Croat. J. Food Sci. Technol. (2020) 12 (2) 258-267

Croatian Journal of Food Science and Technology
journal homepage: www.ptfos.unios.hr/cjfst/

Original scientific paper

DOI: 10.17508/CJFST.2020.12.2.15

Nutrients, antinutrients and amino acids profile of malted quality protein maize (*Zea Mays L.*) based ready-to-eat breakfast cereal fortified with vegetable biomaterials

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ARTICLE INFO

Article history:
Received: May 15, 2020
Accepted: June 30, 2020

Keywords:
alkaloids
amino acids
dietary fibre
flaked breakfast
minerals
protein

ABSTRACT

Breakfast cereal was formulated from malted quality protein maize fortified with cowpea and garden egg with the view to producing a breakfast cereal of high nutrient density. The biomaterials were processed using standard methods to flour samples and blended at various ratios. The blended samples were pregelatinized, flaked, toasted and packaged. The flour and products were analysed for proximate, minerals, anti-nutrients, amino acids profile and dietary fibre using standard methods. The results showed that, as more garden egg was added, protein (9.94 - 10.67 %), fat (4.84 - 6.12 %) and fibre (4.19 - 7.07 %) increased. The amino acids profile recorded a boost with addition of cowpea but reduced with garden egg. The tannin (0.55 - 0.66 %), alkaloids (0.01 - 1.49 %), soluble (7.04 - 10.50 %) and insoluble fibre (23.38 - 30.50 %) increased with garden egg increase. However, the mineral content reduced with addition of garden egg. The study concluded that inclusion of cowpea and garden egg to breakfast cereal formulation boosted the nutritional value.

Introduction

The target of consuming food is to nourish the body system by supplying all the necessary nutrients required for energy, growth, development and maintenance of body reactions. Habitually foods are consumed in the morning, afternoon and in the evening. Out of all these arrangements, breakfast is very important for a good start of the day. Traditionally, cereals are consumed in many parts of the world as breakfast either as hot or ready to eat cereals. Breakfast cereals are cradle-to-grave foods. Ready-to-eat (RTE) cereals are usually among the first solid foods offered to infants because they are easy to eat and digest. For adults, cereals provide the low-fat, high-fibre, easy-to-chew, easy-to-digest alternative that is required for good health (Rosentrater and Evers, 2018). According to previous studies eating breakfast is correlated with better nutrition, improved work or classroom performance, better social and emotional behaviours, increased longevity and better overall health (Fast et al., 1990; Rosentrater and Evers, 2018).
Breakfast cereals have been produced from wheat, maize, millet, sorghum, etc. in many parts of the world. However, each of the grains is known to be deficient in one or more essential amino acids. Quality protein maize is a bio-fortified maize containing double the level of lysine and tryptophan in common maize (Vassal et al., 1993; Prasanna et al., 2001). It has been utilized in the production of several complementary foods and animal feeds (Akumoa–Boateng, 2002; Giwa and Ikujenlola, 2009; Abiose et al., 2015). In the recent times cereals are expected to meet the health and nutrition considerations of the consumers, reasons why food processors are adding functional ingredients and fortifying with essential nutrients. Special attention is being given to the increase in dietary fibre while balancing/ maintaining the requirement of protein and other valuable nutrients. Cowpea is a legume of high protein value. It is used as staple food in many parts of Africa where it is either eaten alone or as complement of other foods. The seed is a major source of plant proteins and vitamins for man, feed for animals, and also a source of cash income (Dugie et al., 2009). Cowpea is considered as an incredible source of many other health promoting components, such as soluble and insoluble dietary fibre, phenolic compounds,

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minerals, and many other functional compounds, including B group vitamins (Liyanage et al., 2014) thus, cowpea is considered as a nutrient dense, food which contributes greatly toward improving the quality of human health by offering a number of health benefits (Jayathilake et al., 2018). Garden egg or eggplant is fruit that is high in fibre and other valuable nutrients. It is eating as vegetables. Garden eggplants contains numerous nutrients which are all needed in the body predominantly for growth, repair of worn out tissues and then for protection. They are made up of several vitamins and minerals, dietary fibre, proteins, antioxidants, as well as phyto chemicals that possess antioxidant activity. Dietary fibre present can be used in weight management (Lawande and Chavan, 1998; Noda et al., 2000; Olusanya, 2008; Ossamulu et al., 2014). Breakfast cereal manufacture has made use of different combinations of food biomaterials to achieve a specific goal, however, there is paucity of information on the use of group of biomaterials (quality protein maize, cowpea and garden egg) as breakfast cereal raw materials. Therefore, the main aim of this study was to produce and evaluate flour blends from malted quality protein maize, cowpea and garden egg as potential breakfast cereal raw materials in Africa.

