CHEMICAL COMPOSITION AND AMINO ACIDS PROFILES OF COMPLEMENTARY BLENDS DEVELOPED FROM MALTED AND FERMENTED QUALITY PROTEIN MAIZE ENRICHED WITH SOYBEAN FLOURS

Abiodun Victor **Ikujenlola**[1*], Sumbo Henrietta **Abiose**[1]
[1]Department of Food Science and Technology, Obafemi Awolowo University, Ile-Ife, Nigeria
[*]E-mail: avjenlola@gmail.com; +2348033843674

Abstract
Background: The study was carried out to produce complementary diets from quality protein maize (QPM) enriched with soybean flour, with a view to producing diet that could alleviate malnutrition in children.
Materials and Methods: Malted and fermented maize flour samples were produced separately by malting and fermenting the maize grains. The soybean seeds were soaked, dehulled, steamed, dried, milled, and sieved to produce soy flour. The resulting flour samples were blended at ratios 100:0; 70:30 (maize: soy). The samples were analyzed for proximate composition, amino acid profiles, mineral content and anti-nutritional factors using standard methods.
Results: The results showed that there was no significant difference (p<0.05) between the proximate composition of maize varieties subjected to similar treatments. The addition of soybean increased the levels of the protein (17.02-21.50%) and fat (8.30-10.26%) of the samples. The addition of soybean to QPM improved the level of lysine (3.50-4.10 g/100g protein), leucine (8.20-11.23 g/100g protein) than in normal maize products. The level of the anti-nutrients reduced in the malted and fermented products. Malting and fermentation processes, and enrichment with soybean improved the levels of sodium (68.50-135.22 mg/l00g), potassium (56.26-106.21 mg/100g), and calcium (69.58-196.30 mg/100g).
Conclusion: The study concluded that nutritious complementary diet of better quality could be produced from the quality protein maize compared to common maize.

Keywords: malnutrition, malting, fermentation, essential amino acid, lysine, antinutrients

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1. INTRODUCTION

The growth and adequate development of infants are important during breastfeeding and after cessation of breastfeeding. Malnutrition is caused by short supply of essential nutrients to infants; this has been responsible for various infections and infantile mortality (Victora *et al.*, 2016). In developing countries, there have been records of high infantile mortality as a result of inadequate provision of nutritious meal to children during their weaning age. There are various efforts to reduce the rate of mortality resulting from malnutrition by provision of various diets produced from cereals for example maize, sorghum, millet, etc. and legume e.g cowpea, soybean, ground nut, etc.(Abeshu *et al.*, 2016). Most of the time, the efforts have not yielded expected results due to one or more of the following; method of processing, types of crops, maternal food choice and nutrition education. Maize has been in use as complementary food from time immemorial. In most part of the world, maize has emerged as one of the most important crops as food, feed and in industrial applications. It contributes over 20% of the total calories in human diets in 21 countries, and over 30% in 12 countries that are home to a total of more than 310 million people (Eshetie, 2017). The normal maize according to Vassal (l994), lacks two vital amino acids namely lysine and tryptophan, which are required by monogastric animals. These essential amino acids cannot be synthesized by mono-gastric animal including man; it has to be supplied through food (Akumoa-Boateng, 2002; Abiose andIkujenlola, 2014). The research of the International Maize and Wheat Improvement Centre(CIMMYT) brought about the new hybrid a derivative of opaque-2 maize called quality protein maize (QPM) which is biofortified maize from conventional breeding work. It has hard endosperm, with similar yield to normal maize and nutritionally enhanced (Eshetie, 2017). Soybean (*Glycine max*) is noted for quality protein and high oil content which are required for good health in both children and adults. Soybean has high amount of protein and other vital nutrients. Its protein is high in lysine but low in methionine (Iwe, 2003). Cereals and legumes complement each other nutritionally. Malting and fermentation have been reported to be effective and convenient for improving nutritional value of cereals (Hotz *et al*., 2001). Malting and fermentation are processes found to be nutrient enhancer (Agu and Aluya, 2004). The aim of this study was to produce and assess complementary food from malted/fermented quality protein maize enriched with soybean flour.

2. MATERIALS AND METHODS

Materials

The materials used for the study were two maize varieties (white Quality Protein Maize (QPM)
'Obatampa' var. and white normal Maize (NM) MZ03 var.) and Soybeans obtained from International Institute of Tropical Agriculture (IITA), Ibadan.

