Physico-chemical and antioxidant qualities of fermented quality protein maize and carrot (D*aucus carota)* blends

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Abstract

The aim of this study as to assess the physico-chemical and antioxidant quality of co-processed quality protein maize and carrot blends. Two maize varieties; a yellow coloured quality protein maize (QPM)-(ART/98/SWI) and a yellow coloured normal maize endosperm - (Suwan-I-SRY) were used. Each maize variety was divided into three portions; a portion was co-fermented with carrot and in ratio 80:20, the second portion co-milled with carrot and maize in ratio 80:20 while the last portion fermented whole to serve as the control. The proximate, mineral composition, functional, antioxidant and sensory properties of the flour were determined. The results show that percentage flour yield ranged between 65.50 and 75.5% with co-fermented QPM having the highest yield. The crude protein content ranges between 1.34 and 2.37% with significant difference at $P \leq 0.05$. Co-milled samples; CMQPM and CMNYM with 2.37 and 2.24% crude protein, respectively were significantly higher than the co-fermented samples with 1.67 and 1.56% crude protein, respectively. The Ca and Fe contents ranged from 14.53 to 54.63mg/g and 4.41 to 14.14mg/g, respectively. The Bulk density, water absorption capacity, dispersibility, and wettability of the samples ranged 0.41 to 0.48g/ml, 1.12 to 1.53ml, 82.33 to 86.50ml, and 6.62 to 14.195, respectively. The pH ranged between 3.95 and 4.40 indicating that all the samples were acidic. The total carotenoids and total phenol contents of the blends ranged from 5.40 to 15.53 mg/100g and 17.36 to 42.87 mg/100g, respectively. The formulations are hereby recommended for use in both commercial and industrial production of complementary food.

Keywords: Complementary Foods, Antioxidants, Quality Protein Maize, Co-processing, Nutrients

Introduction

Complementary foods are foods other than breast milk or infant formular (liquids, semi-solids, and solids) introduced to an infant to provide nutrients. One of the popular indigenous fermented foods in Nigeria is "*ogi"* which is a fermented cereal porridge made from maize (Adesokan *et al*., (2010). Prepared *ogi* (pap) is used as the first native food for weaning babies. It also serves as breakfast meal for pre-school, school children and adults (Jude-Ojei, 2017). Maize is considered a staple food in most countries of the world. Apart from wheat and rice, maize is the third most widely food crop in the world. Maize provides over 20% of total calories in human diets in twenty one countries for over thirty million people (Shiferaw *et al*, 2011). According to Gliszczynska-Swiglo, (2006), naturally, maize is enriched with macronutrients as well as micronutrients like β–carotene, vitamin B complex and essential minerals; phosphorus, magnesium, copper and zinc. Though, zein - a protein present in maize lacks some essential amino acids such as lysine and tryptophan. Recent researches that led to the development of quality protein maize (QPM) have proven that the quality of maize protein (zein) can be improved such that it will contain all the essential amino acids required for adequate nutrition (Vasal, 1993; Srinivasan *et al.* 2004; IASRI, 2011). In addition, QPM has been reported to possess antioxidant properties (Gliszczynska-Swiglo, 2006) and so they are able to protect the body against free radical induced degenerated diseases.

According to the report of Wu *et al.* (2014), approximately one billion people worldwide have inadequate protein intake. In most developing countries including Nigeria, protein deficiency and malnutrition have remained a major nutritional challenge. Also, vitamin A deficiency which is one of the leading preventable causes of night blindness affects a large population of the world especially in developing countries such as Nigeria. In order to combat or prevent these deficiencies, dietary protein and vitamin A fortification is essential (Omar and Jose, 2002).

Quality protein maize (QPM) is an improved maize strain with higher lysine and tryptophan contents compared to conventional maize strains (Krishna and Motukuni, 2019). QPM grain contains almost twice as much lysine and tryptophan, amino acids that are essential for humans and monogastric animals but are limiting amino acids in grains. Carrot, botanically known as *Daucus carota* is one of the popular root vegetable grown throughout the world which is an important source of dietary carotenoid (Torronen *et al*, 1996). Carrot contains carotene which is a precursor of vitamin A. Carotenoids are class of pigments ranging from yellow to red in colour and are found mainly in plants. Mateljan (2011) also stated that all varieties of carrots contain valuable amounts of antioxidant nutrients; such antioxidants are traditional antioxidants like vitamin C, as well as beta-carotene, alpha-carotene.