Materials and methods

Collection of materials

Quality protein maize (*Zea mays*) was purchased from Teaching and Research Farm, Obafemi Awolowo University, Ile Ife. Cowpea (*Vigna unguiculata* L. Walp) seeds and garden (*Solanum melongena*) egg fruits were purchased from the Sabo Market, Ile Ife. The Cowpea and Garden egg species were authenticated at the Department of Crop Protection and Production, Obafemi Awolowo University, Ile Ife. All chemicals used were of analytical grade.

Methods

Production of malted Quality Protein Maize flour

Malted QPM flour was prepared using the method described by Abiose and Ikujenlola (2014). Maize grains were sorted, cleaned, steeped for 8 h and spread in a germinating chamber for 72 h with watering twice a day. Germination was halted by drying at 60 °C for 12 h. The sprouts were separated by applying soft abrasion on the seed in between palms after which the de-sprouted grains were milled into flour and packaged (Fig. 1) in a high density polyethylene bag until needed for analysis.

Production of cowpea flour

Cowpea seeds were manually sorted to remove impurities and 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 at 60 °C for 12 h, milled, sieved and packaged in high density polythene bag (Fig. 1) until needed for analysis (Adediran et al., 2013).

Production of garden egg flour

The stalks of the garden egg fruits were removed and washed. They were cut into slices without peeling off the skin by using a slicer. 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 (Fig. 1) until needed for analysis (Scorsatto et al., 2017).

Sample formulation of flaked breakfast cereal

Samples of potential breakfast cereal were formulated by mixing malted QPM flour with cowpea flour and garden egg flour at the ratios of 100:0:0 (QPM100%); 90:10:0 (90% malted QPM, 10% cowpea); 85:10:05 (85% malted QPM, 10% cowpea, 5% garden egg); 75:10:15 (75% malted QPM, 10% cowpea,15% garden egg); 65:10:25 (65% malted QPM, 10% cowpea, 25% garden egg); 55:10:35 (55% malted QPM, 10% cowpea, 35% garden egg).

Production of flaked breakfast cereal

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 at 75 °C for 90 min (Fig. 2). The resulting products were cooled and then packaged into an air tight container (Usman, 2012).

Proximate and Mineral Analyses of flour blends

The samples were analysed for moisture, crude fat, crude protein, ash, crude fibre, carbohydrate content (by difference) based on the method of analysis of the Association of Official Analytical Chemists (AOAC, 2016). Total carbohydrate was calculated by difference and the energy value was calculated as follows: Energy (kcal) = 4× (g protein + g carbohydrate) + 9× (g fat).

The selected mineral elements (Na, Ca, K, Fe and Zn) concentrations were determined from solution obtained from wet digestion of sample ash with mixture of HCl solution and nitric acid (1:1 v/v) using Alpha 4 Atomic Absorption Spectrophotometer (A.O.A.C. 2016).

Amino acid determination

The amino acid profile in the sample was determined using methods as described by Sparkman *et al*. (1958) reported by Laminu et al. (2014). The sample was defatted, hydrolysed, evaporated in a rotary evaporator and then loaded into the Technicon Sequential Multi Amino Acid Analyzer (TSM).

Determination of Tannins

The modified vanillin – hydrochloric acid (MV–HCl) method of Price et al. (1978).

Determination of phytate

The phytate content of the samples were determined following the method described by Reddy et al. (1978).

