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Research Article

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Potential Complementary Food from Quality Protein Maize (*Zea mays* L.) Supplemented with Sesame (*Sesamum indicum*) and Mushroom (*Oudemansiella radicata*)

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Abstract

The study developed and assessed blends of quality protein maize (QPM), defatted sesame seed and mushroom flours as potential complementary food. The crops were processed to flour separately using standard methods. The flours were blended at various proportions of 100:0:0; 70:30:0; 70:0:30; 70:15:15. The proximate, mineral, amino acids profile, functional and sensory properties of the blends were analysed. The results showed that protein ranged between 10.64% and 25.32%, fat 2.41%-4.67% and ash 3.88%-6.90%. The packed bulk density ranged between 0.52 and 0.69 g/ml, water absorption capacity of the samples was 76.60% to 93.30%. Leucine 7.13-7.44 g/100 gcP was the most abundant essential amino acid while tryptophan 1.28-1.32 g/100 gcP was the least. The essential amino acid index and predicted biological values ranged between 45.89%-95.56% and 38.32%-92.46% respectively. The samples were acceptable to the panelists however, the 100%QPM sample was most preferred. The study concluded that supplementation of QPM with sesame and mushroom improved the nutritional, functional and sensory quality of the blends. This product is a potential alternative to exorbitant commercial complementary food in Nigeria.

Keywords: Amino acids; Bulk density; Lysine; Malnutrition; Total amino acid

Introduction

In developing economies, infants are expected to be breastfed for the first six months. Thereafter the provision of energy and other valuable nutrients from breast milk becomes difficult to meet the nutritional requirement of the fast-growing infants. To maintain a steady growth and development of the infant without any adverse effect; it is important to provide complementary food alongside with the breast milk to compensate for extra demand due to the growth and development of the infant. Traditionally, thin gruels from locally available cereal and tuber which are not in any way close to meeting the nutritional requirement of the infant at this stage are fed to them. This has been implicated as a cause malnutrition in infants which has accounted for high percentage of mortality among infants in most developing countries [1]. In developing countries various stakeholders have advocated for the utilization of cereals, grain legumes and other different crops to solve this problem. However, there are still unexploited crops in this regard that could be utilized to ameliorate the menace.

The composition of edible mushrooms shows that it is high in essential oils, protein (including all the essential amino acids), vitamins, minerals, lectins, fibre and bioactive compounds [2]. Mushroom has medicinal value and meaty flavour; these are the reasons why most people eat it [3]. Mushrooms as food are a potential solution to inadequate supply of protein and minerals [4,5]. The use of mushroom in the production of complementary food is scarce. Quality protein maize is a bio-fortified maize which contain lysine and tryptophan; first and second limiting amino acids in common maize [6]. It has been used to produce several products like breakfast and complementary foods [7] animal feed, etc. Sesame seed is known for its high oil content and good quality protein. It has been blended with cereal in weaning food production [8]. There is scanty information on the utilization of mushroom, sesame and QPM blends as weaning food for children. Therefore, there is the need to explore the nutritional qualities of these crops in the production of weaning food for children. The aim of this study was to produce and assess some nutritional quality of blends of QPM, sesame and mushroom as potential ingredients for weaning food.

Materials and Methods

The raw materials used for this study were quality protein maize which was purchased from the teaching and research farms of the Obafemi Awolowo University, Ile-Ife, Nigeria, sesame seeds and mushroom were purchased from King's market, Owo, Ondo state. The mushroom was identified at Department of Crop Protection and Production, Obafemi Awolowo University, Ile-Ife, Nigeria as *Oudemansiella radicata.*

Production of quality protein maize flour

The QPM flour was produced using the method reported by Ikujenlola [9]. The grains (Figure 1) were thoroughly dry cleaned of dirt and adhering materials by winnowing. The cleaned grains were conditioned (to moisture content 20%), decorticated, dried (MRC oven, UK) at 60°C for 12 hours and milled. It was sieved (to 400 mesh) and packaged in high density polyethylene bag until needed.