Several attempts had been made by researchers to fortify ogi in order to meet the expected nutritional requirement of infants; Valdez *et al*. (2005) conducted a study on infant food using QPM and chickpea. Oladeji (2018) has reported on quality of co-processed QPM and carrot complementary Food. Adeola *et al*. (2012) investigated the effects of carrot pomace on the chemical and sensory attributes of ogi. Some of these researches successfully improved the protein content of ogi, but little or no studies had been carried out to asses antioxidant quality of ogi which is needed for healthy growth and prevention of degenerated diseases among infant population. Co-processing carrot with maize could improve it vitamin and other antioxidant properties. This study therefore studied the effect of co-processing on the physico-chemical antioxidant and sensory qualities of carrot /*ogi* blends.

Materials and Methods

Materials

Yellow Quality protein maize (ART|98|SWI) and normal yellow maize (SUwan-1-SRY) were obtained from the institute of Agricultural Research and Training (IAR&T) Ibadan, Nigeria. Carrot was obtained from Marian market, Calabar. The reagents used were of analytical grade.

Preparation of the flour blends

The maize grains and fresh carrot roots were sorted and cleaned to ensure wholesomeness. The sorted grains were divided into three groups, respectively, one batch of each maize types was fermented whole adopting the method modified by Adesokan *et al*. (2010) for traditional preparation of ogi. The other two batches were co-fermented and co-milled with 20% carrot and 80% maize respectively. Co-fermented and co-milled carrot/ogi flours were produced just like traditional ogi but with inclusion of carrot at different stages of production (Oladeji *et al*., 2014). For co-fermented blends; the maize and carrot were steeped in clean water in a plastic container with cover for 72hours, while for co-milled blends; the carrot was added after fermentation but before milling. The water was decanted after 72hours and the maize wet milled into slurry and sieved using a muslin cloth to separate the pomace from the filtrate. The filtrate was allowed to settle in order to solidify the ogi paste. The ogi paste was oven dried at 70 ^{o}C for 12hours. The dried ogi cake was fine milled to flour.

Proximate composition determination

The percentage moisture content, crude protein, total ash content, crude fibre and crude fat of the various flour samples were determined according to AOAC (2000) methods. Total carbohydrates were calculated by difference; by subtracting the sum of the percentage protein, fat, ash and moisture from 100, the resulting value gives the percentage carbohydrate of the various ogi flours.

Mineral content determination of the samples

The analysis for essential minerals was carried out by Atomic Absorption Spectrophotometric method. A sample of digest was used to determine some elements; calcium (Ca), iron (Fe) and magnesium (Mg) on the Atomic Absorption Spectrophotometer (Perkin Elmer, model 402) while sodium and potassium was determined by flame emission photometry.

Determination of functional properties of the sample flours

Bulk density was determined according to the method of Siddique *et al*. (2010). Flour dispersibility was determined by the method described by Kulkarni *et al.* (1991). Wettability and water absorption capacity of the flour blends were determined according to the method of

Okezie and Bello (1988). The pH was measured with a Hanna checker pH meter (Model HI 1270) after it was calibrated with buffer 4.0 and7.0.

Antioxidants properties determination

Ascorbic acid concentration of the blend was determined using the 2, 6- dichlorophenol-indophenol titration method described in AOAC (2000). Total carotene of the samples was determined according to the method of Sallaur *et al.* (1990). The extractable phenol was determined on the extracts using the method reported by Singleton *et al*. (1999) as modified by Ogunmoye *et al.* (2012). The extractable flavonoid of extract was determined using a slightly modified method reported by Meda *et al*. (2005).

Sensory evaluation

A 50g of *maize-carrot* flour was reconstituted in 80 ml cold water and 500 ml hot water was thereafter added until a viscous gruel was formed. All the samples were prepared using the same standard and were evaluated for colour, taste, aroma, texture and overall acceptability. Twelve-member semi-trained panels constituting students, technical and academic staff members of the Department of Food Science and technology, University of Calabar, based on familiarity with the product were used for sensory test. The samples were rated on a 9-point Hedonic scale which was quantified from one for dislike extremely to nine like extremely.

