ORIGINAL SCIENTIFIC PAPER

Quality protein maize (Zea mays L.) fortified with vegetable biomaterials based breakfast cereal: functional, pasting and sensory characteristics

Abiodun Victor Ikujenlola*, Foyinsade Omorinola Onireti

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

*Corresponding author: avjenlola@gmail.com

Abstract

The aim of this study was to determine the functional properties and sensory characteristics of flour blends and flaked ready-to-eat breakfast cereals produced from quality protein maize, cowpea and garden egg. The flour blends and flaked breakfast cereal were analysed for functional properties and sensory characteristics respectively using standard methods. The results showed that loose and packed bulk density (0.41-0.38 g/ml; 0.63-0.71 g/ml), reconstitution index (75.67-59.68) reduced with the increase in garden egg proportion, while the swelling (1.29-2.99 g/g), water absorption (132.00-263.33%) and oil absorption (95.67-133.00 g/ml) capacities increased with garden egg and temperature increase. The trough (1.21 to 5.00 RVU) and final viscosity (1.79 to 11.59 RVU) increased with increase levels of garden egg to the blends. The mean scores for taste (6.07-4.07) and aftertaste (6.60-2.87) by the panelists showed a decline with increase in the level of garden egg addition when the flaked breakfast cereal was served alone. The mean scores for texture ranged from 7.67-4.87, 6.73-5.46 and 6.87-5.33 for breakfast cereal served alone, served with water and consumed with milk respectively. The overall acceptability of the ready-to-eat breakfast cereal from cowpea and maize alone ranked best of all the blends and compared favourably with the commercial sample. Meanwhile, sample containing cowpea and maize compared favourably with commercial sample in all the parameters assessed. The study concluded that addition of cowpea and garden egg improved some selected functional properties. Ready-to-eat breakfast cereal of good acceptability to the panelists was produced from the selected biomaterials. This will also promote the utilization of cowpea and garden egg thereby ensuring food security.

Keywords: aftertaste; appearance; bulk density; final viscosity; water absorption capacity

Introduction

The popularity of maize (Zea mays L.) as a crop is largely due to its diverse functionalities as a food source for both humans and animals. Maize can be consumed off the cob, parched, boiled, fried, roasted, ground, malted and fermented for the production of many traditional foods, such as breads, tortillas, porridges, polenta, gruel, cakes, snacks, breakfast foods and alcoholic beverages (Rosentrater and Evers, 2018). Maize kernels can be further processed for use as food thickeners, sweeteners, cooking oil and non-consumables (Duensing et al., 2003).
Corn flakes are one of the most popular ready-to-eat (RTE) breakfast cereals in the world (Fast and Caldwell, 1990; Rosentrater and Evers, 2018). Their production process has remained relatively unchanged over the past several decades. Corn flakes are produced by two methods: traditional and extrusion-cooking (indirect method). In the traditional method, a mixture of de-germed yellow maize grits, water and flavourings, such as syrup, sugar, malt and salt, are pressured-cooked. The cooking is completed when the colour of the grits has changed from chalky-white to light golden brown, the grits have become soft, translucent and no raw starch remains. The cooked grits are then dried at 66 °C, tempered to a firm but slightly plastic state, flaked by passing between rollers and toasted or dried to a final specified moisture content (Rooney and Serna-Saldivar, 1991; Rosentrater and Evers, 2018). Before tempering, the cereal is generally treated to restore vitamins lost through cooking and is often coated with sweet flavourings to make it more attractive (Serna-Saldivar, 2010). Despite the various applications of maize from time immemorial, its utilization has been hampered by the low protein and limiting essential amino acids.
Quality protein maize is one of the varieties of maize. It is biofortified maize which was developed from conventional modification of high protein opaque-2 maize with better lysine and tryptophan contents (Prasanna et al., 2001, Abiose et al., 2015). It has been used in the production of several food products such as weaning food, animal feed, biscuit, bread, etc. (Akuamoa-Boateng, 2002; Giwa and Ikujenlola, 2010; Abiose et al.,2015). Cowpea is a well known legume which is consumed in different forms in Africa where it serves as a good source of protein. It has been utilized in the production of complementary foods, soups, snacks and breakfast meals. The total protein content (20 -25%) of cowpea is approximately two-to four-fold greater than cereal and tuber crops. The chemical and nutritive characteristics of legume foods placed them as natural complements to cereal based diets (Ihekoroye and Ngoddy, 1985).
Garden egg, a vegetable is commonly consumed as sauce, it is also eaten fresh or cooked depending on the preference of the consumers and the culture (Ossamulu et al., 2014). It is reported to be high in protein, vitamins, antinutrients and fibre (Oyeyemi et al., 2015). The production of breakfast meal has received a lot of attentions from many food processors and scientists. However, the use of blend that employed the use of quality protein maize, cowpea and garden egg is not common.
Malting is the limited controlled germination of steeped grains during which starch and other macronutrients are broken down to smaller units with the aid of inherent endogenous enzymes such as amylase, protease and other enzymes that are activated during malting process. Germination involves modification/changes in the nutritional, biochemical, and sensory characteristics of the food (Hotz and Gibson, 2007; Omowaye-Taiwo et al., 2015). The aim of the study was to determine the functional properties and sensory characteristics of flour samples and ready-to-eat breakfast cereal which were produced from the selected biomaterials.

Materials and methods

Collection of materials

Quality protein maize (Zea mays) was purchased from Teaching and Research Farm, Obafemi Awolowo University, Ile Ife, Nigeria. Cowpea (Vigna unguiculata L. Walp) seeds and garden egg (Solanum melongena) fruits were purchased from the Sabo Market, Ile Ife, Nigeria. The Cowpea and Garden egg species were identified and confirmed as authentic species of the biomaterials at the Department of Crop Protection and Production, Obafemi Awolowo University, Ile Ife, Nigeria.

Production of flour samples

The production of various flour samples (malted quality protein maize, cowpea and garden egg flour samples) were carried out as reported by Onireti and Ikujenlola (2020). Each biomaterial was cleaned separately. Cleaned maize grains were steeped for 8 h and germinated for 72 h with watering twice a day. Germination was terminated by drying for 12 h at 60 °C. The sprouts were separated by applying soft abrasion on the grain in between palms after which the de-sprouted grains were milled into flour and packaged.
Cleaned cowpea seeds were soaked in water at room temperature (32±2 °C) for 10 min to soften the testa, which were manually removed and washed off. The cleaned cotyledons were oven dried (cabinet dryer) at 60 °C for 12 h, milled, sieved and packaged (Adediran et al., 2013).
The stalks of the garden egg fruits were removed and washed. The cleaned garden egg fruits were sliced into appropriate goemetry using slicing/dicing machine. The sliced garden eggs were dried at 60 °C in hot air oven for 12 h, milled and packaged in a high density polyethylene bag (Scorsatto et al., 2017).