Determination of Alkaloid

Five grams of sample was weighed into a conical flask, 200 ml of 10% acetic acid was added in ethanol. It was shaken and allowed to stand for 4 h, after which it was filtered. The filtrate was allowed to evaporate to about one quarter of its original volume. Few drops of concentrated NH_4OH solution were added to precipitate the alkaloid. The precipitate formed was filtered through a weighed paper. The filter paper was placed in the oven and allowed to dry at 60 °C for 60 min. The filter paper was reweighed and the weight was recorded.

$$Alkaloids(\%) = \left(\frac{W_2 - W_1}{W_1}\right) \times 100$$

where:
W_1 = initial weight of filter pape
W_2 = weight of filter paper after drying

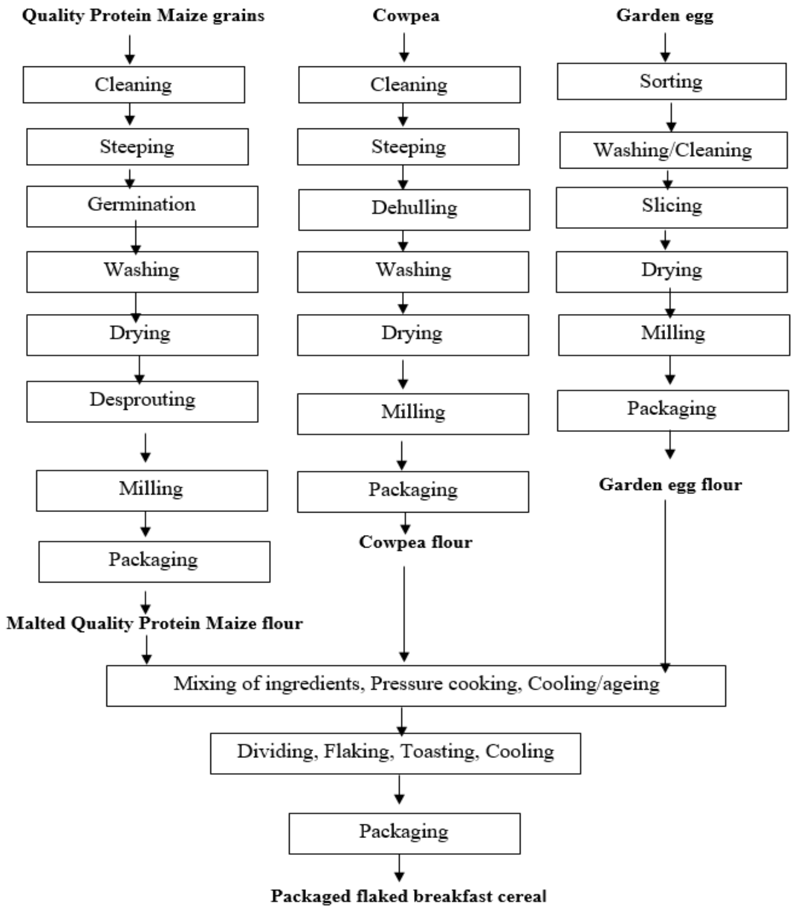

Fig. 1. Production of component flour samples and flaked Breakfast cereal Sources: Abiose and Ikujenlola (2014), Usman (2012)

Total Dietary Fibre Determination

The total dietary fibre Assay kit (TDF – 100A; Sigma-Aldrich, St. Louis, Missouri, USA) based on the enzymatic-gravimetric method published in the AOAC (AOAC, 2016) was used.

Statistical Analysis

All analysis was done in triplicate. 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 ($p \leq 0.05$) (IBM SPSS 21).

Results and discussion

Proximate Composition of the Flour samples and Flaked Breakfast Cereal

The proximate composition of flour samples and flaked breakfast cereal is presented in Table 1. The crude protein of the raw biomaterial samples ranged between 8.40 and 21.81 %. The protein content of garden egg (20.25%) was higher than the value (9.7%) reported by Hussain et al. (2011) and lower than the value (36.35%) reported by Oyeyemi et al. (2015). This variations may be due to the soil type, garden eggplant cultivar and some other environmental conditions (Mut et al., 2010).

The crude protein of the flaked breakfast cereal ranged between 9.94% and 10.67%. There was increase in the protein value of the flakes as more garden egg and cowpea were added. This agrees with report of Ikujenlola (2010) on the complementation of cereal with legume which led to an appreciable increase in the level of protein in the diet. Protein is required for good growth, healthy living, maintenance and production of the cells and tissues in the body (Abiose et al., 2015).

