Journal of Advancements in Food Technology
Volume 1 | Issue 1

Research Article Open Access

Assessment of Physico-Chemical Properties, Pasting Profiles and Sensory Scores of Co-Processed Quality Protein Maize and Carrot Complementary Food

Oladeji B.S.*

Department of Food Science and Technology, University of Calabar, Calabar, Nigeria

***Corresponding author:** Oladeji B.S., Department of Food Science and Technology, University of Calabar, Calabar, Nigeria, Tel: +2348034860726, E-mail: oladejistephen35@yahoo.com

Citation: Oladeji B.S. (2018) Assessment of Physico-Chemical Properties, Pasting Profiles and Sensory Scores of Co-Processed Quality Protein Maize and Carrot Complementary Food. J Adv Food Technol 1(1): 104. doi: 10.15744/2639-3328.1.104

Received Date: June 27, 2018 **Accepted Date:** August 16, 2018 **Published Date:** August 20, 2018

Abstract

The aim of this study is to determine the physico-chemical properties, pasting profiles and sensory scores of complementary food from co-processed maize and carrot. TZE-YPOP-DT-STR-QPM and normal maize; SUWAN-ISR were selected for this study. Each variety was divided into two portions; a portion was co-milled with 20% carrot while the other portion was co-fermented with 20% carrot. The samples were prepared by drying them in a cabinet drier at 60°C for 12 hours. Proximate composition, mineral content, physicochemical and pasting profile the flour blends were determined. Also, colour indices and sensory scores of the flour samples were also measured. Protein content ranges between 5.68 and 7.11% with significant differences at $p<0.05$. The Na and K (1.09 and 15 mg/100g) values of 20% Co-milled QPM (20CMQPM) were significantly higher than other samples. pH ranged between 3.37 and 3.47 meaning that all the samples are in acidic range. The reconstitution index of co-milled samples was significantly higher than co-fermented flours with 20CMQPM with the highest value of 97.7%. Peak viscosity and peak time ranges were 184.08 to 235.88RVU and 5.44-5.69 mins, respectively. Sample 20CMQPM was rated highest in taste, colour, and aroma and overall acceptability with significant differences at $p<0.05$. It was concluded that quality protein maize could be co-processed with carrot to reduce its bulkiness and improve it nutritional quality and pasting property. Co-milled samples particularly displayed better nutritional quality with acceptable physical and sensory characteristics than the co-fermented samples

Keywords: Maize Variety; Complementary Foods; Co-Processing; Bulk Density; Pasting Profile; Sensory Scores

Introduction

Complementary foods are the initial nutrients providing foods given to infants alongside with breast milk after six months of age and are consumed by more than 90% of infants in Nigeria. Prevalence of under nutrition and micronutrients deficiency is high among infants and young children of six months to two years old [1]. Due to the fact that infants are very vulnerable nutritionally during complementary feeding therefore; introduction of semi-solid foods at the expense of breast milk must provide adequate nutrients for the rapid phase of growth and development. These are specially prepared diets to meet the particular nutrient and physiological needs of the infant [2]. A complementary food must have a high calorie and micronutrient density, be in a "low bulk" or drinkable form, free of bacterial contamination, and must be of a quantity that can be consumed at one feeding. In Nigeria, the first complementary food is usually a thin cereal porridge made from fermented maize, millet, or sorghum. It was observed that the porridge contain about 36-43 kcal/ml and so if taken 200 -300 ml three to four times daily will sufficiently provide require energy [3]. Cereals are the most important staple food being the major sources of carbohydrates. Compositionally, cereals consist of 12-14 % water, 65-75 % carbohydrates; 2-6%, lipids and 7-12% protein on dry weight basis. In their natural form whole grain cereals are also significant contributor of vitamins, minerals like manganese, zinc, copper and magnesium and considerable iron but with low bio- availability. According to TASS the quality protein maize (QPM) has received special distinction among the cereals due to presence of high amount of two essential amino acids viz., lysine and tryptophan and low content of prolamins [4]. Therefore, it can be utilized for diversified purposes in food and nutritional security as infant food, health food/mixes, convenience foods, specialty foods and emergency ration. It is also useful in fulfilling the protein requirements of different sections of society (infants, lactating mothers' convalescing patients, Kwashiorkor diseased, old persons etc) to prevent malnutrition. Its green cob is very nutritious, tasty and liked by people. Carrots had been described as nutritional heroes because they store a goldmine of nutrients. Mateljan also stated that all varieties of carrots contain valuable amounts of antioxidant nutrients. Such antioxidants are traditional antioxidants like vitamin C, as well as phytonutrient antioxidants like beta-carotene, alpha-carotene, beta-carotene, and lutein, hydroxycinnamic acids (caffeic acid, coumaric acid and ferulic acid), and anthocyanidins (cyanidins and malvidins) [5]. Emphasizes have been placed on the use of local food material for complementary food formulation by WHO/UNICEF since 1971. This is to be guided by principles such as high nutrients content, general acceptability and the like [6,7]. Valdez *et al.* conducted a study on infant food using QPM and chickpea [8]. Fermented Maize gruel (ogi) has been fortified with Nile Tilapia (*Oreochromis niloticus*) by Fasasi *et al.* and baobab fruit powder [9,10]. Ikujenola investigated the formulation of complementary foods from quality protein maize; normal maize and soybean. He also assessed the effect of malting and fermentation on the functional properties, nutritional qualities; organoleptic properties as well as the storage stability of the products [11]. However, little information is available in literature on co-processing of cereal and vegetables and also on utilization of carrot in complementary foods. This present study therefore is geared towards formulation of complementary food from quality protein maize, co-fermented and co-milled with carrot to improve the protein quality of normal maize *ogi*- a complementary and also to evaluate the effect of the processing on the physico-chemical properties, pasting profile and sensory score of the products.