Sample formulation of flaked breakfast cereal

Samples of breakfast cereal were formulated by mixing malted quality protin maize (QPM) flour with cowpea flour and garden egg flour at varying ratios as presented in Table 1.

Production of flaked breakfast cereal

The ready-to-eat flaked (RTE) breakfast cereal was produced by adopting the method reported by Onireti and Ikujenlola (2020). To 100 grams of each blended flour samples, 0.1 g of sweetener, 1 g of salt, 6 ml of vegetable oil, 4 g of hydro-colloid and 75 ml of water were added and mixed to obtain homogeneous viscous paste. It was cooked under pressure for 30 minutes to gelatinize starch. The dough was allowed to cool/age at room temperature and then divided into fragments. After cooling, the dough was flaked using a manual pasta cutting machine, after which it was toasted in multipurpose oven at 75 0C for 90 minutes. The resulting products were cooled and then packaged into an air tight container (Usman, 2012).

Table 1. Sample formulation of flaked breakfast cereal

Sample code	Sample	QPM	Cowpea	Garden egg
A*	QPM100%	100	0	0
B	Cowpea100%	0	100	0
C	Garden egg100%	0	0	100
D	90:10:0	90	10	0
E	85:10:5	85	10	5
F	75:10:15	75	10	15
G	65:10:25	65	10	25
H	55:10:35	55	10	35

Functional properties determinations

The functional properties of the flour samples and flour blends were determined using standard methods. These include packed and loose bulk density determined using the method reported by Siddique et al. (2010), the reconstitution index was determined according to the method of Akpapunam et al. (1997), while the pH was determined by the method of A. O. A. C. (2016). The water absorption capacity (WAC) was determined by methods of Sosulski (1962) and Rutkowski and Kozlowska (1981). Swelling capacity and oil absorption capacity were determined using the methods reported by Takashi and Sieb (1988) and Beuchat (1977) respectively.
The pasting profile was studied using a Rapid Visco Analyser (RVA) series 4 (New Port Scientific NSW, Australia). The sample 3.0 g was weighed and 25 ml of distilled water was dispensed into a canister. Paddle was placed inside the canister this was placed centrally onto the paddle coupling and then inserted into the RVA machine. The measurement cycle was initiated by pressing the motor tower of the instrument. The 12 minute profile was used. The time- temperature regime used was idle at temperature 50 0C for 1 min., heated from 50 0C to 95 0C in 3 min. 45 s, then held at 95 0C for 2 min 30 s the sample was subsequently cooled to 50 0C over 3 min 45 s period followed by a period of 2 min where the temperature was controlled at 50 0C (Newport Scientific, 1998).

Sensory evaluation of products

Consumers' acceptability of the ready-to-eat flaked breakfast cereal was carried out using the method described by Okafor and Usman (2016). Three sensory experiments were conducted with the same set of panelists who were selected from the University community. The fifteen (15) semi-trained panelists were individuals who are familiar with the product. Their selection was based on their willingness to participate. A 9- point Hedonic scale ranging from 1 - Dislike extremely, 2- Dislike very much, 3- Dislike moderately, 4- Dislike slightly, 5 - Neither like nor dislike, 6- Like slightly, 7- Like moderately, 8- Like very much and 9- like extremely was used and the quality parameters assessed were appearance, taste, after taste, crispness, texture and overall acceptability. The samples were presented separately. Each sample was coded and the score sheet was presented for scoring in well illuminated laboratory. A set of the sample was served alone, another set served with water while the last set was served and consumed with milk. The protocol was carried out according to the approved guidelines for sensory evaluation by Research Committee, Department of Food Science and Technology, Obafemi Awolowo University, Ile-Ife, Nigeria.

Statistical analysis

The data generated from each sample was subjected to statistical analysis using one-way analysis of variance (one-way ANOVA) tests. The difference in the mean was separated using the Duncan's new multiple Range test (p<0.05). Data was analyzed by statistical package for Social Sciences (Version 20; SPSS Inc., Chicago, IL, USA) (IBM SPSS 20) (Arkkelin, 2014).

Results and discussion

Functional properties of the flour and flour blends

A functional property describes how ingredients behave during preparation and cooking, how they affect the finished food product in terms of how it looks, tastes, feels and aceptability.

Packed and loosed bulk density

The packed bulk density of the flour samples (Table 2) ranged between 0.45 and 0.86 g/ml. There were significant differences (p<0.05) in the samples. The sample with 100% Cowpea had the highest bulk density value of 0.86g/ml while 100% garden egg sample had the lowest mean score of 0.45 g/ml. This could be due to the high fibre content present in garden egg which made to be lighter. The addition of cowpea to maize has no sigificantt difference (p<0.05) from the 100% maize sample.
The loose bulk density of the flour samples ranged between 0.30g/ml and 0.52g/ml while the flour blends ranged between 0.39 and 0.41g/ml. There were significant differences (p<0.05) in the flour blend samples. Diets that have low bulk densities enable ease of swallow during consumption and promotes easy digestibility of the food (Osundahunsi and Aworh, 2002). The bulk density is a reflection of the load the flour samples can carry, if allowed to rest directly on one another. The density of processed products dictate the characteristics of its container or package product density which influences the amount and strength of packaging material, texture or mouth feel (Lewis, 1990, Malomo et al., 2012, Tiencheu et al., 2016). Bulk density is a measure of heaviness of solid samples, which is important for determining packaging requirements, material handling and application in the food industry (Falade and Okafor, 2018).

Oil absorption capacity (OAC)

The OAC of flour samples ranged from 108.00 to 203.67 g/ml at ambient temperature, while the OAC of flour blends ranged from 95.67 to 133.00 g/ml. There were significant differences (p<0.05) between the blended samples as the garden egg inclusion was increased. This might be due to the presence of fibre in garden egg. The result agrees with the report of Tiencheu et al. (2016) who worked on OAC of maize based weaning food. The addition of cowpea alone reduced the oil absorption capacity of the sample D.
OAC is an important functional property that enhances the mouth feel while retaining the flavour of food product (Adebowale and Lawal, 2004). Absorption of oil by food products improves mouth feel and flavour retention and this makes it an important property in food formulations. OAC has been attributed to physical entrapment of oil and the binding of fat to the polar chains of protein. It was reported by Omueti et al. (2009) that more hydrophobic proteins show superior binding of lipids; this implies that non-polar amino acids side chains bind the paraffin chains of fat. This implies that sample H (55% maize:10%cowpea:35%garden egg) is likely to retain more flavour and have better mouth feel when compared with the other blends. Plant fibres are known to be good absorbent of oil; they exhibit high affinity for oil and water (Wong et al., 2016).