Methods

Production of malted, fermented maize and soybean flour samples

Malting of the maize grains was carried out as shown in Figure 1. The maize grains (QPM and NM) were cleaned, washed, steeped in tap water for 8 hours at room temperature. The steeped grains were allowed to germinate in a germinating chamber for a period of 72 hours with watering four times daily. The germinated grains were thereafter washed two times. This was followed by steaming of the grains for 10 minutes to pre-gelatinize the starch. The steamed grains were dried at 60°C for 20 hours, milled, sieved and packaged in polythene bags and kept until required (Sajilata *et al*., 2002). For fermented flour, the grains were steeped/fermented for 72 hours. The fermented grains were thoroughly washed, wet milled, sieved, drained, dried (60°C, 12 hours) and packaged in po1ythene bags and kept until required as shown in Fig. I (Usman *et al*., 2016).

Soybean flour was produced according to Iwe (2003) as shown in Figure 1. The soybean seeds were cleaned and soaked in warm water (into which 0.2 % $NaHC0_3$ was added) for 3 hours. The soaked seeds were decorticated, washed, steamed for 1 hour and dried in a cabinet dryer at 60°C for 12 hours. The dried seeds were milled, sieved (50 mesh) and packaged in polyethylene bags until needed.

Formulation of Complementary diets

The dietary blends were formulated at 100:0 and 70:30 (maize flour: soybean flour) in accordance with the recommendation of World Health Organization (FAO/WHO/UNU, 1985).

Proximate composition and Mineral content determination

The moisture, ash, fat, crude protein and crude fibre of the samples were determined using the methods of AOAC (2005). Carbohydrate content was estimated by difference. Caloric value was determined by calculation using the Atwater's conversion factors. The mineral content of the flour samples were determined using the standard method of AOAC (2005).

Amino acid content determination

The amino acid profile was determined using the method reported by Kaga et al. (2002) and Abiose and Ikujenlola (2014). The amino acid analysis was determined at the Department of Zoology, University of Jos, using the High Performance Liquid Chromatography (HPLC) specifically the Technicon TSM (technosequential multisample) analyser for amino acid.

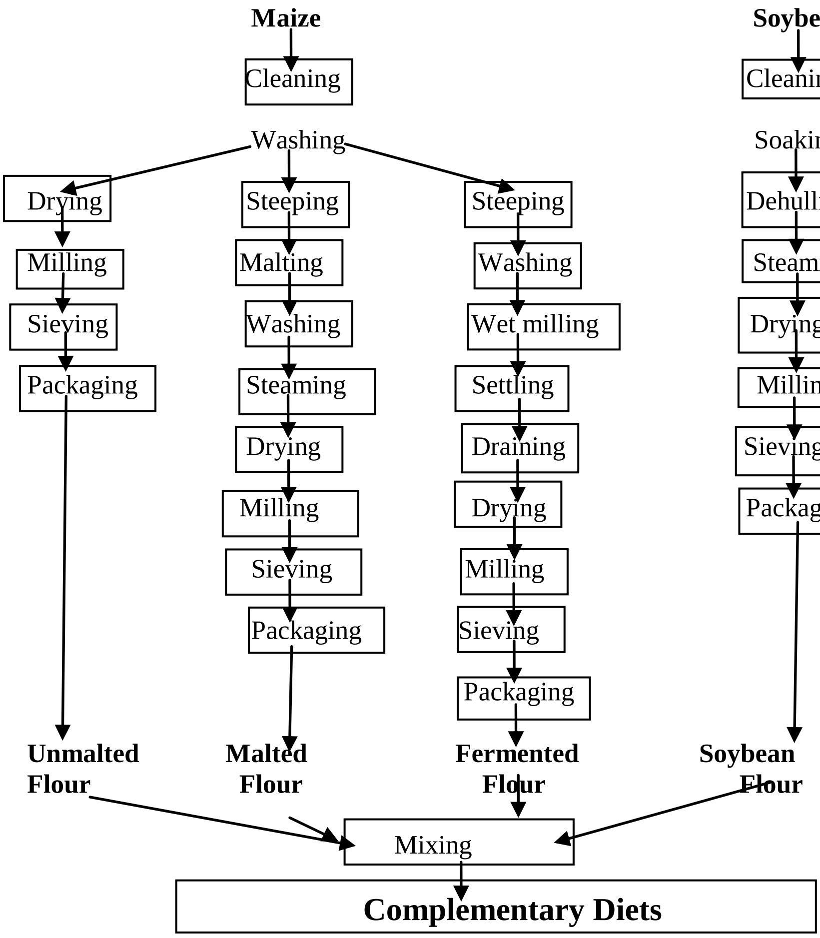

Fig.l: Production of unmalted, malted, fermented maize and Soybean flour samples

The chemical indices of the Amino acid of the complementary diets

The various chemical indices were calculated from the relationship given in the following formula according to Abiose and Ikujenlola (2014):