Statistical Analysis

Experimental data were generated in three replicates and the result expressed as mean ± standard deviation. Analysis of variance (ANOVA) was performed and difference in mean values were valuated using Duncan's multiple range test of SPSS statistics software version 17 of 2002.

Results and discussion

Percentage Yield of the flour blends

The percentage yield of the carrot-ogi flour blends are presented in Table 1.The percentage yield of the flour blends ranged between 65.50 and 75.05%. The percentage yield of 20% carrot co-fermented and 20% carrot co-milled QPM are 75.05 and 71.52%, respectively. The percentage yield of 20% carrot co-fermented and 20% carrot co-milled normal yellow maize are 69.50 and 65.62%. However, co-fermented formulations have higher yields that co-milled blends in both maize varieties. Generally, QPM yields in different treatments were found to be higher compared to their normal endosperm (Table. 1). The high yield reported of QPM variety agrees with the study by Cordova *et al.* (2000) that one of the advantages of QPM over normal maize endosperm is its higher yield.

Proximate composition of the flour blends

The proximate composition of the flour blends are presented in Table 2. The crude protein content of the flour blends ranged between 1.34 and 2.37% which was comparable with 1.8% to 2.0% reported for baobab-ogi by Adejuyitan *et al.* (2012*).* There was increase in the protein content of CFNYM and CMNYM from 1.34 to 2.24% and 2.37%, respectively. The protein content of CFQPM (2.50%) was higher than that of CMQPM (1.56%). There was no significant difference in the moisture content of CFQPM, CMQPM, CFNYM, CMNYM and WQPM (75.05%, 71.52%, 69.50%, 65.62%, and 70.65%), respectively. Change in moisture content will dramatically affect flavor and texture as well as physical and chemical properties of the co-processed flour. The total ash content of the blends was between 0.50 and 1.50%. Though, the effect of co- fermentation and co- milling did not follow a particular trend, the ash content of co-processed flour was moderately higher with WQPM having the highest value followed by CMQPM (0.99%). This result was within the range (0.8 -1.0%) reported by Adejuyitan *et al.* (2012) for boabob ogi and lower than 1.62 - 2.27% reported for maize tilapia fish flour according to Fasasi *et al.* (2007) and Adejuyitan *et al.* (2012). The moderately high total ash content is desirable for rich composition because in turn this may also have antioxidant advantage as some mineral like sodium, have been proven to have antioxidant properties. The crude fibre ranged between 0.49 and 0.51%. Fibre plays a major role in the digestive health. It increases healthy gut bacterial, which lower inflammation in the body (Vikas *et al*, 2012).Crude fat contents ranged between 11.50 and 19.90%. Carbohydrate content of the ogi flour ranged between 68.15 and 76.83%.

Mineral Contents of the Flour Blends

The flour mineral content ranged from 4.41-15.14 mg/100g, 6.60 -20.55 mg/100g, 14.53 - 54.63mg/100g,18.00-31.15mg/100g and 17.65-25.35mg/100g for iron, sodium, calcium, potassium and magnesium, respectively (Table 3). There were significant ($p \leq .05$) differences in iron, sodium and calcium content of the flour blends. This result show that co-fermentation with carrot caused a significant increase on the macro element contents. The increment in mineral composition showed significant contribution of carrots to micro nutrients in the blends. Calcium helps in bone and teeth formation. It also plays a role in heart and muscle functions. Iron values obtained for WNYM, CMQPM and WQPM (5.98 mg/100g, 15.14 mg/100g and 4.41 mg/100g) are lower than those obtained for CFQPM, CFNYM and CMNYM (15.14 mg/100g, 11.81 mg/100g and 9.08 mg/100g) flour blends, respectively. Iron plays an important role in red blood cell production. The potassium value of NYM (18.00 mg/100g) flour is lower than the values obtained for CFQPM, CMQPM, CFNYM and CMNYM (29.13mg/100g, 31.15mg/100g, 28.40 mg/100g, 30.05 mg/100g, 28.40 mg/100g) flours (Table 3).

Potassium helps in maintaining pH balance and nerve function (Soetan *et al.*, 2010).

Functional properties of the flour blends

The functional properties of the ogi flour blends are shown in Table 4.The bulk density of the flour blends ranged between 0.41 and 0.48g/ml which was comparable to values obtained by Oladeji, (2018) who observed a reduction in the bulk density of the blends with the inclusion of carrot. The reduction of bulk density will be an advantage in using the flour blends for complementary diet. There were no significant ($p>0.05$) differences between WNYM and CFQPM, CMQPM and CMNYM, respectively.