Reconstitution index

The reconstitution index for the flour samples ranged between 21.00 and 74.67. There were significant differences (p<0.05) between the flour samples. The reconstitution index of the flour blends ranged between 59.68 to 75.67. There were significant differences (p<0.05) between the blended samples. The ability of the samples to absorb water and remain suspended could be responsible for the observed differences among the samples. During reconstitution, starch is gelatinized; the more the starch the better the reconstitution (Ikujenlola, 2016). Sample D (90% QPM: 10% cowpea) reconstituted well to produce gruels of fine consistency during mixing. Inclusion of garden egg reduced the ability of the flour blends to form gruels of fine consistency during mixing.

pH

The pH of the biomaterial flour samples ranged between 5.1 and 6.4 while the flour blends ranged between 6.1 and 6.53. There was slight significant difference (p<0.05) between the samples. Fruit or food products are classified as acidic, neutral or alkaline depending on the pH.

Table 2. Functional properties of the flour and flour blends

Sample code	Packed bulk Density (g/ml)	Loosed Bulk Density (g/ml)	Oil Absorption Capacity (g/g)	Reconstitution Index	pH
A*	0.710.01b	0.440.01b	108.00±1.00d	74.670.57a	6.20±0.10d
B	0.860.02a	0.520.01a	98.67±6.43de	69.001.00b	6.40±0.10abc
C	0.450.01e	0.300.04f	203.67±5.51a	21.001.00e	5.10±0.10e
D	0.710.01b	0.410.02c	95.67±6.06e	75.670.57a	6.53±0.12a
E	0.700.01bc	0.410.01c	106.67±8.14de	64.001.00c	6.43±0.12ab
F	0.60.01c	0.400.01c	119.67±1.15c	63.001.00c	6.27±0.15bcd
G	0.650.02d	0.30.01de	126.67±7.23bc	60.670.57d	6.20±0.10cd
H	0.630.01d	0.380.01e	133.00±4.36b	59.68±0.58 d	6.10±0.10d

The mean values on same column with different superscripts are significantly different (p < 0.05). Where: A*= 100% Quality protein maize; B=100% Cowpea; C = 100% Garden egg; D=90% Quality protein maize, 10% Cowpea;E= 85% Quality protein maize, 10% Cowpea, 5% Garden egg; F= 75% Quality protein maize, 10% Cowpea, 15% Garden egg; G= 65% Quality protein maize, 10% Cowpea, 25% Garden egg; H= 55% Quality protein maize, 10% Cowpea, 35% Garden egg.

Table 3. Water absorption capacity of the flour and flour blends at different temperatures (%)

Sample code	30 °C	60 °C	70 °C	80 °C	90 °C
A*	121.332.31d	139.332.08e	140.332.52e	145.006.56d	156.338.08e
B	127.673.51d	141.675.51e	143.333.79e	149.670.76d	161.674.04e
C	360.331.60a	367.674.73a	442.001.53a	445.6718.77a	455.6717.50a
D	132.005.10d	136.008.19e	139.679.24e	153.6713.87d	161.0012.49e
E	147.334.51c	151.004.36e	154.001.00e	174.6711.02cd	175.008.66e
F	171.672.02e	203.332.50d	209.6715.95d	211.670.74c	235.678.03d
G	240.336.43b	248.332.66c	252.6717.21c	284.0010.93b	271.0016.46c
H	263.339.86b	300.338.05b	318.673.79b	319.0012.68b	315.3315.5 b

The mean values on same column with different superscripts are significantly different ($p < 0.05$). Where: A*= 100% Quality protein maize; B=100% Cowpea; C = 100% Garden egg; D=90% Quality protein maize, 10% Cowpea;E= 85% Quality protein maize, 10% Cowpea, 5% Garden egg; F= 75% Quality protein maize, 10% Cowpea, 15% Garden egg; G= 65% Quality protein maize, 10% Cowpea, 25% Garden egg; H= 55% Quality protein maize, 10% Cowpea, 35% Garden egg.

Human life requires a controlled pH level of about 7.4 (a slightly alkaline range of 7.35 to 7.45). It was observed that the samples were between the range of being slightly acid and neutral, which could be termed safe for consumption. One of the reasons for measuring pH in food is to avoid producing foods that can cause health problems to consumers.

Water absorption capacity (WAC) of the flour samples and flour blends

Water absorption capacity (WAC) gives information on the amount of water available for gelatinization (Ghavidel and Mehdi, 2011). The water absorption capacity (Table 3) at ambient temperature (30 0C) for the flour samples ranged between 121.33 and 360.33%. At raised temperature from 60 0C, it ranged from 139.33 to 367.67 %; while at 90 0C, the WAC ranged from 156.33 to 455.67%. Meanwhile, the WAC of flour blends ranged between 132.00 and 263.33% at 30 0C, while at 60 0C it ranged from 136.00 to 300.33% and at 90 0C WAC ranged from 161.00 to 315.33%. It was observed that the water absorption capacity of both the flour and the flour blends increased with increase in temperature. At raised temperatures water is absorbed much easily, due to the softening of the biomaterials. Also the addition of garden egg improved the absorption capacity; this may be due to increase in fibre that is prominent in garden egg. The observation of this study is not in agreement with the report of Babarinde et al. (2019) who reported a decrease in the water absorption of sweet potato base breakfast meal. The addition of cowpea to maize reduced the water absorption capacity over the temperature range under consideration.
This observation is in agreement with the submission of Nassar et al. (2008), who reported orange peel and pulp containing dietary fibre incorporated in biscuit formulation showed an increase in water absorption. The flour with high water absorption capacity may have more hydrophilic constituent such as polysaccharides. Food products with low water absorption capacity may have reduced microbial activities; hence the shelf-life of such product could be extended. Gruels of low water absorption capacity will require more solid to increase the consistency to eating viscosity; this will invariably increase the level of total solids (Afam-Anene and Ahiarakwem, 2014).

Swelling capacity

The swelling capacity (Table 4) of flours ranged from 1.22-7.49 g/g at 60 0C; at 70 0C it ranged from 1.35-7.55 g/g; while at 80 0C it ranged from 1.63-8.08 g/g and at 90 0C it ranged between 2.21-8.47 g/g. Swelling capacity of the flour blends increased significantly ($p<0.05$) with increase in garden egg flour as well as increase in temperature. This parameter determines the amount of water absorbed and retained under specific condition. The residual moisture content of the biomaterials could affect the swelling capacity of the samples.
Pasting properties of the formulated diets
Figure 1 (a-h) shows the pasting characteristics of the flour samples and flour blends. The functionality of pasting is dependent upon factors such as granule size, amylose/amylopectin ratio and starch property (Simi and Abraham, 2008). The pasting properties of a food refer to the changes that occur in the food as a result of application of heat in the presence of water. These changes affect texture, digestibility, and end use of the food product.