$TAA = Total\ amino\ acids\ in\ test\ protein$

$EAA = Essential\ amino\ acids\ in\ test\ protein$

$NEAA = Non - essential\ amino\ acids\ in\ test\ protein$

$$\frac{EAA}{NEAA} = \frac{Essential\ amino\ acids\ in\ test\ protein\ \ x\ 100}{Non - essentail\ amino\ acids\ in\ test\ protein}$$

$$\frac{EAA}{TAA} = \frac{Essential\ amino\ acids\ in\ test\ protein\ \ x\ 100}{Total\ amino\ acids\ in\ test\ protein}$$

$$\frac{C.S}{P.S} = \frac{Total\ amino\ acids\ in\ test\ protein\ x\ 100}{Total\ amino\ acid\ in\ reference\ protein\ (egg)}$$

$$EAAI = \frac{Essential\ amino\ acids\ in\ test\ protein\ x\ 100}{Essential\ amino\ acid\ in\ reference\ protein\ (egg)}$$

Anti-nutrients content analysis

The anti-nutrients determined were tannin, oxalate and phytate. Tannin content was determined by the method of Makkar and Goodchild (1996). Oxalate content was determined by the method of Nwika *et al*. (2005) and phytate content was determined by the method of Kwanyuen and Burton (2005).

3. RESULTS AND DISCUSSION

Proximate Composition of Complementary Diets

The proximate composition of the various complementary diets produced from the maize varieties and soybean are presented in Table 1. The moisture content for the diets ranged between 7.50 and 9.10 %. Moisture level for complementary diet should be less than 10 %, diet containing higher moisture content is susceptible to fast deterioration (PAG, 1971). Low water activity inhibits the growth and proliferation of microorganisms, thereby extending the keeping quality of the product (Abiose and Ikujenlola, 2014). Neither the varieties of maize nor the addition of soy bean affected the moisture content of the diets.

The fat content (Table 1) in the diets (3.54 and 10.26 %) increased with the enrichment with soybean. According to Iwe (2003) soybean contains about 20%fat mainly of unsaturated fatty acids. Fat adds more calories to the diets and improves flavour. However, excess of fat may impair the keeping quality of the diets.

The protein content of the samples ranged between 8.24 - 21.50%. Malted normal maize and malted quality protein maize samples had protein contents of 10.96 % and 10.92 % respectively. There was no significant difference ($p > 0.05$) between the protein content of the products subjected to the same treatments. This result agrees with the findings of Bai (2007) who showed that quality protein maize does not contain a higher percentage of crude protein than normal maize. According to Abiose and Ikujenlola (2014) normal maize and quality protein maize contain 9.80% and 9.72 % protein respectively. The diets that contained 30 % soybean had higher protein content that ranged between 16.30 and 21.50 %. The addition of soybean increased the quantity of the protein. The fortification of the quality protein maize with soybean will be an added advantage to the infants since better quality protein will be available to them and this will promote good growth, this will reduce morbidity and mortality in infants. The results of the diets containing soybean fall within the acceptable ranges of the recommendations by WHO that the protein of complementary foods should be between 12- 15 % (FAO/ WHO Codex, 1994).

The ash content (Table 1) of the diets ranged between 1.02 and 2.66 %. The ash content determines the mineral composition of the products. Malting improved the ash content of the diets. This result agrees the report of Marero *et al*. (1988) on similar products.

The formulated diets had between 1.00 and 2.32 % crude fibre. Fermentation and malting processes were observed to reduce the levels of the crude fibre. The range obtained in this study was below the 5 % upper limit recommended by PAG(1971). Diets meant for infants are expected to contain low fibre due to the status of the gastro intestinal system of the infant.

The carbohydrate content of the complementary diets was between 54.79 % and 77.90 %for NM products while the QPM products ranged from 55.94 % to 76.90 %.