The water absorption capacity of the flour blends was between 1.1 and 1.53ml. There were significant differences ($\leq$ 0.05) in the water absorption capacity of the various flour blends. The variation in WAC values indicated differences in the degree of availability of water binding availability sites among starches (Awuchi *et al*, 2019). The pH of the flour blends was within the acidic range of the pH scale (3.95-4.40). There are significant differences between pH values of samples WNYM and CFNYM blends. Fermentation of maize with carrot caused a reduction in the pH values of the various blends.

Antioxidant properties of ogi flours

The results of carotene content of the flour samples in Table 5 showed that there were significant differences in the total carotenoid content of all the flour samples at $P\leq0.05$. The total carotene values ranged from 5.40 to 15.53mg/g of the samples. Although 100% QPM (5.53mg/g) had higher total carotenoids content than normal yellow (7.93mg/g) maize, the result showed that carrot co-processed with normal yellow maize had higher carotenoid content (10.89 and 11.2mg/g) for CFNYM and CMNYM, respectively than carrot co-processed with QPM (5.40 and 6.82mg/g) for CFQPM and CMQPM, respectively. Carotene is essential in maintaining healthy eyes keep the skin and lining of the nose, healthy (Bendich, 1990). Inclusion of carrot caused a decrease in the total phenol content (24.41 and 32.61mg/g) of CFQPM and CMQPM, respectively. There was increase in the total phenol content (24.9mg/g) and 32.61mg/g for CFNYM and CMNYM, respectively. The total flavonoid content ranged from 0.21 to 0.97mg/g. There was significant $P\leq0.05$ difference in the total flavonoid content of the samples. There is reduction in the total flavonoid content of the samples on inclusion of carrot. The ascorbic acid content of the samples was between 0.62 and 1.24mg/g. Fermentation with inclusion of carrot increased the ascorbic acid content (1.24mg/g) 0f CFNYM. The total carotenoid and ascorbic acid content of carrot co-processed with normal yellow maize increased with the inclusion of carrot. This shows a *significant contribution of carrot to the vitamin C and carotenoids content of a study in which sorghum-ogi was fortified with pawpaw (Oluseyi et al, 2010). Ascorbic acid is needed for the repair of homes in all parts of the body. One of the important properties of ascorbic acid is its antioxidant activity which helps to prevent certain diseases such as cancer, cardiovascular disease, common cold, age related degeneration and cataract (Sudha et al., 2017).*

Sensory Quality of the Reconstituted Ogi Blends

A comparison of the prepared gruel from co-fermented and co-milled flour blends showed significant difference at P≤0.05 in the colour of the ogi gruel (Table 6). Ogi gruel from CFQPM had less preference in terms of colour compared to the other blends. There was no significant difference in the aroma, texture and over all acceptability of the various ogi gruels.

Conclusions and Recommendation

This study evaluated the effect of co- processing on the quality of various flour blends. The results indicated that; From this research, it is observed that; co-fermented and co-milled blends had good flour yields with 20% carrot co-fermented with 80% quality protein having the highest flour yield. Co-milling carrot with fermented normal yellow maize was better than co-fermentation. Co-milling of carrot with quality protein maize and normal yellow maize had better physicochemical and antioxidant properties with 20% carrot co-milled with 80% yellow maize having the highest protein content and antioxidant property. Sensory scores showed that there was no significant difference in the taste, aroma, texture and overall acceptability of the flour blends. There was a significant difference in the colour of the blends with 20% carrot co-fermented with 80% normal yellow maize having the most preference in terms of colour. This study thus recommends that these formulations (maize-carrot blends) can be used for commercial and industrial production of complementary foods in Nigeria.