The crude fat content of the biomaterial samples ranged between 2.28 and 5.51 %. There were significant differences ($p<0.05$) between the flour samples. The crude fat of the flaked product ranged between 4.84 and 6.12 %. It was observed that the fat content of the flaked product was higher than the fat in constituent flour samples which may be due to the fat that was added during production of the flaked breakfast cereal. Fat, a macronutrient, is essential for energy, body insulation and transportation of fat soluble vitamins among other things however, excess of it leads to excess energy and triggers rancidity on storage.

The crude fibre of the flour samples ranged between 2.50 and 15.43 % while the crude fibre of the flaked product ranged between 4.19 and 7.07 %. The high fibre content of sample C (100% garden egg flour) is in agreement with values reported by Ossamulu et al. (2014) and Oyeyemi et al. (2015). Food rich in fibre has the advantage of fullness and bulky stool. Moreover, increased fibre intake in diet is said to aid in weight management (Birketvedt et al., 2005). Some of the commercial breakfast cereals average low fibre content.

Ash content of the flour samples ranged between 0.85 and 7.04%. Sample A* (100% QPM) had the least ash content of 0.85% among the flour samples. This result is similar to the value of 0.66 % reported by Ikujenlola and Adurotoye (2014). The ash content of the flaked product ranged between 2.46 and 4.15%. There were significant differences ($p<0.05$) between the flaked products. Ash content increased in the samples as the amount of garden egg incorporated into flour increases. Ash content determines the mineral composition of food product (Eze and Kanu, 2014).

The moisture content of the biomaterial samples ranged between 7.26 and 8.61% while flaked products ranged between 6.67 and 10.18%. There were significant differences ($p<0.05$) between the samples. Sample C had the highest moisture content of 8.61% while sample A* had the lowest moisture content of 7.26%. The low value of moisture in 100% QPM is similar to the value (7.90%) reported by Ikujenlola (2016). Moisture content can be used as an index of stability and susceptibility of the product to fungal infection. Low water activity inhibits the growth and proliferation of micro-organism, thereby extending the keeping quality of the product (Abiose and Ikujenlola, 2014). This further implies that low moisture content of the product will have a positive effect on its shelf stability but high moisture content will have negative effect on the shelf stability of the product, thereby the food product becomes less stable which will lead toward oxidation reactions if other environmental factors are favourable.

The carbohydrate content of the flour samples ranged between 45.00 and 76.35 % while the value of carbohydrate ranged between 61.82 and 71.91 %. QPM supply most of the carbohydrate at the expense of both cowpea and garden egg. Carbohydrate content decreased with increase in proportion of garden egg. This implies that high fibre based foods has low calorie, which may be useful in weight control and *diabetes mellitus* conditions (Bonsu et al., 2002).

The amount of calories in a quantity or volume of a food preparation is called the energy density of the food and is a good index for comparing the true value of different foods (Sajilata et al., 2002). The energy density of the samples depends on the values of fat, protein and carbohydrate of the diets. Individuals require adequate supply of energy to meet all the physiological functions of the growing system. The energy value of the flour samples ranged between 293 and 380 kcal. The energy value of the flaked products ranged between 344.10 and 370.98 kcal. It was observed that inclusion of garden egg reduced the energy value of the diet; this could be due to the low calorie content of garden egg. Sajilata et al. (2002) recommends a range of 400 to 435 kcal and 350 to 400 kcal/100 g for men and women respectively.

Mineral Content of the Flour and Flour Blends

Minerals are important components of diets which performs various physiological and metabolic functions in the body. There was variation in the values of the mineral elements present in various samples as shown in Table 2.

The Calcium (Ca) content of the flour samples ranged between 7.89 and 349.74 mg/100 g. There was significant difference (p<0.05) between the flour samples. Sample A* (100% QPM) had the highest value of calcium content of 349.74 mg/100 g. Sample C (100% garden egg flour) had the calcium content of 9.96 mg/100 g. Garden eggs are said to be a good source of calcium (Chinedu et al., 2011). However, the value obtained in this study is higher than the value of 3.68 mg/100 g reported by Agoreyo et al. (2012) for garden egg. Calcium is a macro mineral that is needed by the body in large amounts. It is also important in bone and teeth formation (Dobson, 2010).