Materials and Methods

Collection of Materials

Two blends of maize varieties were studied; a yellow coloured QPM variety was studied in comparison with yellow colored normal maize variety. The QPM variety: TZE-YPOP-DT-STR-QPM was obtained from IITA, Ibadan while the normal maize; SUWAN-ISR was obtained from IAR and T, Ibadan. Intact whole seeds were picked manually and stored at refrigeration temperature for further investigations.

Production of Co-Fermented and Co-Milled Flour Blends

Co-fermented and co-milled carrot/ogi flours were produced following the production of *ogi* but with the inclusion of carrot on the production line [12]. The difference in their production lies at the stage of inclusion of carrot. For co-fermented; the carrot fraction was included before fermentation while for co-milled; carrot fraction was included after fermentation but before milling.

Proximate Composition

The flour blends were analyzed for moisture content, crude fat, crude protein, total ash content and crude fibre according to the method of analysis of the Association of Official Analytical Chemists while carbohydrate content of the blends were determined by difference [13].

Mineral Content Analysis

The analyses for essential minerals were carried out by Atomic Absorption Spectrophotometric method. A sample of digest was used to determine some elements (calcium, magnesium, manganese, copper, iron and zinc) on the Atomic Absorption Spectrophotometer (Perkin Elmer, model 402) while sodium and potassium were determined by flame photometry.

Physicochemical and Functional Properties

The particle size distribution of flour blends was carried out using a sieve analysis technique with the aid of Endecotts Test Sieve Shaker (SN 9229, Endecott Lt, England). Flour dispersibility was measured using the method of Punita [14]. The pH was measured using standard method AOAC with a Hanna checker pH meter (Model HI 1270) after calibrating the pH meter with buffer 4 and 7 [15]. Bulk density was determined according to the method of Okezie and Bello [16]. While swelling power and solubility were determined on the blends at 60, 70, 80 and 90°C using a modified version of the method of Sathe and Salunkhe [17]. The reconstitution index was estimated by the method of Akpapunam and Markakis [18].

Pasting Profile the Flour Blends

The pasting profiles were measured using a Rapid Visco Analyser (Newport Scientific Australia). Blends (2.5 g) each of the flour blends were weighed into a dried empty canister; 25 ml of distilled water was dispensed into the canister containing the sample. The solution was thoroughly mixed and the canister was well fitted into the RVA, as recommended. The slurry was heated from 50 to 95°C with a holding time of 2 mins followed by cooling to 50°C with 2 mins holding time. The rate of heating and cooling were at constant rate of 11.25°C/min. Peak viscosity, trough, breakdown, final viscosity, set back, peak time and pasting temperature were read from the pasting profile with the aid of Thermocline for Windows Software connected to a computer.

Measurement of Colour Indices Of Flour Blends

The colour of maize flour blends were measured using a colour measuring instrument (CM 700d Spectrophotometer (Konica Minolta), and the values expressed on the L*, a*, b* tristimulus scale. The L*-value represents the lightness index; a*-value represents the degree of redness (-a*) or greenness (+a*); and b*-value represents the degree of yellowness (-b*) or blueness (+b*). The instrument was initially standardized (L*=90.29, a*=1.37, b*=0.06) using a white reference standard (white duplicating paper sheet, 80g/m^2).