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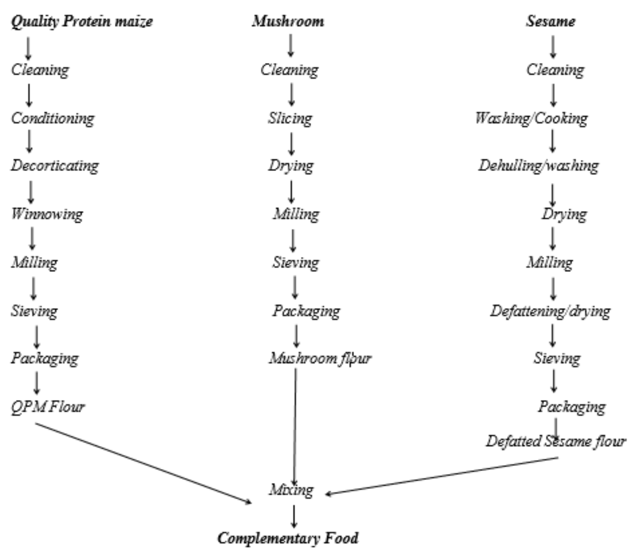

Figure 1: Production of QPM, Mushroom and defatted Sesame flours.

Production of mushroom (*Oudemansiella radicata*) flour

The mushroom was sorted, cleaned, sliced and spread on the tray of a Cabinet drier. Drying in a MRC cabinet drier (MRC oven, UK) was carried out at 60°C for 12 hours (Figure 1). After drying, the mushroom was then milled and packaged in water and air tight polyethylene bag until needed [10].

Production of defatted Sesame seed (*Sesamum indicum*) flour

The sesame seeds were cleaned of all dirt and other adhering materials by winnowing. The defatted sesame seed flour was produced by applying the method of Moharran et al. as shown in Figure 1.

Formulation of complementary food blends

The flours were formulated into different samples by using different ratios (100:0:0; 70:30:0; 70:0:30; 70:15:15) of the flours (QPM: defatted Sesame: Mushroom) respectively. The formulated samples were coded as QPM; QPM: SES; QPM: MUS; QPM: SES: MUS respectively.

Proximate composition analyses of macronutrients

The standard procedures of AOAC [11] were adopted in the determination of the proximate composition of the various weaning food blends while Carbohydrate content was determined by difference, that is:

% Carbohydrate=100 – (% Crude fibre+% Fat+% Ash+% Moisture+% Crude protein).

Gross energy

Calculated energy value of the samples was determined by calculation from fat, carbohydrate and protein content using the Atwater's conversion factor that is the sum of 4.0 kcal/g carbohydrate, 4.0 kcal/g protein and 9.0 kcal/g fat [12].

Mineral composition determination

The mineral content of the samples was determined using the standard method described in AOAC [11].

Functional properties determination

The selected functional properties of the flours determined included bulk density, water absorption capacity, oil absorption capacity, swelling capacity and reconstitution index following the methods reported by Gopaldas et al. [13].

Pasting properties determination

The pasting characteristics of the flour were determined with a Rapid Visco Analyzer (RVA) (Model RVA 3D+, Newport Scientific Australia). About 3.0 g of the sample was weighed into a cleaned and dried empty canister; then 25 ml of distilled water was dispensed into the canister containing the sample. The solution in slurry form was thoroughly mixed. The slurry was heated from 50°C-95°C with a holding time of 2 min followed by cooling to 50°C with 2 min holding time. The rate of heating and cooling were at a constant rate of 11.25°C per min. with the aid of thermocline for windows software connected to a computer the peak viscosity, trough, breakdown, final viscosity, set back, peak time and pasting temperature were read from the pasting profile [14].

Amino acid determination

Sample preparation and hydrolysis for amino acid analysis: The sample (2.5 g) was weighed into the extraction thimble and fat was extracted with a mixture of chloroform/methanol (2:1 v/v) using a Soxhlet apparatus [11]. The extraction lasted for 5-6 hours. The defatted sample (about 30 mg) was weighed into glass ampoules. Seven milliliters of 6 mol/L HCl were added and oxygen expelled by passing nitrogen gas into the samples. The glass ampoules were sealed with a Bunsen flame and put into an oven at 105 ± 5°C for 22 h. The ampoule was allowed to cool; the humins in the content was removed by filtration. A rotary evaporator operated at 40°C under vacuum was used to dry the filtrate. Each residue was dissolved with 5 mL of acetate buffer (pH 2.0) and stored in a plastic specimen bottle kept in the deep freezer.