Peak viscosity is the ability of starch to swell freely before their physical breakdown (Sanni et al., 2004). The values of peak viscosity (Figs. 1 a-h) of the flour samples from this study ranged between 3.88 to 204.79 RVU while the flour blends ranged from 3.50 to 10.63 RVU. High peak viscosity is described as reflecting fragility of the swollen granules, which first swell and then break down due to mechanical shear. The high peak viscosity of sample C containing 100% garden eggs agrees with the report of Brennan and Samyue (2004), who reported high peak viscosity in potatoes fibre in the evaluation of starch degradation and textural characteristics of dietary fibre enriched biscuits. Inclusion of garden egg increased the peak viscosity of the flour blend samples. This may be due to high water holding capacity of the fibre and a tendency to form a networked gel structure. Peak viscosity can also be referred to as the maximum viscosity developed during or soon after the heating, and it is often correlated with the final product quality and also provides an indication of the viscous loads likely to be encountered during mixing (Olumurewa et al., 2019).
Trough viscosity or hold period refers to the ability of paste to withstand breakdown during cooling. It is the minimum viscosity value in the constant temperature phase of rapid visco-analysis profile. The values of trough viscosity (Figs. 1 a-h) of the flour samples ranged between 1.63 and 181.96 RVU while the flour blends ranged from 1.21 to 5.00 RVU. Breakdown viscosity is described as a parameter which measures the resistance to heat, shear of dough (Falade and Kolawole, 2012) and stability of starch gel during cooking. According to Ocheme et al., (2018), high breakdown viscosity could reduce the ability of flour to withstand heating and shear stress during cooking.
It is also an index of the stability of starch (Akanbi et al., 2009). The values of breakdown viscosity of the biomaterials ranged between 2.25 and 22.83 RVU while the flour blends ranged between 2.29 and 8.58 RVU. The higher the breakdown viscosity, the lower the ability of samples to withstand heating and shearing stress during cooking (Adebowale et al., 2005). Since breakdown viscosity is an estimation of paste resistance to disintegration in response to heat and shear, lower breakdown viscosity showed greater resistance which would be expected of flours with lower peak viscosities. This implied that sample C is more stable to heat and

mechanical shear than the other samples.

Final viscosity indicates the ability of the material to form a viscous paste to gel after cooking and cooling as well as the resistance of the paste to shear force during stirring (Adebowale et al., 2005). The values for the final viscosity (Figs. 1 a-h) of the flour samples varied between 2.21 to 389.46 RVU while the flour blends ranged between 1.79 to 11.59 RVU. Among the flours and flour blends, sample C had the highest final viscosity of 389.46 RVU while sample A had the least final viscosity of 2.21 RVU. Shimelis et al. (2006) earlier observed that final viscosity is a factor used in the determination of the ability of starch to form various gel or paste after cooling and that less stability of starch paste is commonly accompanied with high value of breakdown. It was observed that as more garden egg was added the final viscosity increased.

The setback values (Figs. 1 a-h) for the flour samples ranged from 0.58 to 207.50 RVU while the flour blends ranged from 0.58 to 6.59 RVU. According to Shittu et al. (2001), set back has a serious implication on digestibility of starch pastes when consumed. The setback correlates with retro-gradation of starch molecules. Higher setback values may result in reduced paste digestibility. This implies that addition of garden egg to the flour may reduce the paste digestibility.

The peak time (Figs. 1 a-h) is a measure of cooking time of the meal (Adebowale et al., 2005). It ranged between 3.50 and 7.00 minutes for the flour samples, and 3.50 to 4.67 minutes for the flour blends. Pasting temperature is an indication of the gelatinization temperature during processing. It is the temperature at which the first detectable increase in viscosity is measured and it is an index characterized by the initial change due to the swelling in starch (Liang and King, 2003).

Physical characteristics of the ready-to-eat flaked breakfast cereal

The pictorial view of the ready-to-eat breakfast cereal produced from blends of malted quality protein maize, cowpea and garden egg is presented in Figures 2(a-f). It was observed from the figures that the addition of more garden egg to the other biomaterials produced more darker products and the texture also became coarser. The addition of 10% cowpea to maize produced flakes of brighter colour than those ones with garden egg (Fig. 2b). The appearance of products have influence on the consumer's choice of such products. Consumers are interested in products that appear good. Since these are new products more nutritional education and sensitisation will be required to encourage and convince consumers about the products.

Sensory evaluation of the flaked breakfast cereal

The scores for sensory parameters (Appearance, Taste, Aftertaste, Crispiness Texture, and Overall acceptability) assessment of flaked breakfast cereals are shown in Tables 5, 6 and 7 for breakfast cereal served alone; breakfast cereal consumed with water and breakfast cereal served with milk respectively.

Appearance

Consumers' acceptability of food can be influenced by the appearance quality of the meal; this all important sensory attribute was rated best in the control (Tables 5-7). It was scored 7.73, 8.00 and 7.33 for breakfast cereal served alone, served with water and served with milk respectively. In each of the presentations, the scores/values for appearance declined as more garden egg flour was added. It appears that the panelists scored the quality attribute higher for samples consumed with milk. Addition of garden egg made the product darker, this might have resulted in reduced preference for the samples.

Taste

Sample H containing 55% QPM, 10% cowpea and 35% garden egg had scores of 4.07, 3.33, and 4.20 for breakfast cereal consumed alone, served with water and consumed with milk respectively (Tables 5-7). The consumers' preferences in terms of taste declined as more garden egg flour was added. Adding up to 5% was acceptable. Garden egg has somewhat bitter taste which most consumers detest (Chinedu et al., 2011). However, the nutrient responsible for the bitterness has some functional advantage to wellbeing of consumers. According to Food Insight (2011), taste is the main attribute consumers take into account when purchasing a product. The control sample (I) was most preferred by the panelists. Samples A and D were not significantly different ($p>0.05$) in terms taste. With good nutrition education and advocacy this type of products can find acceptance among the target consumers. Serving with milk may reduce or mask the bitter taste.

