POTENTIAL COMPLEMENTARY FOOD FROM QUALITY PROTEIN MAIZE (*ZEA MAY* L.) SUPPLEMENTED WITH SESAME (*SESANUM INDICUM*) AND MUSHROOM (*OUDEMANSIELLA RADICATA*)

Ikujenola Abiodun Victor[1]*, **Ogunba** Beatrice Olubukola[2]

[1]Department of Food Science and Technology
[2]Department of Family, Nutrition and Consumers Sciences
Obafemi Awolowo University, Ile-Ife, Nigeria.
*E-mail:avjenlola@gmail.com.

ABSTRACT
The study developed, processed and assessed blends of quality protein maize (QPM), defatted sesame seed and mushroom flours as potential complementary food. The crops were cleaned and sorted before being processed to flours separately using standard methods. The flours were blended at various proportions of 100:0:0; 70:30:0; 70:0:30; 70:15:15 (QPM: defatted Sesame: Mushroom). The proximate and mineral compositions, amino acids profile and functional properties of the blends were analysed using standard methods. The flour blend was reconstituted to form gruel at 20% dry matter for the sensory analysis. 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/100gcP) was the most abundant essential amino acid while tryptophan (1.28 – 1.32 g/100gcP) 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

Key words: Amino acids; bulk density; lysine; malnutrition; total amino acids.

Received: 02.05.2018 Reviewed: 03.09.2018 Accepted: 21.09.2018

1.INTRODUCTION

In developing economies, infants are expected to be breastfed for the first six months. At about six months of age, the supply of energy and some nutrients from breast milk is no longer adequate to meet the growing infant's needs. 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 requirements of the infants at this stage are fed to them. This has been implicated as a cause of malnutrition in infants which accounted for major cause of infantile mortality in most developing countries (Samuel, 2013). In developing countries various stakeholders have advocated for the utilization of cereals, grain legumes and other crops to solve this problem. However, there are still unexploited crops in this regard that could be utilized to ameliorate the menace.

Edible mushrooms are excellent sources of essential oils, protein (including all the essential amino acids), vitamins, minerals, lectins, fibre and bioactive compounds (Rezaeian *et al*., 2016). Most people eat mushrooms, mostly because of its flavour, meaty taste and medicinal value. Mushrooms can be used as food to solve the problems of shortage of protein and minerals (Teklit, 2015). Information on the use of mushroom in the production of complementary food is scarce. Quality protein maize is a biofortified maize which contain high level of lysine and tryptophan; two limiting amino acids in common maize (Prassana *et al*., 2001). It has been used for the production of several products like complementary foods, animal feed, etc. (Abiose *et al*., 2015). Sesame seed is known for its high oil content and good quality protein. It has been blended with cereal in weaning food production (Ikujenlola and Fashakin, 2005). There is no information on the utilization of blends of mushroom, sesame and QPM blends as complementary food for children. Therefore, the aim of this study was to produce and assess the nutritional quality of potential complementary foods from QPM, sesame and mushroom.

2. MATERIALS AND METHODS

The materials used for this study were quality protein maize (QPM) 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 characterized and 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 according to the method reported by Ikujenlola and Adurotoye (2014) shown in Figure 1.

Production of mushroom (*Oudemansiella radicata*) flour

The mushroom was sorted, cleaned, sliced and dried in a cabinet drier (MRC oven, UK) at 60 ^{0}C for 12 hours according to the method of Muyanja *et al*. (2014) as shown in Figure 1.

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

The sesame seeds were cleaned of all dirt and extraneous materials by winnowing. The defatted sesame seed flour was produced by adopting the method of Moharran *et al.* (1990) as shown in Figure 1.