Amino acid analysis: The amino acid analysis was by the TSM (Technicon Sequential Multisample) Amino Acid Analyser (Technicon Instruments Corporation, New York). The period of analysis was 76 min for each sample. The gas flow rate was 0.50 mL/min at 60°C with reproducibility consistent within ± 3%. The net height of each peak produced by the chart recorder of the TSM (each representing an amino acid) was measured and calculated. The amino acid values reported were the averages of two determinations. Norleucine was used as the internal standard.

Tryptophan analysis: The tryptophan content was determined in a separate analysis. The weighed samples were placed in polypropylene tubes and after the addition of the internal standard (norleucine), they were hydrolysed in 4.67 mol/LKOH containing 1% (w/v) thiodiglycol for 18 h at 110°C. After hydrolysis, KOH was neutralized with 2.4 mol/L perchloric acid, and the supernatant was adjusted to pH 3.0 with acetic acid. A 20 µL aliquot of the hydrolyzed sample was subjected to derivatization as described above. The solution of amino acid standard was supplemented with tryptophan. Quality assurance for the tryptophan determination was obtained by demonstrating that the method yielded the correct number of tryptophan residues for egg white lysozyme. Tryptophan analysis was performed using a Waters C18 reversed phase column (3.9 × 150 mm) (Waters Milford, MA) and the solvents and gradient conditions were as described by Ijarotimi et al. [15]. It was necessary to use this elution protocol in order to adequately separate tryptophan from ornithine which results from the alkaline hydrolysis of arginine.

Predicted nutritional quality

Predicted protein efficiency ratio (P-PER): The method reported by Ijarotimi et al. [16] for protein efficiency ratio determination using the following equation was adopted.

$$PER=0.06320\ [X_{10}]-0.1539$$

Where: X_{10}=Thr+Leu+Phe+Lys+His+Met+Val+Arg+Tyr+Ile

Essential amino acid index (EAAI): The nutritional qualities of the samples were determined on the basis of the amino acid profiles. The method of [17] was adopted to calculate the essential amino acid index (EAAI).

$$EAAI \approx n\sqrt{\frac{100a\ x100b\ x....100j}{av\ x\ bv\ x....jv}}$$

Where: n=number of essential amino acids, a, b, …j=the essential amino acid of the test sample; av, bv…jv=the essential amino acid of reference protein (egg).

Biological value (BV): The following equation credited to Oser [18] was used for BV determination.

BV=1.09 (EAA Index)-11.7.

Nutritional index (NI): The formula described by Chang and Hayes [19] was used to calculate nutritional index of the food samples.

$$\text{Nutritional index}\left(\text{NI}\right)=\frac{\text{EAAI}\times\ \%\ \text{protein}}{100}$$

Sensory evaluation of the supplemented QPM samples

The method of Agu et al. [20] was adopted in evaluating the sensory quality of the coded samples. Twenty semis trained panelists drawn from the University community was used in the assessment exercise. All panel members were either nursing mothers or had nursed baby before, who are used to weaning food. The panelists were given specific instructions on what to do. The following attributes colour, texture, aroma, taste and overall acceptability were evaluated. A 9-point Hedonic scale was used where 9=like extremely and 1=disliked extremely.

Statistical analysis

The SPSS version 15.0 was used in analyzing the data collected from the study. The mean and standard deviation were calculated from the triplicate analyses of the samples. The analysis of variance (ANOVA) was carried out to determine level of significant differences between the means of proximate composition, minerals, sensory and functional properties; the means were separated using the Duncan multiple range test at $p<0.05$.