Sensory Evaluation

Sensory test of the product was carried out by using sensory evaluation process as described by Larmond [19]. Test was performed on all the blends. A twenty member untrained panelists consisting of lecturers, technologists and students of Food Science and Technology Department of Obafemi Awolowo University, Ile-Ife, Nigeria were engaged to evaluate the sensory characteristic of the products. The products was prepared (3:10 wt/vol. for flour and water) under the same condition of temperature, using the same volume of water, coded and rated for colour, taste, aroma, consistency, thickness and overall acceptability. Blends were evaluated for all sensory attributes on a 9- point Hedonic scale which was quantified from one for like extremely to nine dislike extremely.

Results and Discussion

Yield of Flour Products

Co-milled formulations recorded lower yields than their co-fermented counterparts in both varieties; 67.60%, 70.17% and 66.67%, 69.33% for 20% carrot co-milled and 20% carrot co-fermented respectively and QPM recorded higher yield (Table 1) [20]. The high yield reported for QPM variety agreed with several studies; Cordova *et al.* observed that Quality Protein Maize is a special type of maize though with exactly the same qualities as normal maize in grain texture, taste and colour but possess almost double the levels of lysine and tryptophan with higher yield.

Parameters	SAMPLES			
	20CFNM	20CFQPM	20CMNM	20CMQPM
%Yield	67.6	70.17	66.67	69.33
Protein (g/100g)	7.11±0.20a	6.09±0.15c	5.68±0.02d	6.87±0.01b
Moisture (g/100g)	4.99±0.52ab	5.05±0.26a	3.74±0.28c	5.11±0.11a
Fat (g/100g)	3.76±0.06a	4.14±0.12a	3.80±0.04a	3.74±0.03a
Ash (g/100g)	1.37±0.23b	1.83±0.12a	1.89±0.15a	1.44±0.12b
Crude fibre (g/100g)	0.93±0.23a	0.67±0.12ab	0.67±0.15ab	0.57±0.12b
Carbohydrate (g/100g)	81.34a	81.72a	83.72c	81.77b
Mg (mg/100g)	0.38a	0.36c	0.27d	0.24b
Na (mg/100g)	0.53a	0.32a	0.56a	1.09a
K (mg/100g)	10.42b	6.74c	14.17a	15.00a
Ca (mg/100g)	20.83c	35.00b	35.83b	50.00a
Fe (mg/100g)	5.07c	17.92a	4.78d	9.89b
Cu (mg/100g)	0.11a	0.07b	0.05c	0.03d
Mn (mg/100g)	0.36ab	0.03b	0.03b	0.01b
Zn (mg/100g)	2.02c	3.36b	3.95a	3.38b

Table 1: Yield, Proximate composition and mineral of the flours Values reported as means± standard deviation. Mean values followed by different roman letters in a roll are significantly different ($p \leq 0.05$)

Key: 20CFNM-20% carrot co-fermented with normal maize, 20CFQPM-20% carrot co-fermented with quality protein maize, 20CMNM-20% carrot co-milled with normal maize, 20CMQPM-20% carrot co-milled with quality protein maize.

Proximate Composition of Flour Blends

The crude protein contents of the flour blends ranged from 5.68 to 6.87% (Table 1). The range of protein contents obtained for the flour blends (5.68 - 8.40%) was higher than 1.8 to 2.2% reported for Baobas-ogi by Adejuyitan *et al.* [10]. The result is however comparable with 4.10 to 8.96% reported for sorghum-ogi fortified with pawpaw (Ajanaku *et al.* [21]. Crude fat contents ranged between 3.74 and 4.14% without any significant difference at 95% confident limit. The result obtained agreed with 4.00% crude fat content reported for fermented maize flour by Fasasi *et al.* [9]. The close similarity in the crude fat contents of the flour blends is an indication that all the samples will have relative storage stability as they are not likely to be susceptible to rancidity which may negatively affect both the colour and the flavour of the product. Total ash content of the flour blends ranged between 1.37 and 1.89% (Table 1). Though, the effect of co-fermentation and co-milling did not follow a particular trend, yet, the ash content of co-processed flour blend was relatively high with 20CMNM having the highest value of 1.89% closely followed by 20CFQPM (1.83%). This result is higher than the range (0.8-1.0%) reported by Adejuyitan *et al.* for *baobab ogi* and close to 1.62 to 2.27% earlier reported for maize-tilapia fish flour Fasasi *et al.* [9,10]. The high total ash content is desirable for richer mineral composition which in turn may also have antioxidant advantage as some minerals notably; Selenium, Sodium and so on have been proved to have antioxidant properties. The crude fibre ranged between 0.57 and 0.93% for all the blends (Table 1). Co- fermented blends had higher crude fibre than co-milled blends. The crude fibre of QPM blends (0.67and 0.57%) are lower than the normal maize variety (0.93 and 0.67%) with 20CMQPM having the lowest crude fibre value (0.57%). This could indicate that QPM have better digestibility tendency and consequently will be more available for body utilization compared to normal maize blends. Carbohydrate level ranged between 81.34 and 83.72% (Table 1). This range is similar to the reports earlier studies for fermented maize flours [9,10,22].