The potassium content of the biomaterials ranged between 87.62 and 311.09 mg/100 g. The potassium content 239.27 mg/100 g of sample C (100% Garden egg) agrees with the report by Agoreyo et al. (2012) who reported that garden egg had a potassium content of 238.10 mg/100 g.

Table 1. Proximate Composition of QPM, Cowpea and Garden egg Flour Samples and Flaked Breakfast Cereal

Sample Code	Protein (%)	Fat (%)	Fibre (%)	Ash (%)	Moisture (%)	CHO (%)	Energy Value (kcal)
A*	8.40 ± 0.24^{b}	4.65 ± 0.19^{a}	2.50 ± 0.13^{b}	0.85 ± 0.01^{b}	7.26 ± 0.20^{b}	76.35 ± 0.03^{a}	380.81 ± 0.65^{a}
B	21.81 ± 0.35^{a}	2.28 ± 0.09^{c}	3.44 ± 0.08^{b}	3.91 ± 0.05^{b}	7.34 ± 0.24^{b}	61.21 ± 0.17^{b}	352.61 ± 1.50^{b}
C	20.25 ± 1.26^{a}	3.66 ± 0.18^{b}	15.43 ± 1.90^{a}	7.04 ± 2.89^{a}	8.61 ± 0.37^{a}	45.00 ± 0.28^{c}	293.90 ± 4.57^{c}
A	9.94 ± 0.09^{e}	4.84 ± 0.21^{d}	4.19 ± 0.01^{f}	2.46 ± 0.05^{f}	6.67 ± 0.24^{e}	71.91 ± 0.60^{a}	370.98 ± 0.17^{a}
D	10.16 ± 0.14^{d}	5.14 ± 0.16^{cd}	4.49 ± 0.04^{e}	2.59 ± 0.02^{e}	7.50 ± 0.06^{d}	70.01 ± 0.06^{b}	367.21 ± 1.29^{b}
E	10.22 ± 0.01^{cd}	5.27 ± 0.04^{c}	5.16 ± 0.03^{d}	2.79 ± 0.04^{d}	7.80 ± 0.07^{cd}	68.60 ± 0.11^{c}	362.78 ± 0.73^{c}
F	10.29 ± 0.02^{c}	5.65 ± 0.21^{b}	6.14 ± 0.02^{c}	3.21 ± 0.01^{c}	8.23 ± 0.04^{c}	66.49 ± 0.17^{c}	357.99 ± 1.15^{d}
G	10.50 ± 0.02^{b}	6.04 ± 0.06^{a}	6.31 ± 0.02^{b}	3.37 ± 0.05^{b}	8.86 ± 0.23^{b}	64.93 ± 0.30^{e}	356.09 ± 0.73^{d}
H	10.67 ± 0.04^{a}	6.12 ± 0.02^{a}	7.07 ± 0.03^{a}	4.15 ± 0.07^{a}	10.18 ± 0.25^{a}	61.82 ± 0.37^{f}	344.10 ± 1.49^{e}

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

Table 2. Mineral Composition of the Flour and Flour Blends (mg/100 g)

Sample	Calcium (Ca)	Potassium(K)	Sodium(Na)	Iron (Fe)	Zinc (Zn)
A*	349.74 ± 0.83^{a}	311.09 ± 1.24^{a}	4.61 ± 0.04^{b}	4.22 ± 0.05^{d}	4.22 ± 0.08^{a}
B	7.89 ± 0.01^{g}	87.62 ± 0.02^{f}	6.43 ± 0.05^{a}	78.12 ± 0.22^{a}	0.64 ± 0.02^{g}
C	9.96 ± 0.02^{g}	239.72 ± 0.34^{de}	1.20 ± 0.02^{g}	2.80 ± 0.15^{e}	0.65 ± 0.00^{g}
D	307.26 ± 4.02^{b}	280.02 ± 1.29^{b}	4.58 ± 0.03^{b}	10.21 ± 1.03^{b}	3.75 ± 0.19^{b}
E	271.41 ± 5.12^{c}	255.79 ± 3.14^{c}	4.08 ± 0.04^{c}	9.09 ± 0.43^{bc}	3.33 ± 0.10^{c}
F	233.99 ± 4.09^{d}	246.64 ± 5.58^{cd}	3.72 ± 0.10^{d}	9.18 ± 1.17^{bc}	2.94 ± 0.09^{d}
G	199.90 ± 7.29^{e}	236.59 ± 6.44^{de}	3.38 ± 0.17^{e}	9.26 ± 0.85^{bc}	2.58 ± 0.12^{e}
H	169.28 ± 2.45^{f}	229.60 ± 4.34^{e}	3.03 ± 0.11^{f}	8.61 ± 0.97^{c}	2.25 ± 0.02^{f}