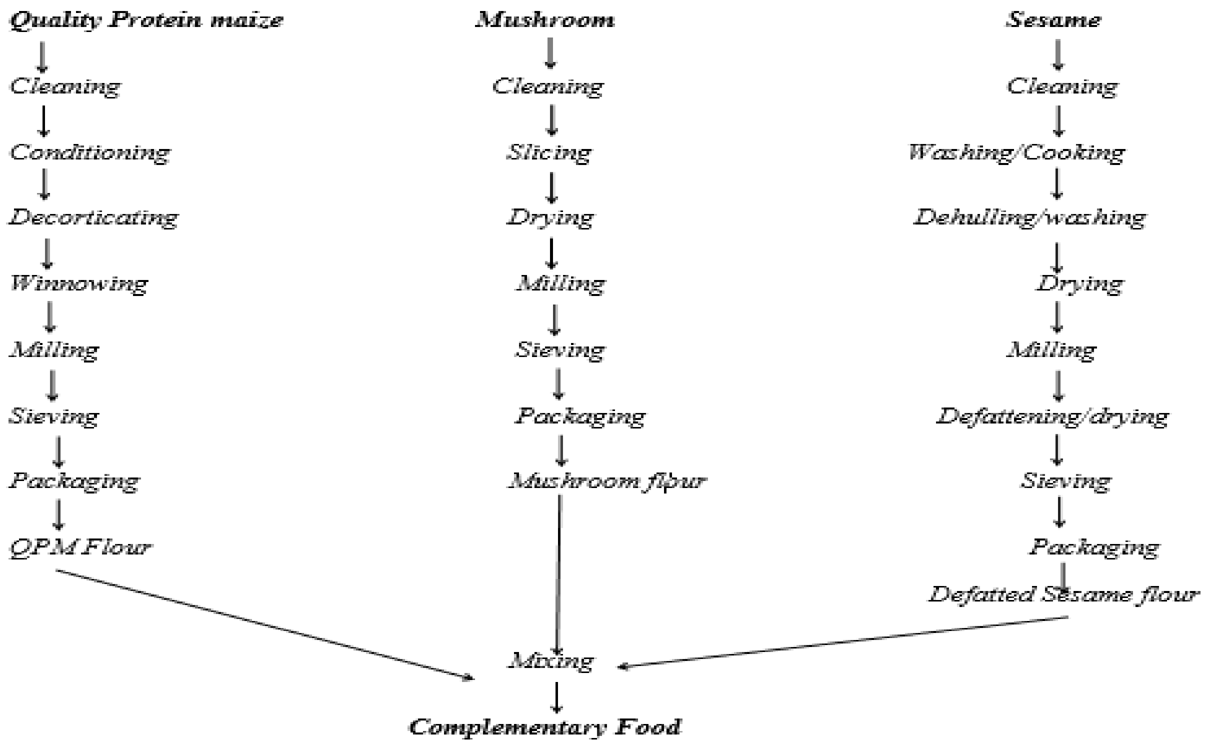

Figure 1: Production of QPM, Mushroom and defatted Sesame flours.

Formulation of complementary food blends

The flours were formulated into various 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 flour blends

The proximate composition of the food blends was determined using the standard procedures of Association of Official Analytical Chemists (AOAC, 2005) while Carbohydrate content was determined by difference, that is;
% Carbohydrate = 100 - (% Moisture + % Fat + % Ash + % Crude fibre + % Crude protein).

Gross energy

Energy of the samples was determined by calculation from fat, carbohydrate and protein content using the Atwater's conversion factor; 4.0 kcal/g protein, 9.0 kcal/g fat and 4.0 kcal/g carbohydrate (Ijarotimi *et al.*, 2015).

Mineral composition determination

The standard method described by Association of Official Analytical Chemists was used for mineral content analysis of the samples (AOAC, 2005).

Functional properties determination

The selected functional properties of the diets determined included bulk density, water absorption capacity, oil absorption capacity, swelling capacity and reconstitution index of the flours were determined following the methods described by Gopaldas and John (1992).

Pasting properties determination

Pasting characteristics were determined with a Rapid Visco Analyzer (RVA) (Model RVA 3D+, Newport Scientific Australia). First, 3.0 g of the sample was weighed into a dried empty canister; then 25 ml of distilled water was dispensed into the canister containing the sample. The solution was thoroughly mixed and the canister was well fitted into the RVA as recommended. The slurry was heated from 50-95 ^{o}C with a holding time of 2 min followed by cooling to 50 ^{o}C with 2 min holding time. The rate of heating and cooling were at a constant rate of 11.25 ^{o}C per min. Peak determinations. Norleucine served as the internal standard.

The tryptophan content was determined in a separate analysis as described by Ijarotimi and Keshinro (2013).

Predicted Nutritional Quality

Predicted protein efficiency ratio (P-PER)

Protein efficiency ratio of the flour sample was calculated according to the predicted protein viscosity, trough, breakdown, final viscosity, set back, peak time and pasting temperature were read from the pasting profile with the aid of thermocline for windows software connected to a computer (Newport Scientific, 1998).

Amino acid determination

Sample preparation for amino acid analysis

About 2.5g of each sample was weighed into the extraction thimble and fat was extracted with a chloroform/methanol (2:1, v/v) mixture using a Soxhlet apparatus (AOAC, 2005). The extraction lasted for 5–6hours.