Results and Discussion

Proximate composition of supplemented QPM samples

The results of the proximate composition of the blends produced from QPM, sesame and mushroom are presented in Table 1. From the results the protein value of the samples varied between 10.44% and 25.32%. The result of the protein of 100% QPM agrees with the result (9.72%) reported by Abiose et al. [7] for a variety of QPM grains. The addition of both sesame and mushroom improved the level of protein of the diets. The supplemented diet stands a better chance to sustain infants with respect to protein quality. According to Prassana and Abiose et al. [6,7] QPM contain high level of lysine and tryptophan which are lacking in common maize. The daily recommended intake of protein for infants (6-12 months) is 13.0-13.5 g/day [21]. The supplemented QPM samples are expected to meet this allowance. Protein is a vital macronutrient required for growth and development of infants. The absence or inadequate protein has been responsible for the decline or falter growth among children especially after cessation of breastfeeding. The attending outcome of this has been infantile mortality which has been on the increase in some parts of Africa especially the war/terrorism ridden region of Nigeria. The samples under consideration contained reasonable amount of protein which could meet the recommended allowance for infant if fed judiciously.

The fat and ash contents of the blends ranged between 2.41%-4.67% and 3.88%-6.90% respectively. From Table 1, it was observed that the addition of both sesame and mushroom to QPM was responsible for the increase in fat and ash contents respectively. For food meant for infants the fat should be below 10% according to the recommendation of Protein Advisory Group [22]. The ash content of the diet determines the levels of the inherent minerals present in the diet. The ash content 3.88%-6.90% was higher than the ash content reported by Bassey et al. [23] for weaning food produced from banana supplemented with cowpea and peanut.

The result showed that the crude fibre ranged from 3.55 to 5.79% while the moisture content of the blends was 9.32% for QPM and 10.68% for QPM: SES. Low moisture content is required in weaning food in order to prolong the shelf stability; the higher the moisture content the less stable the food will be toward oxidative reactions if other environmental factors are favourable. The values reported in this study are within the range (5%) recommended by Samuel [22]. The carbohydrate and energy contents of the blends ranged from (51.04-66.20%) to (329.29-353.15 kcal) respectively. The calculated energy requirements for a weaning infant of 4-to 5-month-old is 414 kJ (99.04 kcal)/kg per day while 397 kJ (94.97 kcal)/kg is for the 8 to 9-month-old [24]. The supplemented diet is expected to meet the recommended energy allowance for weaning infant. The proximate composition of the supplemented diets compared favourably with the composition of weaning food (protein content in the range of 13.9-14.2%; and moisture, ash, fat, and calories in the range of 5.45%-6.15%, 4.20-4.61 g, 1.27-1.60 g, and 348-364 kcal per 100 g respectively) reported by Gahlawat et al. [25].

The mineral content of QPM and supplemented QPM samples

The mineral composition of the blends (Table 2) shows that the most abundant of the minerals was potassium (698.57-1262.00 mg/100 g). The addition of both sesame and mushroom had improvement on the content of the minerals which will be advantageous to the intending consumers. This observation is similar to other findings such as that potassium is the most abundant mineral in Nigerian agricultural products. Potassium is vital to heart function [26]. It plays a major

Parameter/ sample	QPM	QPM:SES	QPM:MUS	QPM:SES:MUS
Protein	10.64 ± 1.06[c]	20.69 ± 1.06[b]	25.32 ± 0.11[a]	21.56 ± 1.14[b]
Fat	3.25 ± 0.06[a]	4.67 ± 0.28[a]	2.65 ± 0.04[b]	2.41 ± 0.02[b]
Ash	3.88 ± 0.01[c]	4.26 ± 0.04[b]	6.90 ± 0.11[a]	4.44 ± 0.17[b]
Crude fibre	5.79 ± 0.11[a]	4.18 ± 0.07[b]	3.55 ± 0.09[c]	4.37 ± 0.04[b]
Moisture	9.32 ± 0.18[b]	9.89 ± 0.36[b]	10.68 ± 0.06[a]	10.26 ± 0.04[a]
Carbohydrate	66.20 ± 2.09[a]	57.09 ± 3.23[b]	51.04 ± 2.02[c]	56.97 ± 3.02[b]
Energy (kcal)	336.61 ± 4.38[b]	353.15 ± 6.56[a]	329.29 ± 4.29[c]	335.81 ± 5.47[b]
Mean ± SD				

Table 1: Proximate composition of QPM and supplemented QPM samples (%).

role in skeletal and smooth muscle contraction, making it important for normal digestive and muscular function. Calcium and iron ranged between (107.40-66.36 mg/100 g) and (1.25-2.54 mg/100 g) respectively. The sodium, zinc and magnesium ranged from (42.50-268.20 mg/100 g), (2.36-3.35 mg/100 g) and (95.29-167.47 mg/100 g) respectively.