The mean values along the same column with different superscripts are significantly different (p < 0.05) using Duncan multiple range test. 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

The potassium content of the flour blends ranged between 229.60 and 280.02 mg/100 g. Potassium is another important mineral required for proper body functioning. It helps to lower blood pressure by balancing out excess salt. High potassium has been reported to have protective effect against excess sodium intake (Agoreyo et al., 2012).

The sodium content of the biomaterials ranged between 1.20 and 6.43 mg/100 g while the flour blends ranged between 3.03 and 4.58 mg/100 g. The value of sodium in garden egg in this study is higher than 0.63 mg/100 g reported by Eze and Kanu (2014). Inclusion of garden egg reduced the sodium content of the flour blends. Sodium is an essential electrolyte that helps to maintain the balance level of water in and around the body. It further aids in proper muscle and nerve functioning. Low sodium has been reported to be of advantage in maintenance of high blood pressure levels (Lichtenstein et al., 2006).

The level of iron in the flour samples ranged between 2.80 and 78.12 mg/100 g. The iron content present in the flour blends ranged between 8.62 and 10.21 mg/100 g. The iron content present in sample C (100% Garden egg) in this study agrees with the report by Agoreyo et al. (2012) who reported similar value (2.75 mg/100 g) for iron content present in garden egg. Iron is required for haemoglobin production (Nelson and Cox, 2005) which carries oxygen from the lungs to the body cells. Iron also helps to regulate metabolism, body temperature, immune function and cognitive development (Adeyeye and Fagbohun, 2005).

Zinc content of the samples ranged between 0.64 mg/100 g and 4.22 mg/100 g. There were significant differences ($p<0.05$) between the flour samples. Zinc content of the flour blends ranged between 2.25 and 3.75mg/100 g. There were significant differences ($p<0.05$) between the flour blends. The inclusion of garden egg reduced the zinc content of flour blends. Zinc is required for the proper functioning of reproductive system, tissue growth and repair (Prasad, 2013).

The recommended daily allowance for calcium is 1000 mg/d, iron 8 mg/d, zinc 11 mg/d, potassium 4.7 g/d and sodium 1.3 g/d for adult (Dietary reference intake, 2001, 2005, 2010). The values of minerals for the diet may have been influenced by the content of the minerals in the garden egg. It was observed that the garden egg was low in some minerals determined. However, these minerals are needed in the body in moderate amounts as they are important in daily function and processes.

Amino Acids Composition of Flaked Breakfast Cereal

Table 3 shows the amino acid composition of the flaked breakfast cereal. Amino acids are referred to the building blocks of proteins.

Table 3. Amino Acid Composition of the Flaked Breakfast Cereal (g/g Protein)