Mineral Contents of the Flour Blends

The quantities of these minerals varied from 0.24 to 0.38 mg/100g, 0.32 to 1.09 mg/100g, 6.74 to 15.00 mg/100g and 20.83 to 50.50 mg/100g for magnesium, sodium, potassium and calcium, respectively (Table 1). The result of our earlier study observed a decrease in maize flour due to fermentation [23]. However, co-fermentation and co-milling with carrot caused a significant increase in all the macro-element contents notably calcium from 12.42 to 15.00 mg/100g to the range of 20.83 to 50.00 mg/100g obtained in this study (Table 1) [23]. The increment in mineral composition shows the significant contribution of carrots to micronutrients in the blends. Calcium values obtained for 20CFNM and 20CFQPM (20.83 and 35.00 mg/100g) flours were lower than the values (35.83 and 50.00 mg/100g) obtained for 20CMNM and 20CMQPM flours. This suggests that more of the nutrients were retained in co-milled flour blends than their co-fermented counterparts. Also, the zinc composition of the flour blends was relatively good (Table 1). The value (0.11 mg/100g) for copper obtained in 20CFNM agreed with 0.09 mg/100g reported for Baobab-ogi at 20% addition of baobab pulp [10]. However, Adeola *et al.* reported lower value (0.02 mg/100g) of zinc for 20% carrot pomace with fermented maize flour [24]. Mineral elements play important roles in health and disease states of humans and domestic animals. Zinc and selenium are significance to people with HIV; while the latter is an antioxidant that increases immune function [25].

Physico-Chemical Properties of the Flour Blends

The pH of the flour blends was within the acidic range (3.37- 3.47) as shown on Table 2. Significant difference existed between the pH and bulk density values of all the samples at $p<0.05$. The bulk density of co-milled samples (0.47 and 0.50 g/ml) is higher than 0.45 and 0.42 g/ml obtained for 20CFNM and 20CFQPM, respectively which are co-fermented samples. The reduction in bulk density of co-fermented blends might have been resulted from the action of microfloral which had broken down and utilize complex starch and simple sugar of both maize and carrot during fermentation. Ikujenlola *et al.* observed the same reduction in bulk density of both malted and unmalted maize after it had been blended with soybeans from 0.77 to 0.66 g/dm3 and from 0.83 to 0.81 g/dm3 [11]. The reduction of bulk density will be an advantage in using the fermented flour for complementary diet [26]. This kind of complementary food will not be heavy so can be taken anytime of the day without adverse effect on the agility of the consumer. The result of reconstitution index showed that no significant difference existed in the reconstitution index of co-fermented flours of both QPM and normal maize varieties and likewise in co-milled flour blends (Table 2). Sample 20CMQPM had the highest reconstitution index of 97.7% closely followed by 20CMNM (96.3%).

Parameter	Samples			
	20CFNM	20CFQPM	20CMNM	20CMQPM
pH	3.47±0.1a	3.40±0bc	3.43±0.1abc	3.37±0.1c
Bulk Density	0.45±0.03cd	0.42±0.01d	0.47±0.01bc	0.50±0.01a
Flour Dispersibility	70.5±0.5a	69.5±0.5b	69.7±0.3b	68.3±0.3c
Reconstitution index	93.0±1b	91.3±1.2b	96.3±1.5a	97.7±0.3a
Particle size				
150 µm	2.12	2.03	2.59	2.86
315 µm	6.38	4.69	5.49	4.69
630 µm	91.5	93.28	91.92	92.45
63 mm	-	-	-	-

Table 2: Pysico-chemical properties and particle size of the flour blends
Values reported as means± standard deviation. Mean values followed by different roman letters in a roll are significantly different ($p \leq 0.05$)
Key: 20CFNM-20% carrot co-fermented with normal maize, 20CFQPM-20% carrot co-fermented with quality protein maize, 20CMNM-20% carrot co-milled with normal maize, 20CMQPM-20% carrot co-milled with quality protein maize.