According to Olayinka [27] the macro mineral compositions of two varieties of mushrooms are given as sodium, potassium, magnesium and calcium in *P. sajo-caju* are 45.79, 577.42, 39.86 and 165.15 mg/100 g respectively while that of *L. squarrosulus a*re 75.89, 789.67, 36.20 and 281.15 mg/ 100 g respectively. Also, Thatoi et al. [28] reported that the mineral proportions in mushroom are a function of the species, age and the diameter of the fruiting body.

The ratio of Na/K of the food samples ranged from 0.06 to QPM and 0.32 for QPM: MUS blends. The implication of this is that adults could also benefit from this diet especially those that have issues with high blood pressure. Potassium has a beneficial effect on sodium balance. A high intake of potassium can protect against increasing blood pressure and other cardiovascular risks according to Langford [29]. Hence, the sodium to potassium (Na/K) ratio in the body is of great concern for the prevention of high blood pressure. A Na/K ratio less than one is recommended in the diets of people who are susceptible to high blood pressure [30] So adults are encouraged to take advantage of the high potassium in the blends. Zinc is required for the satisfactory growth and maintenance of the human body and magnesium is required for energy generation, oxidative phosphorylation and glycolysis.

The functional properties of QPM and supplemented QPM samples

The functional properties of the blends are shown in Table 3. The loose and packed bulk densities ranged from 0.40-0.42 g/ml and 0.52-0.69 g/ml respectively. The Loose Bulk Density (LBD) is regarded as the lowest attainable density without compression while the Packed Bulk Density (PBD) is the highest attainable density with compression.

The bulk density range was lower than the range 0.91 to 1.19 g/ml reported by Desalegn et al. [31] for complementary blend from QPM and chickpea blends. The addition of both sesame and mushroom to the QPM flour produced blends of low bulk density. Diets meant for infant are expected to be of low dietary bulk because of the capacity of their gastric system which may not be able to handle bulkier food. Nutritionally, it is recognised that loose bulk density promotes easy digestibility of food products, particularly among children with immature digestive system [13,32]. The packaging of the diet is affected by the bulk density of the food. Generally, higher bulk density is desirable for greater ease of dispersibility and reduction of paste thickness [33]. Low bulk density of flour is a good physical attribute which ease transportation and storability of the products; the products could be easily transported and distributed to required locations [34].

The oil and water absorption capacities varied between 103.00%-116.00% and 76.60%-93.30% respectively. While the reconstitution index and swelling capacity of the samples were between 74.00%-93.00% and 28.00%-36.00% respectively. The inclusion of the sesame and mushroom flours increased the water absorption and swelling capacities of the blends, while the amount of dry matter concentration present in reconstituted gruel per meal is a function of the amount of water absorbed by the diet. The lower the water absorption capacities, the more the dry matter that could be added to the mixture; by implication the more the nutrients that would be available for the infant [8].

The water absorption capacity is an indication of the maximum amount of water that a food product would absorb and retain. Its increase in water absorption capacity implies high digestibility of the starch [35,36].

The water absorbed in food has effect on the microbial activities of such food; low water absorption capacity is associated with reduced microbial activities. This by implication can extend the shelf life of such food. The swelling capacity is the amount of water that food samples would absorb and swell within a given temperature and time. All the samples reconstituted well in boiling water with no separation of layers, but the mixture/gruel was homogeneous. The supplementation of QPM with sesame and mushroom improved the reconstitution capacity of the samples.

The pasting properties of the blends are shown in Table 4. The features of the pasting characteristics followed similar trend for viscosity related parameters such parameters: peak viscosity 32.00-42.08 RVU; trough 27.67-37.42 RVU; final viscosity 70.92-93.30 RVU were very low compared to previous study of Ikegwu et al. [37] who worked on similar product. The highest viscosity was found in the