Aftertaste

The scores for sample H (Tables 5-7) containing 55% QPM, 10% cowpea and 35% garden egg were 2.87, 2.87, 3.27 for breakfast cereal served alone, consumed with water and served with milk respectively. Addition of garden egg up to 5% was acceptable. Aftertaste refers to the bitterness or sweetness that lingers in the mouth after consumption of a product. The panelists' scores for this parameter follow similar trend with taste. The bitterness is responsible for the after taste feeling which is one of the attributes of alkaloids. The more the garden egg the more

Table 4. Swelling capacity of the flour and flour blends at different temperatures (g/g)

Sample code	60 °C	70 °C	80 °C	90 °C
A*	1.22g	1.350.03f	1.630.02e	2.210.13e
B	1.390.09f	1.400.02f	1.460.46e	1.800.34b
C	7.490.01a	7.550.01a	8.080.33a	8.470.17a
D	1.290.11fg	1.430.02f	1.500.07e	2.190.05e
E	1.580.01e	1.610.06e	1.710.02e	2.270.06e
F	2.130.03d	2.270.03d	2.470.04d	3.000.20d
G	2.600.06c	3.100.08c	3.140.03c	3.530.11c
H	2.990.05b	3.680.02b	3.890.03b	4.340.27b

The mean values on same column with different superscripts are significantly different ($p < 0.05$). Where: A*= 100% Quality protein maize; B=100% Cowpea; C = 100% Garden egg; D=90% Quality protein maize, 10% Cowpea;E= 85% Quality protein maize, 10% Cowpea, 5% Garden egg; F= 75% Quality protein maize, 10% Cowpea, 15% Garden egg; G= 65% Quality protein maize, 10% Cowpea, 25% Garden egg; H= 55% Quality protein maize, 10% Cowpea, 35% Garden egg.

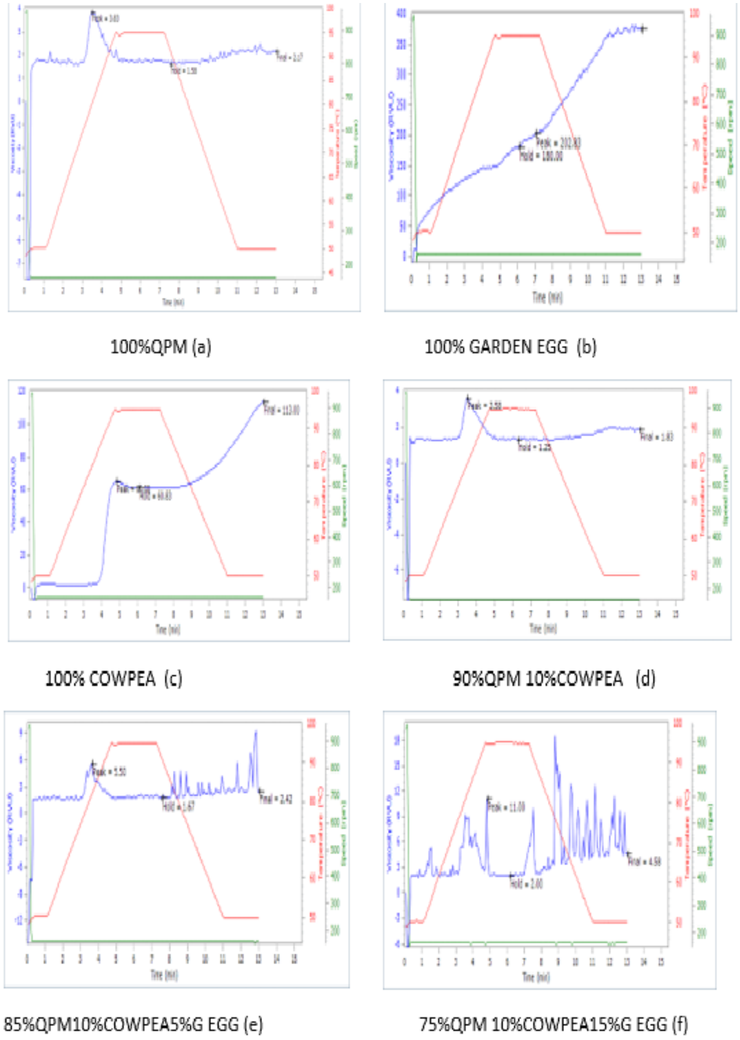

Figure 1 (a-h). Pasting characteristics graphs of the various flour samples and blends

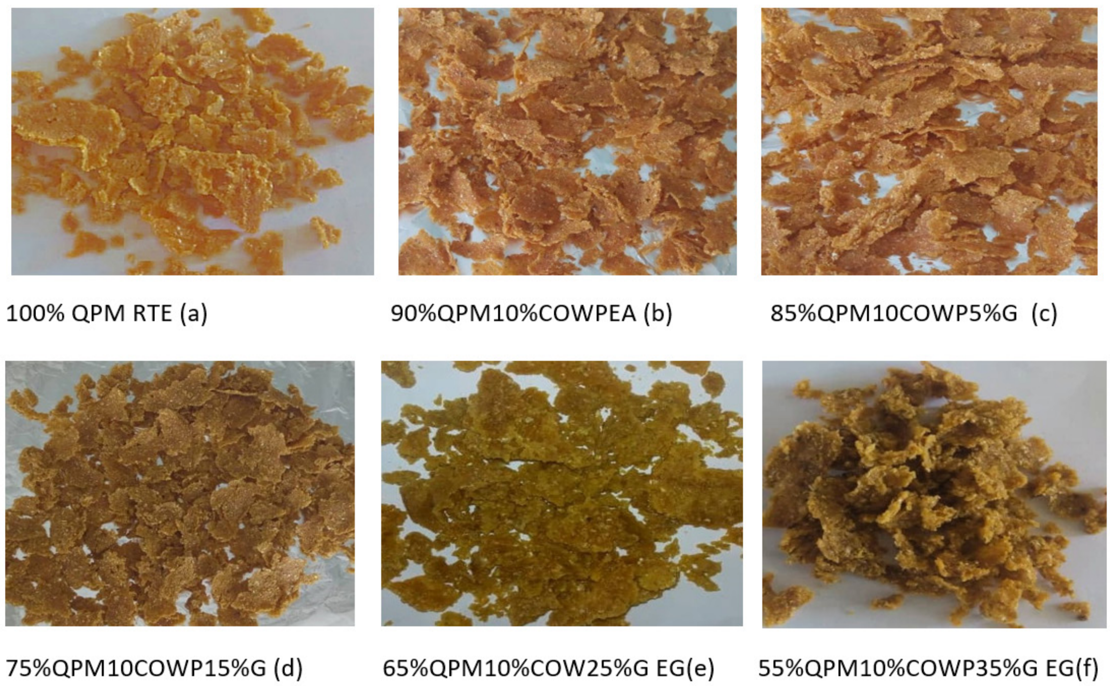

Figure 2(a-f). Pictures of the various RTE breakfast cereal pronounced the aftertaste experienced. Serving with milk or serving hot may reduce the potency of the feeling (aftertaste). Generally, most people prefer sweet food. In order to increase the acceptability of garden egg containing breakfast cereal, more energy have to be exerted in the area of nutrition education. Meanwhile, Samples A and D were not significantly different (p>0.05) in terms aftertaste.