Table 1: Proximate Compositions ofcomplementary diets (%)

Sample	Moisture	Crude Fat	Crude Protein	Total Ash	Crude .fibre	Carbohydrate	Energy (Kcal/100g)
FNM	$8.10\pm0.01_c$	$3.54\pm0.20_f$	$8.24\pm0.05_d$	$1.02\pm0.05_d$	$1.20\pm0.01_d$	$77.90\pm0.03_a$	$376.40\pm0.03_g$
FQPM	$7.50\pm0.20_d$	$3.86\pm0.10_{ef}$	$9.66\pm0.06_{cd}$	$1.06\pm0.01_d$	$1.02\pm0.02_e$	$76.90\pm0.04_a$	$381.00\pm0.04_f$
MNM	$8.60\pm0.12_b$	$4.24\pm0.10_e$	$10.96\pm0.01_c$	$1.82\pm0.02_b$	$1.52\pm0.01_d$	$72.86\pm0.04_{bc}$	$373.40\pm0.04_i$
MQPM	$8.80\pm0.05_{ab}$	$4.40\pm0.10_{de}$	$10.92\pm0.05_c$	$1.80\pm0.02_b$	$1.62\pm0.01_d$	$71.46\pm0.04_c$	$373.10\pm0.04_i$
SNM	$7.60\pm0.12_d$	$10.12\pm0.59_a$	$17.28\pm0.02_b$	$2.63\pm0.01_a$	$1.88\pm0.01_c$	$62.37\pm0.04_d$	$409.70\pm0.04_a$
SQPM	$7.98\pm0.15_c$	$10.26\pm0.12_a$	$17.02\pm0.05_b$	$2.16\pm0.05_b$	$2.20\pm0.01_b$	$60.38\pm0.04_e$	$401.90\pm0.04_b$
SFNM	$8.05\pm0.12_c$	$8.30\pm0.12_c$	$16.30\pm0.05_b$	$2.14\pm0.01_b$	$2.06\pm0.01_c$	$63.15\pm0.03_d$	$392.50\pm0.03_d$
SFQPM	$8.96\pm0.12_{ab}$	$8.50\pm0.01_{bc}$	$17.55\pm0.01_b$	$2.05\pm0.01_b$	$2.25\pm0.01_b$	$60.69\pm0.04_e$	$390.00\pm0.04_e$
SMNM	$9.10\pm0.05_a$	$9.63\pm0.50_a$	$21.50\pm0.05_a$	$2.66\pm0.01_a$	$2.32\pm0.50_b$	$54.79\pm0.04_f$	$391.80\pm0.04_{de}$
SMQPM	$8.70\pm0.05_{ab}$	$9.60\pm0.15_b$	$21.48\pm0.05_a$	$2.16\pm0.01_b$	$2.12\pm0.03_c$	$55.94\pm0.03_f$	$396.10\pm0.03_c$
COM. DIET	4.00 ± 0.00^e	$9.00\pm0.00_{bcde}$	$16.00\pm0.00_b$	$2.30\pm0.00_b$	$5.00\pm0.00_a$	$63.70\pm0.00_d$	400.00 ± 0.00^b

Means of the same column followed by different letters are significant ($p<0.05$)

NOTE:

FNM= Fermented normal maize; FQPM = Fermented quality protein maize; MNM= Malted normal maize; MQPM= Malted quality protein maize; SNM= Soy normal maize; SQPM= Soy quality protein maize; SFNM= Soy Fermented normal maize; SFQPM= Soy Fermented quality protein maize; SMNM= Soy malted normal maize; SMQPM= Soy malted quality protein maize; COMM DIET= Commercial diet

It was observed that adding soy flour to the maize flour reduced the carbohydrate content of the diets. The malted products were lowest in carbohydrate content compared with both fermented and unmalted products. This could be as result of the amylase enzymes that acted on the starch complex in the grain during malting process. Starches are partially broken down to simpler units of dextrin and maltose which is referred to as of starch (Marero *et al*., 1988).

The amount of calories in a quantity or volume of a food preparation is called the energy density of the food (Sajilata *et al*., 2002). The stomach capacity of baby is limited, it is important that the caloric density in the complementary food preparation should be as high as possible so that the baby gets sufficient calories and other nutrients in a small number of feedings (Singhavanich, 1999; Sajilata *et al*., 2002).