Parameter/sample	QPM	QPM:SES	QPM:MUS	QPM:SES:MUS
Calcium (mg/100g)	66.36 ± 5.24^{a}	76.34 ± 2.64^{b}	107.40 ± 6.25^{a}	85.50 ± 7.60^{b}
Iron (mg/100g)	2.54 ± 0.03^{a}	2.25 ± 0.35^{a}	1.25 ± 0.04^{b}	2.25 ± 0.06^{a}
Sodium (mg/100g)	42.50 ± 4.20^{a}	135.10 ± 8.30^{b}	268.20 ± 11.10^{b}	225.45 ± 12.80^{b}
Potassium (mg/100g)	698.50 ± 60.63^{d}	1262.00 ± 101.08^{a}	830.25 ± 60.50^{b}	745.20 ± 50.71^{c}
Zinc (mg/100g)	2.67 ± 0.62^{b}	3.35 ± 0.06^{a}	2.70 ± 0.06^{b}	2.36 ± 0.06^{b}
Magnesium (mg/100g)	95.29 ± 10.23^{d}	120.25 ± 12.35^{c}	167.47 ± 10.02^{a}	155.57 ± 8.90^{b}
Mean ± SD				

Table 2: Mineral composition of QPM and supplemented QPM samples (mg/100g).

Parameter/sample	QPM	QPM:SES	QPM:MUS	QPM:SES:MUS
Loose density (g/ml)	0.42 ± 0.01^{a}	0.40 ± 0.01^{a}	0.40 ± 0.01^{a}	0.42 ± 0.01^{a}
Packed bulk density (g/ml)	0.69 ± 0.02^{a}	0.54 ± 0.01^{b}	0.55 ± 0.02^{b}	0.52 ± 0.01^{c}
Oil absorption capacity (%)	116.00 ± 5.09^{a}	103.00 ± 0.16^{a}	107.00 ± 0.03^{a}	102.00 ± 0.13^{a}
Water absorption capacity (%)	83.30 ± 2.12^{bc}	76.60 ± 3.53^{c}	93.30 ± 2.12^{a}	88.30 ± 3.53^{c}
Reconstitution index (%)	74.00 ± 0.01^{b}	76.00 ± 0.01^{b}	78.00 ± 0.01^{b}	93.00 ± 0.01^{a}
Swelling capacity (%)	28.00 ± 0.01^{c}	32.00 ± 0.01^{b}	36.00 ± 0.01^{a}	33.00 ± 0.01^{b}
Mean ± SD				

Table 3: Functional and pasting properties of QPM and supplemented QPM samples.

100%QPM, while the addition of the sesame and mushroom led to the decline in the values. The ability of starch to swell freely before their physical breakdown is known as peak viscosity. It ranged between 32.00 and 42.08 RVU. Food designed for infant is expected to be of low viscosity this is to prevent suffocation and choking during feeding. The pasting temperature ranged between 92.80 and 93.65°C, peak time was 6.90 min. The pasting temperature indicates the minimum temperature required for sample to cook, energy costs involved and another components stability [38].

Amino acids profile and nutritional quality of the diets

The amino acids profile of the potential weaning or complementary food blends are presented in Table 5. The QPM contained all the essential amino acid especially lysine and tryptophan which are said to be limiting amino acids in common maize. The lysine and tryptophan were 3.70 g/100 g crude protein and 1.32 g/100 g crude protein respectively. The addition of both sesame and mushroom increase the concentration of the amino acids of the products. The most abundant amino acid was glutamic acid 12.56-16.77 g/100 g with a trend of QPM: MUS< QPM<QPM: MUS: SES<QPM: SES. Next to glutamic acid was aspartic acid in all the samples with values ranging from 7.49 – 10.65 g/100 gcP. The least abundant amino acid was cystein (1.50-1.61 g/100 gcP). Similar trend was observed by Mubarak [39] and Adeyeye [32] who worked on the amino acid profiles of mungbean seeds and whole duck egg respectively.

Parameter/sample	QPM	QPM:SES	QPM:MUS	QPM:SES:MUS
Peak viscosity (RVU)	42.08^a	32.83^b	32.00^b	34.42^b
Trough viscosity (RVU)	37.42^a	29.17^b	27.67^c	30.50^b
Breakdown (RVU)	4.67^a	3.67^b	4.33^a	3.92^b
Final viscosity (RVU)	93.30^a	78.67^b	70.92^c	83.58^b
Setback (RVU)	55.92^a	49.50^b	43.25^c	53.08^a
Peak time (min)	6.90^a	6.90^a	6.90^a	6.90^a
Pasting temp (°C)	93.65^a	92.85^a	92.80^a	93.45^a
Mean ± SD				

Table 4: Pasting properties of QPM and supplemented QPM samples.