Hydrolysis of samples

About 30mg of the defatted sample was weighed into glass ampoules. Exactly 7ml of 6mol/L HCl was added and oxygen expelled by passing nitrogen gas into the samples. The glass ampoule was sealed with a Bunsen flame and put into an oven at 105±5 ^{0}C for 22h. The ampoule was allowed to cool; the content was filtered to remove humins. The filtrate was then evaporated to dryness at 40 ^{0}C under vacuum in a rotary evaporator. Each residue was dissolved with 5mL 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 High Performance Liquid Chromatography (HPLC) specifically using the Technicon Sequential Multisample (TSM) Amino Acid Analyser (Technicon Instruments Corporation, New York). The period of analysis was 76min for each sample. The gas flow rate was 0.50mL/min at 60 ^{0}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 value reported was the average of two efficiency ratio equation reported by Ijarotimi et al. (2015).

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

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

Essential amino acid Index (EAAI)

Nutritional qualities were determined on the basis of the amino acid profiles. The essential amino acid index (EAAI) was calculated using the method of Labuda *et al*. (1982).

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

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)

Biological value was computed according to the method of Oser (1959). The following equation was used for BV determination.

BV = 1.09 (EAA Index) – 11.7

Nutritional index (NI)

The nutritional index of the food sample was calculated using the formula described by Crisan and Sands (1978).

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

Sensory evaluation of the supplemented QPM samples

The method of Agu *et al*. (2015) was adopted in the determination of sensory quality of the coded samples. Twenty semi 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 complementary food. The panelists were given specific instructions on what to do. The attributes evaluated were colour, texture, aroma, taste and overall acceptability. Scoring was done on 9-point Hedonic scale where 9 =like extremely and 1=disliked extremely.

Statistical analysis

The data were analyzed using SPSS version 15.0. The mean and standard deviation of the triplicate analyses of the samples were calculated. The analysis of variance (ANOVA) was performed to determine significant differences between the means of proximate composition, minerals, sensory and functional properties; while the means were separated using the new Duncan multiple range test at p<0.05.

3. RESULTS AND DISCUSSION

Proximate composition of supplemented QPM samples

The results of the proximate composition of the blends produced from QPM, sesame and mushroom is presented in Table 1. The results showed that the protein content of the samples varied between 10.44 and 25.32%. The result of the protein of 100% QPM compared favourably with the result (9.72%) reported by Abiose and Ikujenlola (2014) for a variety of QPM grains. The addition of both sesame and mushroom improved the level of protein of the diets. The supplemented diet has a better chance to sustain infants with respect to protein quality. According to Prassana *et al*. (2001) and Abiose and Ikujenlola (2014) QPM contain high level of lysine and tryptophan which are lacking in common maize. The daily recommended intake of protein for infants (6-12months) is 13.0 – 13.5g/day (Institute of Medicine (IOM), 2005). 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 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.

TABLE 1. Proximate and Mineral compositions of QPM and supplemented QPM samples (%).

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}

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

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 (PAG) (1971). 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*. (2013) for weaning food produced from banana supplemented with cowpea and peanut.
The crude fibre ranged between 3.55 and 5.79% while the moisture content of the blends was 9.32% for QPM and 10.68% for QPM: SES. Low moisture content of weaning food will have a positive effect on its shelf stability as the higher the moisture content the less stable the food will be toward oxidative reactions if other environmental factors are favourable.
The carbohydrate and energy contents of the blends ranged from 51.04 – 66.20% and 329.29 - 353.15 kcal respectively. The calculated energy requirements for a weaning infant ideally ranged from 99.04 kcal (414kJ)/kg per day for a 4- to 5-month old to 94.97 kcal (397 kJ)/kg for the 8 to 9 month old (WHO, 1991). 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 reported by Gahlawat and Sehgal (1993); who obtained protein content of 13.9 –14.2% and moisture, ash, fat, and calories in the range of 5.45-6.15%, 4.20–4.61g, 1.27–1.60g, and 348–364kcal per 100g respectively.