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Table 1: Percentage yield of the flour blends

Sample code	Initial Weight (g)	Final Weight (g)	% yield
WNYM	1000	655.00	65.50
CFQPM	1000	750.00	75.05
CMQPM	1000	715.00	71.52
CFNYM	1000	695.00	69.50
CMNYM	1000	656.00	65.52
WQPM	1000	706.00	70.65

Key:
WNYM – 100% Fermented normal yellow maize
CFQPM- 20% carrot co-fermented with quality protein maize,
CMQPM-20% carrot co-milled with quality protein maize,
CFNYM- 20% carrot co-fermented with normal yellow maize
CMNYM- 20% carrot co-milled normal yellow maize
WQPM- 100% fermented quality protein maize

Table 2: Proximate Composition of the maize-Carrot Ogi Flour

Sample code	%Moisture	%Ash	%crude Fiber	%crude Protein	%crude Fat	%Carbohydrate
WNYM	7.44±1.47^{b}	0.75±0.25^{bc}	0.50±0.01^{a}	1.34±0.01^{b}	16.50±1.50^{b}	73.47±3.23^{b}
CFQPM	9.11±0.15^{a}	0.50±0.00^{c}	0.50±0.05^{a}	1.56±0.01^{b}	11.50±1.50^{c}	76.83±1.66^{a}
CMQPM	9.20±0.66^{a}	0.99±0.00^{b}	0.49±0.01^{a}	1.67±0.01^{b}	19.50±1.50^{a}	68.15±0.85^{c}
CFNYM	8.98±0.20^{a}	0.75±0.25^{bc}	0.50±0.01^{a}	2.24±0.01^{a}	17.00±1.00^{b}	70.53±1.22^{bc}
CMNYM	9.41±0.01^{a}	1.00±0.01^{b}	0.51±0.01^{a}	2.37±0.51^{a}	15.50±0.50^{b}	71.22±0.02^{b}
WQPM	8.87±0.54^{a}	1.50±0.50^{a}	0.51±0.01^{a}	2.05±0.01^{a}	15.50±0.50^{b}	71.58±0.55^{b}

Values are means of triplicate determination (±SD).The mean values along the same Column with different superscripts are significantly different ($p \leq 0.05$).
Key:
WNYM – 100% Fermented normal yellow maize
CFQPM- 20% carrot co-fermented with quality protein maize,
CMQPM-20% carrot co-milled with quality protein maize,
CFNYM- 20% carrot co-fermented with normal yellow maize
CMNYM- 20% carrot co-milled normal yellow maize
WQPM- 100% fermented quality protein maize

Table 3: Mineral Contents of Flour Blends

Sample Code	Iron (mg/100g)	Sodium (mg/100g)	Calcium (mg/100g)	Potassium (mg/100g)	Magnesium (mg/100g)
WNYM	5.98±0.02^{d}	6.60±0.00^{f}	14.53±0.08^{f}	18.00±0.00^{e}	17.65±0.00^{f}
CFQPM	15.14±0.10^{a}	7.50±0.00^{e}	27.73±0.08^{c}	29.13±0.03^{c}	24.25±0.00^{b}
CMQPM	4.55±0.00^{e}	11.60±0.00^{b}	18.70±0.05^{e}	31.15±0.05^{a}	18.15±0.05^{e}
CFNYM	11.81±0.01^{b}	20.55±0.05^{a}	25.10±0.00^{d}	28.40±0.00^{d}	25.35±0.15^{a}
CMNYM	9.08±0.03^{c}	11.05±0.00^{c}	54.63±0.18^{a}	30.05±0.05^{b}	21.55±0.00^{d}
WQPM	4.41±0.00^{f}	9.50±0.00^{d}	31.28±0.08^{b}	28.40±0.00^{d}	22.93±0.08^{c}

Values are means of triplicate determination (±SD).The mean values along the same column with different superscripts are significantly different ($p \leq 0.05$)
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CMNYM- 20% carrot co-milled normal yellow maize
WQPM- 100% fermented quality protein maize

Table 4: Functional Properties of Flour Blends

Sample Code	Bulk Density(g/ml)	WAC (ml)	Dispersibility (ml)	pH	Wettability (s)
WNYM	0.41 ± 0.25^{c}	1.53 ± 0.46^{a}	86.00 ± 1.00^{a}	4.40 ± 0.10^{a}	7.74 ± 0.16^{c}
CFQPM	0.41 ± 0.01^{c}	1.24 ± 0.02^{ab}	83.33 ± 0.58^{b}	4.20 ± 0.10^{b}	7.86 ± 0.42^{c}
CMQPM	0.45 ± 0.01^{ab}	1.12 ± 0.04^{b}	82.33 ± 0.58^{b}	4.15 ± 0.05^{b}	7.33 ± 0.03^{d}
CFNYM	0.45 ± 0.01^{b}	1.24 ± 0.01^{ab}	83.00 ± 0.50^{b}	3.95 ± 0.05^{c}	6.62 ± 0.12^{e}
CMNYM	0.46 ± 0.2^{ab}	1.17 ± 0.01^{ab}	83.50 ± 0.50^{b}	4.15 ± 0.05^{b}	9.21 ± 0.19^{b}
WQPM	0.48 ± 0.01^{a}	1.28 ± 0.17^{ab}	86.50 ± 0.50^{a}	4.21 ± 0.01^{b}	14.19 ± 0.06^{a}