Crispiness and texture

The crispiness scores (Tables 5-7) ranged between 6.80-4.80, 6.80-5.33 and 6.93-5.40 for breakfast cereal samples consumed alone, served with water and consumed with milk respectively. Crispiness has been related to the behaviour of product when subjected to shear stress. It is how friable or crunchy a food product behaves. The crispiness of a product determines acceptability of the product because consumers do not like soggy products (Hough et al., 2001). The scores for texture ranged from 7.67-4.87, 6.73-5.46 and 6.87-5.33 for breakfast cereal served alone, served with water and consumed with milk respectively. The texture of the flaked products refers to consumers' appraisal of the outlook of the product when served alone, with water or in milk. It was generally observed that both crispness and texture follow similar trends. As more portion of garden egg was added the scores reduced. This may be due to the presence of high fibre in the products containing garden egg which made it looks coarse. Santos et al. (2017) reported that fibre increases

Table 5. Sensory evaluation of flaked breakfast cereal served alone

Sample code	Sample ratio	Appearance	Taste	Aftertaste	Crispiness	Texture	Overall acceptability
A*	100.00	7.000.76ab	6.070.28bc	6.600.24b	6.800.01b	7.670.90ab	6.400.06bc
D	90:10:0	6.600.24b	6.730.80b	6.470.19b	6.530.52b	6.930.59bc	6.800.77b
E	85:10:5	6.270.70b	5.930.88bc	4.730.28cd	6.130.50bc	6.530.74c	6.130.36bc
F	75:10:15	5.270.67c	5.470.47cd	4.530.55cd	5.730.22cd	6.470.74c	6.070.22bc
G	65:10:25	5.000.51c	4.730.58de	4.200.67d	5.200.10de	5.400.30d	5.470.60cd
H	55:10:35	4.330.20c	4.070.94e	2.870.46e	4.800.86e	4.870.96d	4.600.06d
Control(I)	Commercial sample	7.730.46a	7.800.26a	7.67.40a	7.670.82a	8.200.68a	8.070.80a

The mean values on same column with different superscripts are significantly different (p < 0.05). Where: A*= 100% Quality protein maize; D=90% Quality protein maize, 10% Cowpea; E= 85% Quality protein maize, 10% Cowpea, 5% Garden egg; F= 75% Quality protein maize, 10% Cowpea, 15% Garden egg; G = 65% Quality protein maize, 10% Cowpea, 25% Garden egg; H= 55% Quality protein maize, 10% Cowpea, 35% Garden egg; Control (I)= Infinity Cornflakes.

Table 6. Sensory evaluation of flaked breakfast cereal of samples served with water (ambient temperature)

Sample code	Sample ratio	Appearance	Taste	Aftertaste	Crispiness	Texture	Over acceptability
A*	100:0:0	7.270.46ab	6.600.06b	6.200.68b	6.800.86ab	6.730.70a	6.670.70b
D	90:10:0	6.730.80bc	6.400.83bc	6.200.15b	6.670.49ab	6.600.51a	6.730.80b
E	85:10:5	6.270.16cd	6.130.13bc	5.600.60bc	6.670.18ab	6.530.92a	6.270.03bc
F	75:10:15	5.800.42cd	5.470.30cd	4.730.49cd	6.330.62b	6.330.72a	5.670.30cd
G	65:10:25	5.200.78de	4.530.81d	4.130.73d	5.400.64c	5.530.36b	4.870.73de
H	55:10:35	4.470.33e	3.330.10e	2.870.55e	5.330.88c	5.460.55b	4.670.06e
Control(I)	Commercial sample	8.000.65a	7.930.88a	8.000.93a	7.530.25a	7.001.00a	8.000.72a

The mean values on same column with different superscripts are significantly different (p < 0.05). Where: A*= 100% Quality protein maize; D=90% Quality protein maize, 10% Cowpea; E= 85% Quality protein maize, 10% Cowpea, 5% Garden egg; F= 75% Quality protein maize, 10% Cowpea, 15% Garden egg; G = 65% Quality protein maize, 10% Cowpea, 25% Garden egg; H= 55% Quality protein maize, 10% Cowpea, 35% Garden egg; Control (I)= Infinity Cornflakes.

Table 7. Sensory evaluation of flaked breakfast cereal of samples served with milk

Sample code	Sample ratio	Appearance	Taste	Aftertaste	Crispiness	Texture	Over acceptability
A*	100:0:0	6.930.88b	6.600.83b	6.000.20b	6.930.59b	6.870.52b	6.600.12b
D	90:10:0	6.470.41bc	6.470.06b	5.600.68b	6.730.88bc	6.670.05b	6.930.96b
E	85:10:5	6.330.29bc	6.070.22bc	6.000.56b	6.330.35bcd	6.470.52bc	6.600.06b
F	75:10:15	6.070.53bc	5.670.29bc	5.130.25bc	6.270.10bcd	6.400.24bc	6.130.24bc
G	65:10:25	5.730.62cd	5.130.55cd	4.130.81cd	5.800.66d	5.800.47cd	5.330.68cd
H	55:10:35	4.870.96d	4.200.11d	3.270.98d	5.400.55d	5.330.29d	4.530.23d
Control (I)	Commercial sample	7.330.59a	8.330.62a	8.200.68a	7.930.88a	7.530.74a	8.200.68a

The mean values on same column with different superscripts are significantly different (p < 0.05). Where: A*= 100% Quality protein maize; D=90% Quality protein maize, 10% Cowpea; E= 85% Quality protein maize, 10% Cowpea, 5% Garden egg; F= 75% Quality protein maize, 10% Cowpea, 15% Garden egg; G = 65% Quality protein maize, 10% Cowpea, 25% Garden egg; H= 55% Quality protein maize, 10% Cowpea, 35% Garden egg; Control (I) = Infinity Cornflakes.

hardness in extruded breakfast cereals produced from corn with whole peach palm fruit blends.

Overall acceptability

All products presented to the panelists were generally acceptable (Tables 5-7) at varying degrees (6.40-4.60, 6.67-4.67 and 6.60-4.53 for samples consumed alone, served with water and consumed with milk respectively), notably the addition of garden egg affected the preferences for taste, after taste and texture of the samples. Serving with milk improved the consumers' acceptance of the products because some of the bitterness attribute of the products is masked. Garden egg added up to 5% was generally acceptable to the panelists. Meanwhile, the commercial sample was the best followed by the samples A and D. In all the sensory parameters there was no significant difference between the samples A and D. The observations in this study agrees with the report of Babarinde et al., (2019) that addition of African yam bean to sweet potato base breakfast meal reduced the preference of consumers for the fortified meal.

Conclusions

The study concluded that addition of garden egg and cowpea to malted quality protein maize improved some selected functional properties. The oil absorption, water absorption and swelling capacities of the flour blends increased with addition of Garden egg. Also, the peak, final, and breakdown viscosities increased with addition of both cowpea and garden egg flour. These implied that the composite flour samples could find applications in food systems which requires high viscosity. Ready-to-eat breakfast cereal of acceptable and good sensorial quality was produced from the selected biomaterials. However, higher level of garden egg produced coarser and darker products. From the sensorial judgment of the samples the best blend was sample D containing Quality protein maize and cowpea.