The mineral content of QPM and supplemented QPM samples

The mineral composition of the blends (Table 1) shows that the most abundant of the minerals was potassium (698.57 – 1262.00 mg/100g). 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 Oshodi *et al*. (1999) who reported potassium to be the most abundant mineral in Nigerian agricultural products. Potassium is crucial to heart function and plays a key 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/100g) and (1.25 – 2.54 mg/100g) respectively. The sodium, zinc and magnesium ranged from (42.50 – 268.20 mg/100g), (2.36 – 3.35 mg/100g) and (95.29 – 167.47 mg/100g) respectively.
According to Olayinka (2016) 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/100g respectively while that of *L. squarrosulus a*re 75.89, 789.67, 36.20 and 281.15 mg/ 100g respectively.

The functional properties of QPM and supplemented QPM samples

The functional properties of the blends are presented in Table 2. The loose and packed bulk densities ranged between 0.40 – 0.42 g/ml and 0.52 – 0.69 g/ml respectively. The loose bulk density is the lowest attainable density without compression while the packed bulk density is the highest attainable density with compression.
The bulk density range is lower than the range 0.91 to 1.19 g/ml reported by Desalegn *et al*.

(2015) 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, loose bulk density promotes easy digestibility of food products, particularly among children with immature digestive system (Gopaldas and John, 1992). Low bulk density of flour is a good physical attribute when determining transportation and storability since the products could be easily transported and distributed to required locations. The lower the bulk density value, the higher the amount of flour particles that can stay together and thus increasing energy content that could be derivable from such diets (Udensi and Eke, 2000).

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 (Ikujenlola and Adurotoye, 2014).

According to Mbaeyi-Nwaoha and Uchendu (2016) the water absorption characteristic represents the ability of a product to associate with water under condition where water is limiting, in order to improve its handling characteristics and dough making potentials.

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 into layers but the mixture 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 2. The features of the pasting characteristics followed similar trend for viscosity related 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*. (2010) who worked on similar product.

TABLE 2. Functional and pasting properties of QPM and supplemented QPM samples.

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}
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(^{0}C)	93.65^{a}	92.85^{a}	92.80^{a}	93.45^{a}

Mean ± SD

The highest viscosity was found in the 100%QPM, while the addition of the sesame and mushroom led to the decline in the values. The peak viscosity which is the ability of starch to swell freely before their physical breakdown 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 ^{o}C, peak time was 6.90 min. The pasting temperature indicates the minimum temperature required for sample to cook, energy costs involved and other components stability.

Amino acids profile and nutritional quality of the supplemented QPM diets

The amino acids profile of the potential complementary food blends are presented in Table 3. The QPM contained all the essential amino acids especially lysine and tryptophan which are said to be limiting amino acids in common maize. The lysine and tryptophan were 3.70 g/100g crude protein and 1.32 g/100g crude protein respectively. The addition of both sesame and mushroom increased the concentration of the amino acids of the products. The most abundant amino acid was glutamic acid 12.56 – 16.77 g/100g with a trend of QPM: MUS< QPM< QPM: MUS: SES<QPM: SES. Next to glutamic acid was another acidic amino acid, aspartic acid in all the samples with values ranging from 7.49 – 10.65g/100gcP. The least abundant amino acid was cystein (1.50 – 1.61g/100gcP).

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/100gcP, while the least abundant was tryptophan with a range of 1.28 - 1.32 g/100gcP. The addition of both sesame and mushroom flours to QPM improved the concentration of some of the amino acids. The earlier report of Abiose and Ikujenlola (2014) show that QPM contain high concentration of leucine (13.28 g/100gcP) while common maize contain leucine of 8.82 g/100gcP. Previous study (Prassana *et al*., 2001) also established the fact that QPM contain high concentration of both lysine and tryptophan than do in common maize.

The essential amino acids are regarded as the indispensable amino acids which cannot be synthesised in the body at the required level but must be supplied via food. The amino acids valine, leucine and isoleucine are utilized for the synthesis of substrates for gluconeogenesis while phenylalanine is necessary for the synthesis 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).

TABLE 3. Amino acid composition of QPM and supplemented QPM samples (g/100 g cP).

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.

The result (Table 4) 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/100g (QPM), 3.43 g/100g (QPM: SES), 4.54 g/100g (QPM: MUS) and 3.09 g/100g (QPM: SES: MUS). The value of 4.58 g/100g was the highest; however, it is lower than the value of 5.80 g/100g recommended for infants (WHO, 1991). The %TSAA ranged between 3.25 and 5.08%. The total aromatic AA (TArAA) ranged between 6.51 and 8.94 g/100g. This range falls within the range recommended for ideal infant protein (6.8 - 11.8 g/100g) (WHO, 1991).