Effect of Temperature on Swelling Power and Solubility of Flours

Generally, increase in temperature favoured increase in swelling power till 80^{o}C (Figure 1). This is expected as increased in temperature increases thermodynamic mobility thereby enhances penetration of water into the starch granules. However, co-fermented flour blends swell better than co-milled flour blends at 80^{o}C; 6.17, 5.00 and 4.1, 4.02 was obtained for 20CFNM, 20CFQPM and 20CMNM, 20CMQPM flour blends, respectively (Figure 2). This may imply that during fermentation, carrot might have been bound tightly to maize as a result of uniformity better than the co-milled blends so as to allow the granules of co-fermented blends to absorb water better than the co-milled blends. Swelling power is an indication of the water absorption index of the granules during heating and it reflects the extent of the associative forces within the granules [27]. Just like the swelling power of the flour blends, the solubility of 20CFNM and 20CFQPM increased with increase in temperature until 80°C when solubility began to decrease. There was no significant difference in the behavioural pattern of the solubility of co-fermented and co-milled blends with increasing temperature (Figure 2). Both co-fermented and co-milled normal maize flour blends were found to be more soluble at 60°C; 0.75, 0.50 and 0.37, 0.25 for 20CFNM, 20CFQPM and 20CMNM, 20CMQPM flour, respectively (Figure 2). The solubility increased up to 70°C and 80°C where it reached the maximum solubility.

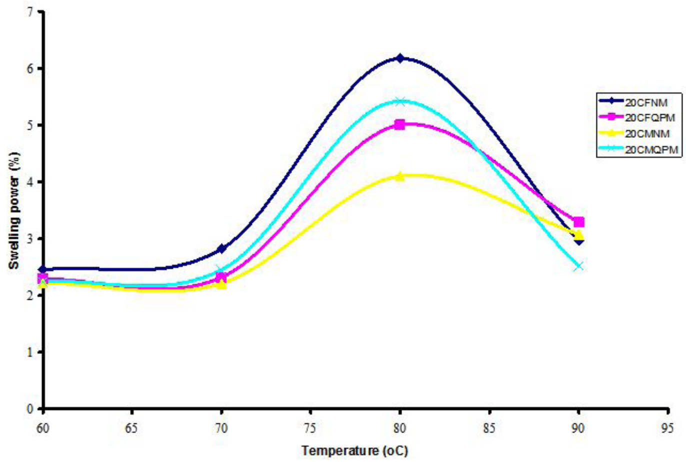

Figure 1: Effect of Temperature on the Swelling Power of Flour Blends
Key: 20CFNM-20% carrot co-fermented with normal maize, 20CFQPM-20% carrot co-fermented with quality protein maize, 20CMNM-20% carrot co-milled with normal maize, 20CMQPM-20% carrot co-milled with quality protein maize.

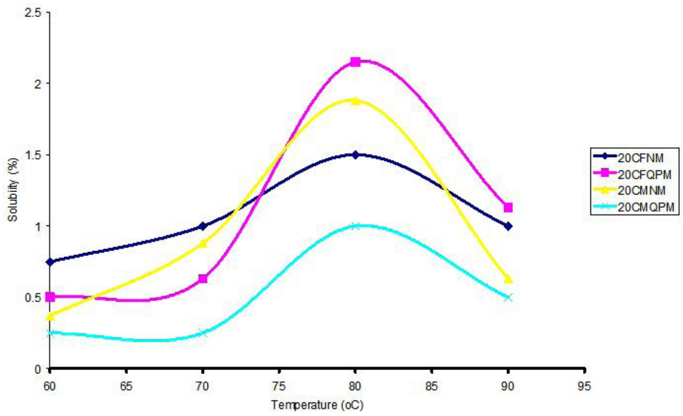

Figure 2: Effect of Temperature on the Solubility of flour blends
Key: 20CFNM-20% carrot co-fermented with normal maize, 20CFQPM-20% carrot co-fermented with quality protein maize, 20CMNM-20% carrot co-milled with normal maize, 20CMQPM-20% carrot co-milled with quality protein maize.