Author Contributions

Ikujenlola conceived and designed the study. Supervised the experiment, analysed the data, wrote the first and final drafts of the article and presented for publication. Onireti carried out the experiment and analysed the data.

Funding

This research received no external funding.

Acknowledgments

Authors expressed their appreciations to the Department of Food Science and Technology, Obafemi Awolowo University, Ile-Ife, Nigeria for support during the study.

Conflicts of Interest

The authors declare no conflict of interest

References

Abiose S. H., Ikujenlola A.V., Abioderin F. I. (2015) Nutritional quality assessment of complementary foods produced from fermented and malted quality protein maize fortified with soybean flour. Polish Journal of Food and Nutritional Science 65 (1) 49-56.

AACC (2000) Approved Methods of American Association of Cereal Chemists. American Association of Cereal Chemist, Inc; St. Paul, Minnesota, USA.

Adebowale A. A., Sanni L. O., Awonorin S. O. (2005) Effect of texture modifiers on the physicochemical and sensory properties of dried fufu. Food Sciences and Technology International, 11(5) 373-382.

Adebowale K. O., Lawal O. S. (2004) Comparative study of the functional properties of bambara groundnut (Voandzeia subterranean), jack bean (Canavalia ensiformis) and mucuna bean (Mucuna pruriens) flours. International Food Research Journal, 37 355-365.

Adediran A. M., Karim O. R., Oyeyinka S. A., Oyeyinka A. T., Awonorin S. O. (2013) Physico-chemical properties and akara making potentials of preprocessed jack beans (Canavalia ensiformis) and cowpea (Vigna unguiculata L. Walp) composite flour. Croatian Journal of Food Technology, Biotechnology and Nutrition, 8 (3-4) 102-110.

Afam-Anene O. C., Ahiarakwem J. H. (2014) Nutritional quality, functional and sensory evaluation of complementary food made from cereals, legumes, oilseed and vegetable. Proceedings, 43rd.annual general meeting and scientific conference 3rd -7th.

Akanbi C. T., Nazamid S., Adebowale, A. A. (2009) Functional and pasting properties of a tropical breadfruit (Artcarpus altilis) starch from Ile-Ife, Osun State Nigeria. National Food Research Journal, 16 151-157.

Akpapunam M. A., Badifu G. I. O., Etokudo, E. P. (1997) Production and quality characteristics of Nigerian "Agidi" supplemented with soy flour. Journal of Food Science and Technology, 34(2) 143-145.

Akuamoa-Boateng A. (2002) Quality Protein Maize: Infant feeding trial in Ghana, Ghana Health Health Service Ashanti, Ghana, 1-45.

Arkkelin D. (2014) Using SPSS to Understand Research and Data Analysis. Psychology Curricular Materials. Book 1. http://scholar.valpo.edu/psych_oer/1.

Babarinde G. O., Adeyanju J. A., Omogunsoye A.M. (2019) Protein enriched breakfast meal from sweet potato and African yam bean mixes. Bangladesh Journal of Science and Industrial Research, 54(2) 125-130.

Beuchat L.R. (1977) Functional and electrophoretic characteristics of succinylated peanut flour protein. Journal of Agricultural Food Chemistry, 58 (2) 50-51.

Brennan C. S, Samyue E. (2004) Evaluation of starch degradation and textural characteristics of dietary fibre enriched biscuits. International Journal of Food Properties, 7(3) 647-657.

Chinedu S. N., Olasumbo A. C., Eboji O. K., Emiloju O. C., Arinola O. K, Dania, D. I. (2011) Proximate and phytochemical analyses of Solanum aethiopicum L. and Solanum macrocarpon L. Fruits. Resources Journal of Chemical Science, 1(3) 63-71.

Duensing W.J., Roskens A.B., Alexander R. J. (2003) Corn dry milling: processes, products and application. In: White, P.J., Johnson, L.J. (Eds.), Corn Chemistry and Technology, second ed. American Association of Cereals Chemists Inc., St. Paul, MN, USA.

Falade K. O., Kolawole T. A. (2012) Physical, functional and pasting properties of different maize (Zea mays) cultivars as modified by an increase in γ-irradiation. International Journal of Food Science and Technology, 1-7.

Falade K. O. Okafor C. A. (2015) Physical, functional, and pasting properties of flours from corms of two Cocoyam (Colocasia esculenta and Xanthosoma sagittifolium) cultivars,Journal of Food Science and Technology, 52(6) 3440–3448.