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 observed in the QPM supplemented with mushroom. Next to it was the sample containing equal proportions of sesame and mushroom. According to Oser (1959) as reported by Ijarotimi (2012) food material is said to be of good nutritional quality when its biological values (BV) is high 70-100% and also when the essential amino acid index (EAAI) is above 90%.

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

Sensory Evaluation of QPM and supplemented QPM samples

The sensorial quality assessment results (Table 5) showed that there were significant difference ($p<0.05$) in the taste of the samples. The best sample in terms of taste was the 100% QPM.

TABLE 4. Calculated Nutritional quality of QPM and supplemented QPM samples

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

Total amino acid (TAA), Total non essential amino acid (TNEAA), Total essential amino acid (TEAA), Total sulfur amino acids (TSAAs), Total aromatic amino acids (TAAAs), Total essential amino acids (TEAAs), Predicted protein efficiency ratio(P-PER), predicted biological value(P-BV).

TABLE 5. Sensory evaluation 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}

The addition of the sesame and mushroom resulted in the decline of the preference for the taste of the samples containing the supplement. 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 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.

4.CONCLUSION

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

Conflict of Interest

There is no conflict of interest as far as the study and article are concerned.

Funding

The authors did not receive any grant during the course of the study

ACKNOWLEDGMENT

The authors are grateful to the Department of Food Science and Technology for the provision of some the facilities used in the analysis. Also the contributions of Mr. Emeka Ibe Sunday of Institute of International Tropical Agriculture, Ibadan is commendable.

5. REFERENCES

[1] Abiose, S. H. and Ikujenlola, A. V. 2014. Comparison of chemical composition, Functional Properties and Amino Acids Composition of Quality protein maize and common maize. African Journal of Food Science and Technology 5 (3): 81-89. doi:http:/dx.doi.org/10.14303/ ajfst.2014. 024.

[2] Agu, H.O., Ayo, J.A. and Jideani, A.I.O. 2015. Evaluation of the quality of malted acha-soy breakfast cereal flour. African Journal of Food, Agriculture, Nutrition and Environment 15 (5): 10542-10560.

[3] AOAC. 2005. Official Methods of Analysis 18th ed. Washington DC: Association of Official Analytical Chemists.

[4] Bassey, F. I., Mcwatters, K. H., Edem, C. A. and Iwegbue, C. M. A. 2013. Formulation and nutritional evaluation of weaning food processed from cooking banana, supplemented with cowpea and peanut. Food Science and Nutrition *1(5):* 384–39. DOI: 10.1002/fsn3.51.

[5] Crisan, E.V. and Sands, A. 1978. Biology and Cultivation of Edible Mushrooms. New York: Hangeri Academic Press.

[6] Desalegn, B. B., Abegaz, K. and Kinfe, E. 2015. Effect of Blending Ratio and Processing Technique on Physicochemical Composition, Functional Properties and Sensory Acceptability of Quality Protein Maize (QPM) Based Complementary Food. International Journal of Food Science and Nutrition