Sample	QPM	QPM:SES	QPM:MUS	QPM:SES:MUS
Glycine	3.36	3.19	3.68	3.88
Alanine	5.77	6.14	5.57	4.72
Serine	3.99	3.56	4.40	5.43
Proline	4.10	5.28	3.89	4.64
Valine	2.40	2.20	3.28	3.67
Threonine	3.88	3.79	4.03	4.28
Isoleucine	3.64	3.88	3.69	4.49
Leucine	7.13	7.15	7.15	7.44
Aspartate	10.26	10.65	7.49	9.69
Lysine	3.70	4.03	6.17	5.35
Methionine	1.92	1.93	2.93	1.59
Glutamate	16.41	16.77	12.56	16.69
Phenyalanine	3.77	3.84	4.27	5.75
Histidine	2.21	2.23	2.62	3.01
Arginine	7.65	7.97	6.99	4.76
Tyrosine	2.78	2.67	3.05	3.19
Tryptophan	1.32	1.29	1.27	1.07
Cystine	1.54	1.50	1.61	1.50
TAA	89.19	91.26	89.33	95.03
cP: Crude Protein				

Table 5: Amino acid composition of QPM and supplemented QPM samples (g/100 g cP).

The concentration of the essential amino acid showed that the most abundant essential amino acid (EAA) was leucine with a range of 7.13-7.44 g/100 gcP, while the least abundant was tryptophan with a range of 1.28-1.32 g/100 gcP. The addition of both sesame and mushroom flours to QPM improved the concentration of some of the amino acids. The earlier reports show that QPM contain high concentration of Leucine (13.28 g/100 gcP) compared to common maize (8.82 g/100 gcP). Previous study also established the fact that QPM contain high concentration of both lysine and Tryptophan than do in common maize [6,7].

The essential amino acids are regarded as the obligatory amino acids which cannot be produced in the body at needed level but must be supplied through food. The amino acids valine, leucine and isoleucine are responsible for the synthesis of substrates for gluconeogenesis while phenylalanine is needed for the production of a pigment called melanin that contributes to eye, hair and skin colour. Tryptophan is the precursor for the synthesis of serotonin and aspartate and glutamate serve as ammonia transporters to the liver and kidney for urea synthesis (Kayode et al., 2015) Not listed.

The result (Table 6) showed that the total amino acids (TAA) of the blends ranged from 89.22 to 95.03. The TEAA and TNEAA of the blends ranged between 37.62-43.40 and 45.93-53.62 respectively. The EAAI varied between 45.89% and 95.56%, P-PER ranged between 2.27 and 2.56, P-BV ranged from 38.32% to 92.46% while the Nutritional index ranged between 4.91% and 24.19%. The %TEAA/TAA ranged from 41.98% to 48.58%. The percentage TNEAA/TAA ranged between 51.42 and 58.02%. The total sulphur amino acid (TSAA) of the samples were 3.46 g/100 g (QPM), 3.43 g/100 g (QPM: SES), 4.54 g/100 g (QPM: MUS) and 3.09 g/100 g (QPM: SES: MUS). The value of 4.58 g/100 g was the highest, however, it is lower than the value of 5.80 g/100 g recommended for infants [24]. The %TSAA ranged between 3.25 and 5.08%. The total aromatic AA (TArAA) ranged between 6.51 and 8.94 g/100 g. This range falls within the range recommended for ideal infant protein (6.8-11.8 g/100 g) [24].