Percentage Means Particle Size of the Flour Blends

The mean particle size of maize flour blends obtained is presented in Table 2. Larger percentage of raw flour blends were recovered on sieve size 630 μm, followed by size 315 μm. Both co-fermented and co-milled flour blends had larger particle size than whole maize fermented flour in the earlier study [23]. Percentage retained for samples 20CFNM and 20CMNM were 2.12 and 2.59%, respectively (Table 2). Likewise in co-fermented QPM flour sample; 2.03 and 2.86% were retained for 20CFQPM and 20CMQPM flour respectively. This implies that the particle sizes of co-fermented flour blends are finer than the co-milled flour blends. The effect of fine particle size in co-fermented samples was evidence in better solubility reported in Figure 1.

Pasting Properties of the Flour Blends

The peak temperature of Co-processed (co-fermented and co-milled) ranged between 93.18 and 93.55°C, while the peak viscosity fall between 189.83 and 235.88 RVU without following a particular trend (Table 3). However, breakdown viscosity and final viscosity results showed that the starch structure of co-processed flour blends of QPM are stronger than that of normal maize flour blends. Breakdown viscosity of 100.41 and 127.30 RVU was obtained for 20CFQPM and 20CMQPM, respectively (Table 3). These results indicate that the ability of 20CFQPM flour to form a viscous paste or gel after boiling and cooling is higher than all the flour blends [28]. Breakdown viscosity (30.92, 45.50 RVU) obtained for 20CFNM and 20CMNM is close to the range of 28.17 and 43.58 RVU reported for one to five days fermented white maize flour by Adegunwa *et al.* [28]. While the range of breakdown viscosity obtained for 20CFQPM and 20CMQPM (127.30 and 100.41 RVU) are close to the range 120.00 to 179.83 RVU reported for fermented maize and Nile tilapia flour diet [9]. Final viscosity ranged between 121.58 and 245.67 RVU for all the blends. This is also in agreement with earlier reports [9,28]. Set back values ranged between 37.91 and 88.83 RVU (Table 3) and are higher than the reports of Fasai *et al.* and Adegunwa *et al.* [9,28]. Setback has been correlated with texture of various products; high setback is also associated with syneresis during freeze thaw cycles for example.

Sample	Parameter						
	Peak 1 (RVU)	Trough 1 (RVU)	Breakdown (RVU)	Final Viscosity (RVU)	Setback	Peak Time (mins) (oC)	Pasting Temp
20CFNM	189.83	158.92	30.92	245.67	86.75	5.44	93.25
20CFQPM	235.88	108.58	127.30	183.42	74.84	5.78	93.55
20CMNM	194.25	148.75	45.50	237.58	88.83	5.55	93.54
20CMQPM	184.08	83.67	100.41	121.58	37.91	5.69	93.18

Table 3: Pasting properties of maize flour blends
Values reported as means ± standard deviation. Mean value followed by different letter is significantly different ($p \leq 0.05$)
Key: 20CFNM-20% carrot co-fermented with normal maize, 20CFQPM-20% carrot co-fermented with quality protein maize, 20CMNM-20% carrot co-milled with normal maize, 20CMQPM-20% carrot co-milled with quality protein maize.

Colour Indices Characteristics of the Flour Blends

The colour indices of flour blends are presented in Table 4. The hue angle (h°) of co-processed blends varied from 83.91 to 85.380° with 20CMQPM with the lowest (83.91o). According to Francis and Clydesdale, the hue angle shifting from 0 to 90° connotes a colour change from red to yellow. Meaning that all the sample were between red and yellow zone and are closer to yellow than to red colour [29]. This is expected as both maize varieties used for the study are yellow varieties. Colour is one of the important quality indicators influencing consumer acceptability of maize *ogi* and corn starch while yellow or creamy colour is most preferred. The colour lightness (L*-value) for the flour blends ranged from 82.29 to 90.18 with 20CFQPM having the highest value and is significantly different ($p < 0.05$) from others. L*-value of 20CMQPM (90.18) is higher than 88.42 obtained for 20CMNM meaning that the colour of co-milled QPM is brighter than co-milled normal maize flour blend. The range of L-values obtained in this study is in agreement with 88.8 and 90.0 reported for maize flours (*tuwo*) from different production methods by Bolade [29]. The implication of these observations is that different maize varieties have high tendency of giving unfermented and fermented flours of varying lightness indices; which may be attributed to inherent genetic attributes of each maize type.