Fast R. B., Caldwell E. F. (Eds.), (1990) Breakfast Cereals and How They Are Made. Amer. Assoc. of Cereal Chemists Inc., St. Paul, MN, USA.
Food Insight (2011) Price approaches taste as top influencer for Americans when purchasing foods beverages yet, in a down economy, health is still important to two-thirds of American. http://www.foodinsight.org /Press Release/ Detail. aspx? topic =Price_Approaches_Taste_as_Top_Influencer_ for_Americans_When _Purchasing _ Foods_Beverages.Acesso em. Accessed 9th May, 2020.
Ghavidel R. A., Mehdi G. D. (2011) Processing and assessment of quality characteristics of composite baby foods. World Academy of Science Engineering and Technology, 59 2041-2043.
Giwa E. O., Ikujenlola A.V. (2010) Application of Quality Protein Maize in the formulation of Broiler's finisher feed. Journal of Science, Food and Hospitality, 1(1) 47-50.
Hough G., Buera M. D, Chirife J., Moro. O. (2001) Sensory texture of commercial biscuits as a function of water activity. Journal of Texture Studies, 32(1) 57-74.
Hotz C., Gibson R.S. (2007) Traditional food processing and preparation practices to enhance the bioavailability of micronutrients in plants-based diets. Journal of Nutrition, 137 1097–1100.
Ihekoronye A.I., Ngoddy P.O. (1985) Integrated Food Science and Technology. Macmillan Publishers, New York. pp. 296-301.
Ikujenlola A.V. (2016) Quality and in vivo assessment of precooked weaning food from quality protein maize, soy bean and cashew nut flour blends. Croatian Journal of Food Technology, Biotechnology and Nutrition 11 (1-2) 49-57.
Lewis M.J. (1990) Physical Properties of Food and Food Processing Systems. Hartnolls Limited, Bodman Cornwall, Great Britain.
Liang X., King J. M. (2003) Pasting and crystalline property differences of commercial and isolated rice starch with added amino acids. Journal of Food Science, 68(3) 462 – 510.
Malomo O., Ogunmoyela O. A. B., Adekoyeni O. O., Jimoh O., Oluwajoba S. O., Sobanwa M. O. (2012) Rheological and functional properties of soy- poundo yam flour. International Journal of Food Science and Nutrition, 2(6) 101-107.
Nassar A. G., AbdEl-Hamied A. A., El-Naggar E. A. (2008) Effect of citrus by-products flour incorporation on chemical, rheological and organoleptic characteristics of biscuits. World Journal of Agricultural Science 4 (5) 612–616.
Newport Scientific (1998) Applications manual for the rapid visco-analyzer using thermocline for Windows. Australia: Newport Scientific Pvt Ltd., Warri wood, pp. 2-26.
Ocheme B. O., Adedeji O. E., Chinma C. E., Yakubu C. M., Ajibo U. H. (2018) Proximate composition, functional, and pasting properties of wheat and groundnut protein concentrate flour blends, Food Science and Nutrition, 6(5) 1173-1178.
Okafor G. I., Usman G. O. (2016) Organoleptic properties and perception of maize, African yam bean, and defatted coconut flour-based breakfast cereals served in conventional forms. Food Science and Nutrition, 4(5) 716-722.
Olumurewa J.A.V., Ibidapo P.O., Adebileje J.F. (2019) Evaluation of functional and pasting properties of instant pounded yam/plantain flour. Advances in Obesity, Weight Management & Control's, 9(1) 1–6.
Omowaye-Taiwo O.A., Fagbemi T.N., Ogunbusola E.M., Badejo A.A. (2015) Effect of germination and fermentation on the proximate composition and functional properties of full-fat and defatted Cucumeropsis mannii seed flours. Journal of Food Science and Technology, 52 5257-5263.
Omueti O., Otegbayo B., Jaiyeola O., Afolabi O. (2009) Functional properties of complementary diets developed from soybean (Glycine max), groundnut (Arahis hypo gea) and crayfish (Macrobrachim spp). Electronic Journal of Environmental Agricultural and Food Chemistry, 563-573.
Onireti F.M., Ikujenlola A. V. (2020) Nutrients, antinutrients and amino acids profile of malted quality protein maize (Zea Mays L.) based ready-to-eat breakfast cereal fortified with vegetable biomaterials. Croatian Journal Food Science and Technology, 12(2) DOI: 10.17508/CJFST.2020.12.2.11.
Osundahunsi O. F., Aworh, O. C. (2002) A preliminary study on the use of Temp-based formula as a weaning diet in Nigeria. Plant Foods for Human Nutrition, 57 365-376.
Ossamulu I. F., Akanya H. O., Jigam A. A., Egwim Evans C., Henry Y. (2014) Hypolipidemic properties of four varieties of egg-plants (Solanum melongena.L.). International Journal of Pharmaceutical Science Invention, 3 47-54.
Oyeyemi S. D., Ayeni M. J., Adebiyi A. O., Ademiluyi B. O., Tedela P. O., Osuji I. B. (2015) Nutritional quality and photochemical studies of Solanum anguivi(Lam.) fruits. Journal of Natural Sciences Research, 5.
Prasanna B. M., Vasal S. K., Kassahun B., Singh N. N. (2001) Quality Protein Maize. Current Science 81 1308-1319.
Rooney L.W., Serna-Saldivar S. O. (1991) Sorghum. In: Lorenz, K.J., Kulp, K. (Eds.), Handbook of Cereal Science and Technology. Marcel Dekker Inc., New York, United States.
Rosentrater K. A., Evers A. D. (2018) Kent's Technology of Cereals: An Introduction for Students of Food Science and Agriculture. Woodhead Publishing Series in Food Science, Technology and Nutrition. UK.
Rutkowski A., Kozlowska H. (1981) Preparaty zywnosciowe bialka roslinnego. (Food preparations from plant proteins), Wydamnictwo Naukowo-Techniczne (WNT), Warszawa, Poland, 318-334.
Sanni L. O., Kosoko S. B., Adebowale A. A., Adeoye R. J. (2004) The influence of palm oil and chemical modification on the pasting and sensory properties of fufu flour. International Journal of Food Properties, 7 229-237.
Santos I. V., Steel J. C., Aguiar L. P. J., Marcio Schmiele J. C., de Sales F., das Chagas F., do Amaral S. (2017) African Journal of Food Science, 11(9) 310-317.
Scorsatto M., Pimentel A.C., da Silva A. J. R., Sabally K., Rosa G., de Oliveira M. M. (2017) Assessment of bioactive compounds, physicochemical composition, and In vitro antioxidant activity of eggplant flour. International Journal of Cardiovascular Sciences, 30(3) 235-242.
Serna-Saldivar S. O. (2010) Cereal Grains, Properties, Processing and Nutritional Attributes. CRC Press, Boca Raton, FL, USA.
Shimelis E., Meaza M., Rakshit S. (2006) Physico chemical properties, pasting behaviour and functional characteristics of flour and starches from improved bean (Phaseolus vulgaris L.) varieties grown in East Africa. Journal of Agricultural Engineering International, 8 1-18.
Shittu T. A., Lasekan O. O., Sanni L. O., Oladosu M. O. (2001) The effect of drying methods on the functional and sensory characteristics of pupuru-a fermented cassava product. International Journal of Agricultural Sciences, Science, Environment and Technology, 1(2) 9-16.
Siddique N. A., Meyerb M., Najni A. K., Akram M. (2010) Evaluation of antioxidant activity, quantitative estimation of phenols and flavonoids in different parts of Aegle armelo. African Journal of Plant Science, 4 1-5.
Simi C. K., Abraham T. E. (2008) Physicochemical rheological and thermal properties of njavara rice (Oryza sativa) starch. Journal of Agriculture and Food Chemistry, 56 12105-12113.
Sosulski F.W. (1962) The centrifuge method for determining water absorption in hard red spring wheat. Cereal Chemistry, 39 334-337.
Takashi S., Sieb P.A. (1988) Paste and gel properties of prime corn and wheat starches with and without naïve lipids. Cereal Chemistry, 65 474-483.

Tiencheu B., Achidi, A.U., Fossi, T., Tenyang, N., Ngongang, E.F.T., Womeni H.M. (2016) Formulation and Nutritional Evaluation of Instant Weaning Foods Processed from Maize (Zea mays), Pawpaw (Carica papaya), Red Beans (Phaseolus vulgaris) and Mackerel Fish Meal (Scomber scombrus), American Journal of Food Science and Technology, 4(5) 149-159.

Usman G. O. (2012) Production and evaluation of breakfast cereal from blends of African yam bean (Sphenostylis stenocarp), maize (Zea mays) and defatted coconut (Cocos nucifera). Unpublished M.sc Thesis. University of Nigeria, Nsukka, Nigeria.

Wong C., Tyler M., Sreekala G., Bajwa Dilpreets B. (2016) Impact of fibre treatment on oil absorption characteristics of plant fibre. BioResources, 11(3) 6452-6463.