The results showed a range of 373.10 kcal / 100 g - 409.70kcal / 100 g for energy value of the complementary diets. The energy level of the diets into which soybean was incorporated contained higher energy density as a result of the high level of fat in those diets. The energy requirement for different age groups as recommended by World Health Organization and United Nations Children's Fund was presented in Dewey and Brown (2003). The report indicated that infant of ages 6 - 8, 9 - 11 and 12 - 23 months require 682, 830 and 1092 kcal /day respectively. It is clear from the results presented in Table 1 that diets produced from malted grains and those containing soybean will satisfy the energy requirements of infants.

Amino Acid Composition of Complementary Diets

The amino acid composition of the formulated complementary diets produced from a mixture of maize varieties and soybean is presented in Table 2. It was observed that the amino acids profile of the QPM based diets was significantly higher than those of normal maize based diets. The incorporation of soybean improved the amino acids contents of the two maize varieties. The process of malting improved the amino acids content better than fermentation.

The lysine content of the diets ranged between 2.00 and 4.10 g/100g protein. There was significant difference ($P < 0.05$) in the level of lysine of the complementary diets from normal maize and quality protein maize. Abiose and Ikujenlola (2014) reported that normal maize and QPM contain 1.80 and 2.64g /100g protein lysine respectively. The high level of lysine in the QPM agrees with reports of Akuoma-Boateng (2002); Abiose *et al*. (2015). The levels of lysine in the formulated diets containing soybean were higher than that in the commercial baby food (3.01 g/100g protein). Lysine is essential for optimal growth in infants and for maintenance of nitrogen equilibrium in adults (Akuoma-Boateng, 2002). The two essential amino acids that are required in the highest and lowest quantities in infants are leucine and tryptophan respectively (Pedersen *et al*., 1989). The amino acid compositions showed that the leucine ranged between 6.90 and 10.11g/100g protein for normal maize based diets and for QPM based diets it ranged between 11.39 and 13.81 g/100g. The level of leucine in all the products is higher than the level of leucine in the commercial baby food (6.91 g/100g protein). The scores for leucine in these products are higher than the scores for leucine in the QPM and Normal maize grains analyzed by Ahenkora *et al*. (1995) in Ghana.

The scores for histidine varied between 1.74 and 2.30g/100g for all the products, while the scores for arginine for all the products ranged between 3.50g/100g and 4.80g/100g. There was no significant difference ($p>0.05$) between the values of histidine in the products and the commercial baby food (2.21 g/100gprotein) which served as the control. Also there was no significant difference ($p>0.05$) between the scores of histidine for the two varieties of maize. Histidine and arginine are regarded as essential amino acids for infant and are required for the optimum growth and healthy living.

Chemical indices of the amino acid of complementary diets

The calculated chemical indices of the amino acid of formulated complementary diets are presented in Table 3. The results show that the total amino acids (TAA) ranged between 52.19g/100g protein (fermented normal maize flour) and 65.73g / 100g protein (Soy Malted QPM). The essential amino acid (EAA) ranged between 27.27g/100g (fermented normal maize flour) and 38.50 g/100g protein (malted QPM). There was a significant difference (P<0.05) between the EAA of the normal maize flour and QPM flour according to Abiose and Ikujenlola (2014). The EAA of the fermented normal maize (27.27g/100g protein) was significantly lower than fermented QPM (36.47g/100g protein). The EAA of the commercial baby food was 31.51 g/100g protein, which was lower than that of soy malted QPM (35.68 g/100 g protein).

TABLE 2: Amino acid content of the various complementary diets (g/100g protein)

