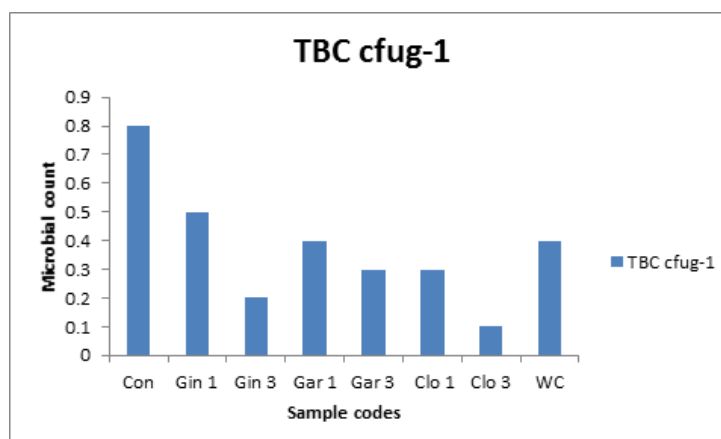


**Figure 4: Microbial Count of Spiced QPM Flour**

*Note* -TBC: Total Bacterial Count

**Key**

- CON A- QPM flour without spices
- CON B- Wheat flour without spices
- GIN 1- QPM flour spiced with ginger at 1%
- GIN 3- QPM flour spiced with ginger at 3%
- GAR 1- QPM flour spiced with garlic at 1%
- GAR 3- QPM flour spiced with garlic at 3%
- CLO 1- QPM flour spiced with clove at 1%
- CLO 3- QPM flour spiced with clove at 3%.



**Figure 5: Microbial Count of Spiced QPM Cake**

TBC: Total Bacterial Count

**Key**

W.C- Wheat cake without spices

CON- QPM cake without spices

GIN 1- QPM cake spiced with ginger at 1%

GIN 3- QPM cake spiced with ginger at 3%

GAR 1- QPM cake spiced with garlic at 1%

GAR 3- QPM cake spiced with garlic at 3%

CLO 1- QPM cake spiced with clove at 1%

CLO 3- QPM cake spiced with clove at 3%.

without addition of spices.

### Conflict of Interest

Authors have declared that no conflict of interest exists.

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