Engineering 5(3): 121-129. Doi: 10.5923/j.food.20150503.03.
[7] Gahlawat, P. and Sehgal, S. 1993. The influence of roasting and malting on the total and extractible mineral contents of human weaning mixtures prepared from Indian raw materials. Food Chemistry 46:253–256.
[8] Gopaldas, T. and John, C. 1992. Evaluation of a controlled 6 months feeding trial on intake by infants and toddlers fed high-energy low bulk gruel versus high energy-high bulk gruel in addition to their habitual home diet. Journal of Tropical Paediatric 38: 278–283.
[9] Ijarotimi, O. S. 2012 Influence of germination and fermentation on chemical composition, protein quality and physical properties of wheat flour (*Triticum aestivum*). Journal of Cereals and Oil seeds 3(3): 35-47. DOI: 10.5897/JCO12.015.
[10] Ijarotimi, S.O. and Keshinro, O.O. 2013. Determination of Nutrient Composition and Protein Quality of Potential Complementary Foods Formulated from the Combination of Fermented Popcorn, African Locust and Bambara Groundnut Seed Flour. Polish Journal Food and Nutrition Sciences 63(3) 155-166. DOI: 10.2478/v10222-012-0079-z
[11] Ijarotimi, O.S., Nathaniel, F.T. and Faramade, O.O. 2015. Determination of Chemical Composition, Nutritional Quality and Anti-Diabetic Potential of Raw, Blanched and Fermented Wonderful Kola *(Bucholzia coriacea)* Seed Flour. Journal of Human Nutrition and Food Science 3(2): 1060.
[12] Ikegwu, O.J., Okechukwu, P.F. and Ekumankan, E.O. 2010. Physico-Chemical and Pasting Characteristics of Flour and Starch from Achi *Brachystegia eurycoma* Seed. Journal of Food Technology 8(2): 58-66. doi: 10.3923/jftech.2010.58.66.
[13] Ikujenlola, A.V. and Adurotoye, E.A. 2014. Evaluation of Quality characteristics of high nutrient dense complementary food from mixtures of malted Quality protein maize (*Zea mays* L) and steamed cowpea (*Vigna unguiculata).* Journal Food Process Technology 5:291.
[14] Institute of Medicine (IOM). 2005. Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids. National Academy Press.
[15] Kayode, R.M.O., Olakulehin, T.O., Adedeji, B.S., Ahmed, O., Aliyu, T.H. and Badmos, A.H.A. 2015. Evaluation of amino acid and fatty acid profiles of commercially cultivated oyster mushroom (*Pleurotus sajor-caju*) grown on gmelina wood waste. Nigerian Food Journal 33(1): 18-20. Doi:10.1016/j.nifoj.2015.04.001.
[16] Labuda, J., Kacerovský, O., Kováč, M. and Štěrba, A. 1982. Výživa a krmenie hospodárských zvierat. Príroda, Bratislava, (Nutrition and feeding of farm animals. Nature, Bratislava) p. 164.
[17] Mbaeyi-Nwaoha, I. E. and Uchendu, N. O. 2016. Production and evaluation of breakfast cereals from blends of acha and fermented soybean paste (okara). Journal of Food Science and Technology 53(1): 50–70. DOI 10.1007/s13197-015-2032-8.
[18] Muyanja, C., Kyambadde, D. and Namugumya, B. (2014), Effect of Pretreatments and Drying Methods on Chemical Composition and Sensory Evaluation of Oyster Mushroom (*Pluerotus Oestreatus*) Powder and Soup. Journal of Food Processing and Preservation,38: 457–465. doi: 10.1111/j.1745-4549.2012.00794.x
[19] Newport Scientific. 1998. Applications Manual for the Rapid Visco Analyzer using Thermocline for Windows. 2-26, Australia: Newport Scientific Pvt. Ltd.
[20] Olayinka, A. A. 2016. Evaluation of the Nutritional Status of Two Edible Mushroom Species in Ekiti State, Nigeria. Food Science and Quality Management 51:32-36.
[21] Oser, B.L. 1959. An Integrated Essential Amino Acid Index for Predicting the Biological Value of Proteins. In: Albanese, A.A., Ed., Amino Acid Nutrition, p. 295-311. New York. Academic Press.
[22] Protein Advisory Group (PAG). 1971. Guidelines on Protein Rich Mixtures for Use in Weaning Foods. Protein Advisory Group, United Nations, 45-76.
[23] Prassana, B.M., Vassal, S.K., Kassahun, B. and Singh, N.M. 2001. Quality Protein maize. Current Science 81(10): 1308-1319.
[24] Rezaeian, S., Saadatmand, S., Sattari, T. N. and Mirshamsi, A. 2016. Antioxidant potential and other medicinal properties of edible mushrooms naturally grown in Iran. Biomedical Research 27 (1): 240-247.
[25] Samuel, O. O. 2013. Infant Mortality in Nigeria: Assessing Knowledge of Predisposing Risk Factors among Mothers and Bacteriological Profile of the Weaning Foods. American Journal of Food and Nutrition 1(3): 22-26.
[26] Teklit, G. A. 2015. Chemical Composition and Nutritional Value of the Most Widely Used Mushrooms Cultivated in Mekelle Tigray Ethiopia. Journal of Nutrition and Food Science 5: 408. doi:10.4172/2155-9600.1000408
[27] Udensi, A. and Eke, O. 2000. Proximate composition and functional properties of flour produced from *Mucuna cochinensis* and *Mucuna utles*. In Udensi, A. and Eke, O. (Eds). Proceedings of the 1st Annual Conference of the College of Agriculture and Veterinary Medicine p. 170–174. Uturu: Abia State University.
[28] World Health Organisation (WHO). 1991. Energy and protein requirements. Report of a Joint FAO/WHO/UNU Expert Consultation. Technical Report Series No. 724. Retrieved on March 12, 2014 from http://www.fao.org/docrep/003/aa040e/aa040e00.HTM