Amino Acid	A	D	E	F	G	H
Leucine	7.30	7.59	7.00	6.60	6.19	5.60
Lysine	4.43	4.64	4.03	3.98	3.82	3.42
Isoleucine	2.68	2.95	2.62	2.36	2.19	2.09
Phenylalanine	4.26	4.52	3.99	3.90	3.72	3.55
Tryptophan	0.95	1.02	0.89	0.84	0.79	0.71
Valine	3.80	3.80	3.60	3.51	3.27	2.98
Methionine	0.88	0.91	0.80	0.69	0.64	0.59
Proline	2.64	2.74	2.64	2.44	2.23	2.13
Arginine	4.65	4.65	4.13	3.96	3.78	3.44
Tyrosine	2.06	2.06	1.89	1.72	1.72	1.55
Histidine	1.98	2.11	1.79	1.72	1.60	1.53
Cysteine	0.97	1.09	0.97	0.91	0.85	0.73
Alanine	3.98	4.13	3.87	3.68	3.49	3.11
Glutamic acid	11.58	11.96	11.2	10.83	10.45	9.99
Glycine	2.99	3.18	2.95	2.90	2.71	2.54
Threonine	2.14	2.25	2.00	1.94	1.89	1.69
Serine	3.19	3.30	3.00	2.97	2.76	2.54
Aspartic acid	8.90	9.12	8.50	8.19	7.60	7.01
Total AA	69.38	72.02	65.87	63.14	59.70	55.20

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

Non-essential amino acids can be made by the body while essential amino acid cannot be made by the body but obtained from diet. From this study, eighteen amino acids were identified in the flaked samples. Glutamic acid ranged from 9.99 - 11.96 g/100 g, aspartic acid ranged from 7.01- 9.12 g/100 g, leucine ranged from 5.6 – 7.59 g/100 g, isoleucine ranged from 2.0 -2.95 g/100 g, lysine ranged from 3.42 - 4.64 g/100 g and valine ranged from 2.98 - 3.80 g/100 g, but did not meet up with the FAO/WHO(1992) standard for adults in which 14 mg/kg/day of leucine, 12 mg/kg/day of lysine, 10 mg/kg/day of isoleucine, and 10 mg/kg/day of valine are required. It was observed that increase in the level of garden egg reduced the amino acid in the sample. The lysine content of normal corn protein is 2.1–2.8 %, whereas that of opaque hybrids, which are rich in protein, is 4.0–6.5 %. Modified opaque hybrids are called 'quality protein maize' (Mertz, 1992). Glutamic acid, aspartic acid and leucine were observed to be the most predominant for the flaked breakfast cereal. Glutamic acid is an acidic amino acid that is essential for cell proliferation (Zhao et al., 2010). Glycine is a major component of human skin collagen, together with other amino acids such as alanine, proline, arginine, serine, isoleucine and phenylalanine form polypeptides that promote re-growth and tissue healing (Witte et al., 2002). Branched chain amino acid (BCAA) valine, isoleucine, and lysine are essential amino acids in which at sufficient amount play important role as energy fuel and stimulate protein synthesis (Brestensky et al., 2015). From this study, leucine, isoleucine and valine have low levels in the samples, which might not be sufficient to stimulate protein synthesis and as a result, these low levels of BCAA in the samples might enhance weight management (Brestensky et al., 2015).

Anti-nutrients properties of the flaked breakfast cereal

The anti-nutrients (phytate, alkaloid, and tannin) of the flaked product are presented in Table 9. The results showed that the anti-nutrients ranged from 0.01 - 0.12, 0.06 - 1.49 and 0.55 - 0.66 mg/100 g for phytate, alkaloid and tannin respectively. It was observed that addition of garden egg increased the level of phytate in the flaked product. According to WHO (2003), the permissible level of phytate is stated as 22.10 mg / 100 g. This implies that phytate level in the flaked products falls within the accepted level and are safe for consumption.

Table 4. Anti-nutrients of Flaked Breakfast Cereal (mg/100 g)

Sample	Phytic acid	Alkaloid	Tannins
A	0.01 ± 0.00^b	0.01 ± 0.00^f	0.55 ± 0.03^f
D	0.03 ± 0.00^b	0.22 ± 0.02^e	0.56 ± 0.03^e
E	0.06 ± 0.00^b	0.30 ± 0.02^d	0.58 ± 0.01^d
F	0.07 ± 0.00^b	0.52 ± 0.03^c	0.59 ± 0.01^c
G	0.09 ± 0.00^b	1.05 ± 0.02^b	0.62 ± 0.02^b
H	0.12 ± 0.00^a	1.49 ± 0.03^a	0.66 ± 0.03^a

The mean values along the same column with different superscripts are significantly different ($p < 0.05$) using Duncan multiple range test. 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

Table 5. Soluble and Insoluble Dietary Fibre of Flaked Breakfast Cereal (%)