From the study, it was observed that the calculated nutritional quality the EAAI, BV and NI were low in 100%QPM compared to the supplemented samples. The addition of sesame and mushroom improved the nutritional quality of the blends. The best result was

Nutritional quality parameter	QPM	QPM:SES	QPM:MUS	QPM:SES:MUS
TAA	89.62	91.26	89.33	95.03
TNEAA	52.00	52.95	45.93	53.62
TEAA	37.62	38.31	43.40	41.41
TEAA/TAA%	41.98	41.98	48.58	43.58
TNEAA/TAA%	58.02	58.02	51.42	56.42
TSAA(Meth + Cystein)	3.46	3.43	4.58	3.09
TSAA%	3.88	3.76	5.08	3.25
TArAA (Phenyl +Try)	6.55	6.51	7.32	8.94
TArAA %	7.34	7.13	8.19	9.41
EAAI (%)	45.89	48.06	95.56	83.86
P-PER	2.47	2.27	2.56	2.46
P-BV (%)	38.32	40.69	92.46	76.71
Nutritional Index (%)	4.91	9.94	24.19	18.08
TAA: Total Amino Acid; TNEAA: Total Non-Essential Amino Acid; TEAA: Total Essential Amino Acid; TSAAs: Total Sulfur Amino Acids; TAAAs: Total Aromatic Amino Acids; TEAAs: Total Essential Amino Acids; P-PER: Predicted Protein Efficiency Ratio; P-BV: Predicted Biological Value				

Table 6: Calculated nutritional quality of QPM and supplemented QPM samples.

Sample	Taste	Colour	Flavour	Appearance	Consistency	Overall acceptability
QPM	6.40 ± 0.89[a]	6.80 ± 1.34[a]	7.20 ± 1.30[a]	7.80 ± 2.17[a]	7.40 ± 0.89[a]	7.40 ± 0.89[a]
QPM:SES	4.40 ± 0.89[bc]	5.80 ± 1.79[ab]	6.00 ± 0.71[ab]	5.60 ± 1.34[a]	5.60 ± 1.34[b]	5.20 ± 1.09[b]
QPM:MUS	3.40 ± 0.89[c]	6.00 ± 1.09[ab]	6.40 ± 1.34[ab]	6.20 ± 1.30[a]	4.60 ± 0.89[b]	5.20 ± 1.30[b]
QPM:SES:MUS	4.60 ± 0.54[b]	4.60 ± 1.41[b]	5.20 ± 1.79[b]	5.80 ± 1.09[a]	5.40 ± 1.34[b]	4.40 ± 0.89[b]
Mean ± SD						

Table 7: Sensory evaluation of QPM and supplemented QPM samples.

observed in the QPM supplemented with mushroom. Next to it was the sample containing equal proportions of sesame and mushroom. According to Oser [18] as reported by Ijarotimi [40] food material is classified as having good nutritional quality when its biological values (BV) is high 70%-100% and when the essential amino acid index (EAAI) is greater than 90%.

In general, mushroom supplemented samples recorded higher values in terms of all the nutritional parameters determined and this indicated its usefulness as food for infants in alleviating the problem of malnutrition.

Sensory evaluation of QPM and supplemented QPM samples

Table 7 showed that the sensorial quality assessment conducted on the various samples were significantly different ($p<0.05$) in the taste. The best sample in terms of taste was the 100% QPM sample. The addition of the sesame and mushroom resulted in the decline of preference for the taste of the samples containing the supplements. There were significant differences ($p<0.05$) between the 100%QPM sample and the other samples in terms of colour and flavour. The fortified samples were not significantly different ($p>0.05$) from each other. There was no significant difference ($p>0.05$) in the appearance of the samples. However, there was significant difference ($p<0.05$) between the 100%QPM and other supplemented samples in term of consistency. The addition of sesame and mushroom reduced the consistency from 7.40 to 4.60 as assessed by the panelists.

The overall acceptability showed that the 100%QPM sample was rated best among the samples while the other fortified samples were not significantly different ($p>0.05$) from each other. In general, the assessment showed that all the samples were acceptable but the 100%QPM was most acceptable. This may be explained by the fact that the panellists are used to maize gruel, unlike the other sample which contained some other items.

Conclusion

The study concluded that addition of sesame and mushroom to quality protein maize improved the protein, some amino acids, crude fiber, and energy among others. The nutritional qualities evaluated compared favorably with qualities of similar products which are used as complementary food produced from cereal and legumes. From the study mushroom could be used as a good supplement to improve the nutritional quality of cereal. Quality protein maize supplemented with mushroom and sesame is a potential weaning/complementary food that mothers in the developing countries can exploit as weaning/ complementary food for breastfed infants.

Conflict of Interest

There is no conflict of interest with respect to the study and article.

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