Blends	a*	b*	L	Chroma (C)	h (O)
20CFNM	1.30c	15.50c	88.30b	15.56c	85.23a
20CFQPM	1.66b	18.47a	82.29c	18.54a	84.88b
20CMNM	1.28c	15.15d	88.42b	15.19c	85.19a
20CMQPM	1.88a	17.58b	90.18ab	17.58b	83.91c

Table 4: Colour indices of flour blends
Values reported as means ± standard deviation. Mean values followed by different letter are significantly different ($p \leq 0.05$)
Key: 20CFNM-20% carrot co-fermented with normal maize, 20CFQPM-20% carrot co-fermented with quality protein maize, 20CMNM-20% carrot co-milled with normal maize, 20CMQPM-20% carrot co-milled with quality protein maize.

Sensory Score of the Flour Blends

A comparison of porridges prepared from co-fermented and co-milled flours showed significant differences in all the attributes measured within and between normal maize flour and QPM flours. Reconstituted product from 20CFNM was less preferred than 20CFQPM in terms of colour, taste, aroma and overall acceptability while in term of consistency; 20CFNM was more preferred than 20CFQPM at $p \leq 0.05$. More so, Co-milled flour blends were more preferred than co-fermented flour blends with significant differences ($p \leq 0.05$). Thus, the overall mean acceptability scores of 2.5 obtained for 20% carrot co-milled with QPM (20CMQPM) closely followed by 20% carrot co-fermented with QPM and by fermented QPM (20CFQPM) flour (Table 5) indicates that QPM products demonstrate superiority over normal maize products. Generally, Sample 20CMQPM is most preferred in term of colour, taste aroma, consistency and overall acceptability.

Blends	Colour	Taste	Aroma	Consistency	Overall Acceptability
20CFNM	5.17d	4.83c	4.83c	3.83b	4.25bc
20CFQPM	4.00b	3.58ab	3.67ab	4.50dc	2.83a
20CMNM	5.58c	3.67ab	3.83ab	4.92d	4.83c
20CMQPM	3.17a	2.75a	2.92a	2.83ab	2.50a

Table 5: Colour indices of flour blends
Values reported as means ± standard deviation. Mean values followed by different letter are significantly different ($p \leq 0.05$)
Key: 20CFNM-20% carrot co-fermented with normal maize, 20CFQPM-20% carrot co-fermented with quality protein maize, 20CMNM-20% carrot co-milled with normal maize, 20CMQPM-20% carrot co-milled with quality protein maize.

Conclusion

The study established that flour of fermented complementary food could be produced from blend of quality protein maize and carrot. It is obvious from the study that co-milling of carrot with fermented maize is better than co-fermentation of carrot with quality protein maize as co-milled blend came up with better physico-chemical properties, nutritional contents and sensory attributes. Sensory score showed that sample 20% of carrot co-milled with 80% QPM is the most preferred in terms of colour, taste, aroma, consistency and overall acceptability. This formula can therefore be recommended for industrial production of complementary food. Nigeria is suitable for adequate quantity of QPM and carrot and expansion of its utilization would stimulate its production and improvement on the agro business in the country.

References

1. Michaelsen KF, Weaver L, Branca F, Robertson A (2003) Feeding and Nutrition of infants and young children Guideline for WHO European Region, with emphasis on the former Soviet Countries. WHO Regional publication, series No.8.

2. WHO (1998) Complementary Feeding of Young Children in Developing Countries: A Review of Current Scientific Knowledge. World Health Organization (WHO) Geneva: 80.

3. Saakia VG, Annoek van de W (2005) Small- scale Production of Weaning Foods: Agromisa Foundation, Wageningen, Agrodok-series No.22.

4. TAAS (2008) Quality protein maize for human nutritional security and development of poultry sector in India. Trust for advancement of agricultural sciences the third Dr. M.S. Swaminathan award. Proceeding and highlights of national symposium, NASC complex, Pusa, New, India.

5. Mateljan G (2011) Health Benefits of carrots. WHfood: FREE Weekly Newsletter.

6. Dewey KG, Brown KH (2003) Update in Technical Issues concerning complementary feeding of young children in developing countries and implications for intervention programs. Food Nutr Bull 24: 5-28.

7. Pelto GH, Levitt E, Thairu L (2003) Improving Feeding Practices. Current Patterns, common constraints and Design of Intervention. Food Nutr Bull 24: 45-82.

8. Valdez CA, Carillo JM, Valenzuela OGC, Escobedo RM, Perez LA, et al. (2005) Infant food from quality protein maize and chickpea optimization for preparing and nutritional properties. International Journal of Food Science and Nutrition 56: 273-85.