Values are means of triplicate determination (±SD).The mean values along the same column with different superscripts are significantly different ($p \leq 0.05$).

Key:

WNYM – 100% Fermented normal yellow maize
CFQPM- 20% carrot co-fermented with quality protein maize,
CMQPM-20% carrot co-milled with quality protein maize,
CFNYM- 20% carrot co-fermented with normal yellow maize
CMNYM- 20% carrot co-milled normal yellow maize
WQPM- 100% fermented quality protein maize

Table 5: Antioxidant Properties of Flour Blends

Sample Code	Total Carotenoids (mg/g)	Total Phenols (mg/g)	Total Flavonoids (mg/g)	Ascorbic Acid(mg/g)
WNYM	7.93 ± 0.01^{d}	17.36 ± 0.15^{e}	0.97 ± 0.25^{f}	0.71 ± 0.11^{c}
CFQPM	5.40 ± 0.20^{f}	20.99 ± 0.16^{d}	0.21 ± 0.20^{e}	1.19 ± 0.04^{ab}
CMQPM	6.82 ± 0.20^{e}	22.04 ± 0.30^{d}	0.29 ± 0.20^{d}	1.10 ± 0.10^{b}
CFNYM	10.89 ± 0.10^{c}	24.91 ± 0.76^{c}	0.39 ± 0.04^{c}	1.24 ± 0.06^{a}
CMNYM	11.21 ± 0.11^{b}	32.61 ± 0.30^{b}	0.44 ± 0.02^{b}	0.62 ± 0.03^{c}
WQPM	15.53 ± 0.16^{a}	42.87 ± 1.51^{a}	0.50 ± 0.04^{a}	1.20 ± 0.01^{ab}

Values are means of triplicate determination (±SD).The mean values along the same column with different superscripts are significantly different ($p \leq 0.05$).

Key:

WNYM – 100% Fermented normal yellow maize
CFQPM- 20% carrot co-fermented with quality protein maize,
CMQPM-20% carrot co-milled with quality protein maize,
CFNYM- 20% carrot co-fermented with normal yellow maize
CMNYM- 20% carrot co-milled normal yellow maize
WQPM- 100% fermented quality protein maize

Table 6: Sensory qualities of the reconstituted flour Blends

Sample	Colour	Taste	Aroma	Texture	Overall acceptability
WNYM	7.40± 1.68^{ab}	6.00±1.77^{b}	6.27±1.28^{a}	7.60±1.06^{a}	7.40±1.50^{a}
CFQPM	6.07±1.79^{c}	7.20±1.32^{a}	5.73±1.58^{a}	6.93±2.22^{a}	6.93±1.87^{a}
CMQPM	7.13±1.30^{abc}	6.00±2.00^{b}	6.47±2.00^{a}	6.93±1.79^{a}	6.87±1.85^{a}
CFNYM	8.00±1.20^{a}	7.27±1.10^{a}	6.60±1.59^{a}	7.47±1.36^{a}	7.60±1.55^{a}
CMNYM	7.13±0.99^{abc}	7.20±1.74^{a}	6.47±1.77^{a}	7.27±1.44^{a}	7.60±1.12^{a}
WQPM	6.53±1.85^{bc}	8.20±0.68^{a}	6.53±1.51^{a}	7.07±0.96^{a}	7.13±1.25^{a}

Values are means of triplicate determination (±SD).The mean values along the same column with different superscripts are significantly different ($p \leq 0.05$).

Key:

WNYM – 100% Fermented normal yellow maize
CMQPM-20% carrot co-milled with quality protein maize,
CMNYM- 20% carrot co-milled normal yellow maize
CFQPM- 20% carrot co-fermented with quality protein maize,
CFNYM- 20% carrot co-fermented with normal yellow maize
WQPM- 100% fermented quality protein maize