Sample	Insoluble Fibre	Soluble Fibre	Total Fibre
A	23.38 ± 0.33^f	7.04 ± 0.06^e	30.42 ± 0.39^f
D	24.19 ± 0.17^e	7.39 ± 0.17^e	31.58 ± 0.34^e
E	25.23 ± 0.21^d	7.91 ± 0.10^d	33.14 ± 0.31^d
F	26.30 ± 0.27^c	8.50 ± 0.26^c	34.80 ± 0.53^c
G	28.24 ± 0.21^b	9.20 ± 0.20^b	37.44 ± 0.41^b
H	30.50 ± 0.20^a	10.50 ± 0.26^a	41.00 ± 0.46^a

The mean values along the same column with different superscripts are significantly different ($p < 0.05$) using Duncan multiple range test. 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

The values for alkaloids in the flaked products ranged from 0.06 to 1.49 mg/100 g. It was observed that the inclusion of garden egg in the diet increased the level of alkaloid. Alkaloids are responsible for the bitter taste of garden egg (Eze and Kanu, 2014) and on the product.

Tannins can be described as an astringent, bitter plant poly phenolic compound that either binds or precipitates proteins and various other organic compounds including amino acids and alkaloids. It is one of the anti-nutrient present in garden egg fruit, its astringency nature causes dry and pucker feeling in the mouth following the consumption of the fruit (Westman, 2007). The values of tannin present in the flaked product ranged between 0.55 and 0.66 mg/100 g. There was increase in tannin value as a result of increase in the level of garden egg. According to WHO (2003), the permissible level of tannin is given as 1.5 mg /100 g. The amounts of tannin in the flaked products were within the permissible level.

Anti-nutrients in plant foods are responsible for deleterious effects related to the absorption of nutrients and micronutrients. However, some antinutrients may exert beneficial health effects at low concentrations. When present at low levels, phytate, lectins, tannins, amylase inhibitors and saponins have also been shown to reduce the blood glucose and insulin responses to starchy foods and/or the plasma cholesterol and triglycerides (Shahidi, 2009).

Total dietary fibre of flaked breakfast cereal

Dietary fibre is referred as the edible carbohydrate polymer of plants, obtained carbohydrate polymers from food raw material by physiological or chemical treatments and has been shown to have a physiological effect or benefit to health. Dietary fibre is the edible part of plants, or similar carbohydrates, which are resistant to digestion and absorption in the small intestine (Almeida et al., 2014). The results showed that insoluble fibre of the flaked product ranged between 23.38 and 30.50 %, soluble fibre ranged between 7.04 and 10.50 % while total dietary fibre ranged between 23.38 and 30.50 %. Sample H containing 55% QPM, 10% cowpea and 35% garden egg had the highest value (30.42%) while sample A containing 100% QPM had the lowest total dietary fibre value of 23.38%. There were significant differences ($p<0.05$) between the samples. It was observed that addition of garden egg increased the insoluble fibre, soluble fibre and total dietary fibre content of the products. This is in agreement with the report of Divya et al. (2018) who reported that there was increase in fibre content with increasing level of oat flour in a processed product due to the higher fibre content in oat flour. Dietary fibre plays a significant role in the prevention of diet-dependent diseases, e.g. obesity, atherosclerosis and colon cancer. The soluble portion of dietary fibre has been reported to reduce elevated blood cholesterol, triglyceride, and glucose levels. Insoluble fibre functions as a water-holding-capacity agent and can reduce intestinal transit time when present in adequate amounts in food (Dziedzic et al., 2012). Food high in fibre has good implication on the weight management of consumers. Dietary fibre has been shown to have palliative effects on diseases, particularly those of the gut, and diabetes mellitus (especially type 2), because dietary fibre has been shown to reduce postprandial glucose elevations in the blood (Tabatabai and Li, 2000).

Conclusion

The ready-to-eat flaked breakfast cereal produced from malted QPM, cowpea and garden egg is coming as novel meal which has the potential of meeting certain nutritional needs of consumers in terms of protein, fibre, amino acids, and minerals. It will enhance the utilisation of garden egg and other biomaterials. This meal also add to list of varieties of breakfast meal available to consumers.

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

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