9. Fasasi OS, Adeyemi IA, Fagbenro OA (2007) Functional and Pasting Characteristics of Fermented Maize and Nile Tilapia (Oreochromis niloticus) Flour Diet. Pakistan Journal of Nutrition 6: 304-9.

10. Adejuyitan JA, Abioye AO, Otunola ET, Oyewole YN (2012) An Evaluation of Some Properties of Baobab Fruit Powder and Ogi Mixes. Transnational Journal of Science and Technology 2: 91-102.

11. Ikujenlola AV, Adetunji FO, Ajala Lola, Ibrahim TA (2008) Effect of storage n physicochemical properties of malted maize and soybean blends. Proceedings of 32nd Annual Conference of NIFST, LAUTECH, Ogbomosho: 343-4.

12. Oladeji BS, Akanbi CT, Ibironke SI (2014) Physico-Chemical and Nutritional Evaluation of Co-Processed Fermented Yellow Maize Ogi (an Infant Diet) and Carrot Blends. Annals. Food Science and Technology 15: 92-102.

13. AOAC (2000) Analysis of the Association of Official Analytical Chemists (AOAC) International, William, H. (ed). 17th Ed., Gaithersburg, MD, USA.: Official Method. 923, 03, 923.05, 962.09, 979.09.

14. Punita G (2006) Physicochemical and sensory studies of Maize product. MSc Thesis Department of Food Service and Nutrition Science India.

15. AOAC (2002) Analysis of the Association of Official Analytical Chemists (AOAC) International, William, H. (ed). 17th Ed., Gaithersburg, and M. D, U.S.A.: Official Method. 982.30, 992.03, 992.04, and 992.26.

16. Okezie BO, Bello AB (1988) Physicochemical and functional properties of winged bean flour and isolate compared with soy isolate. Journal Food Science 53: 450-4.

17. Sathe SK, Salunkhe DK (1981) Isolation, partial characterization and modification of Great Northern Bean (Phaseolus vulgaris L.) starch. Journal of Food Science 46: 617-21.

18. Akpapunam MA, Markakis P (1981) Protein Supplementation of Cowpea with Sesame and water melon seeds. Journal of Food Science 46: 960 -1.

19. Larmond E (1982) Laboratory Methods for Sensory Evaluation. Research Branch, Canada Department of Agriculture. Publication 1636, Ottawa, Canada.

20. Cordova H, Vergara N, Avila G, Alvarado G, Sierra M. (2000) Combining ability and hybrid yield performance of tropical quality protein maize inbred lines. Agronomy Abstracts: 106. Annual meeting of the ASA held at Minneapolis, MN, USA, Nov 5-9.

21. Ajanaku KO, Ogunniran KO, Ajani OO, James OO, Nwinyi OC (2010) Improvement of Nutritive value of Sorghum-Ogi fortified with Pawpaw (Carica Papaya L.). Fruit, Vegetable and Cereal science and Biotechnology 4: 98-101.

22. Oladeji BS (2014) Physico-chemical and Antioxidant Properties of Quality Protein Maize and Carrot Blends. PhD Thesis, Department of Food Science and Technology, Obafemi Awolowo University, Ile-Ife, Nigeria.

23. Adeola AA., Ogunjemilusi MA, Akanbi CT (2012) Effects of Carrot Pomace on the Chemical and Sensory Attributes of Ogi, a Nigerian fermented Food. Nigerian Journal of Nutritional Sciences 33.

24. Wood RJ (2000) Assessment of marginal zinc status in humans. J Nutr130: 1350-4.

25. Ijarotimi OS, Oyewo MT, Oladeji BS (2009) Chemical, functional and sensory properties of roasted bambara groundnut (Vigna subterranean L.Verdc) and cooking banana (Musa spp., ABB genome) weaning diet. African Journal of Food Science 3: 139-46.

26. Ikegwu OJ, Okechukwu PE, Ekumankana EO (2010) Physico-chemical and pasting characteristics of flour and starch from Achi Brachystegia eurycoma seed. Journal of Food 8: 58-66.

27. Adegunwa MO, Alamu EO, Bakare HA, Godwin PO (2011) Effect of fermentation Length and varieties on the qualities of corn starch (Ogi) production. American Journal of Food and Nutrition 1: 166-70.

28. Francis FJ, Clydesdale FM (1975) Food Colorimetry: Theory and Applications. AVI Publisher, Westport, USA: 51-62.

29. Bolade M.K (2010) Evaluation of suitability of commercially available maize grains for 'tuwo' production in Nigeria. African Journal of Food Science 4: 371- 81.