Sample	FNM	FQPM	MNM	MQPM	SNM	SQPM	SFNM	SFQPM	SMNM	SMQPM	Comm.	Egg	FAO/ WHO
Lysine	2.00_f	2.70_e	1.94_f	2.78_e	3.50_d	3.70_c	3.53_{cd}	4.00_c	3.80_c	4.10_e	3.01_{de}	8.16_a	5.80_b
Histidine	1.93_d	2.04_c	1.74_d	2.22_c	1.75_d	2.30_{bc}	1.80_d	2.03_c	1.97_{cd}	2.20_c	2.21_c	3.02_a	2.50_b
Arginine	3.50_d	4.50_b	3.70_f	4.20_c	3.90_c	4.00_c	3.80_c	4.50_b	4.40_b	4.80_a	4.00_c	4.42_b	5.20_a
Aspartic acid	6.06_f	6.69_c	6.03_f	7.04_c	6.51_d	8.07_a	7.08_c	7.40_b	6.81_c	7.70_{ab}	5.17_f	8.12_a	8.00_a
Threonine	2.54_d	3.44_b	2.80_d	3.08_{bc}	2.30_d	2.04_e	2.50_d	3.03_c	2.22_d	2.10_e	2.48_d	4.01_a	3.40_b
Serine	2.05_c	2.19_c	2.00_c	$1.9\ _c$	2.19_c	2.30_c	2.39_c	2.41_c	2.00_c	2.20_c	2.25_c	6.72_b	8.00_a
Glutamic acid	6.80_c	7.11_e	6.20_{ef}	7.30_e	7.96_d	10.06_b	8.20_d	9.11_c	8.36_d	9.95_b	7.19_e	10.11_b	15.00_a
Proline	1.02_c	1.65_c	1.36_c	1.41_c	1.60_c	1.20_c	1.50_c	1.32_c	1.60_c	1.50_c	1.20_e	4.41_b	11.00_a
Glycine	3.40_b	3.40_b	2.25_d	3.25_{bc}	2.75_d	3.55_b	3.16_c	3.09_c	3.00_c	4.01_a	2.30_d	2.22_d	2.20_d
Alanine	2.05_e	2.25_d	1.50_f	1.70_e	2.45_d	2.35_d	2.72_{cd}	2.90_c	2.80_c	3.18_c	2.30_d	4.41_b	6.10_a
Cystine	1.00_b	1.30_a	0.90_c	1.13_a	0.70_{cd}	0.90_c	1.00_b	1.11_{ab}	0.65_d	0.74_{cd}	1.05_b	1.00_b	1.10_a
Valine	2.90_e	3.60_c	3.30_{de}	3.80_{bc}	3.06_{de}	3.24_{de}	3.00_e	3.40_d	3.13_{de}	3.50_c	3.06_{de}	5.32_a	4.00_b
Methionine	1.20_{cd}	1.30_b	1.02_{cd}	1.14_{cd}	1.00_{cd}	0.90_d	1.28_a	1.16_c	1.05_e	1.32_c	2.25_b	2.13_b	3.00_a
Isoleucine	2.80_{cd}	3.20_d	2.50_e	3.10_b	2.70_d	3.00_c	2.80_{cd}	3.00_c	2.70_d	3.34_b	3.00_c	4.08_a	3.00_c
Leucine	6.90_h	11.39_{bc}	10.11_f	13.81_a	8.20_e	12.03_b	7.03_g	11.23_c	7.72_f	10.63_d	7.51_{fg}	6.91_a	7.00_g
Tyrosine	2.54_b	3.22_a	2.30_c	2.73_b	2.69_b	2.32_c	2.16_{cd}	2.46_b	2.09_d	2.57_b	2.58_b	2.66_b	3.10_a
Phenylalanine	3.50_{cd}	4.30_b	3.60_c	4.37_b	3.73_c	3.11_d	3.40_d	3.80_c	3.60_c	3.89_c	3.99_b	3.78_c	6.30_a
Total Amino Acid	52.19_g	64.28_e	53.25_g	64.97_d	56.99_f	65.07_d	57.35_f	65.95_d	57.90_f	67.73_c	55.55_f	$80.48\ _b$	94.70_a

Means of the same column followed by different letters are significant (p<0.05)
FNM= Fermented normal maize; FQPM = Fermented quality protein maize; MNM= Malted normal maize; MQPM= Malted quality protein maize; SNM= Soy normal maize; SQPM= Soy quality protein maize; SFNM=Soy Fermented normal maize; SFQPM= Soy Fermented quality protein maize; SMNM= Soy malted normal maize; SMQPM= Soy malted quality protein maize

Table 3: Chemical indices for the formulated complementary diets

Parameter/ Sample	FNM	FQPM	MNM	MQPM	SNM	SQPM	SFNM	SFQPM	SMNM	SMQPM	COOM Diet	Egg	FAO/ WHO
TAA	52.19g	64.28e	53.25g	64.97d	56.99f	65.07d	57.35f	65.95d	57.90f	67.73c	55.55f	80.48b	94.7a
EAA(%)	27.27h	36.47d	30.71f	38.50c	30.14g	34.32e	29.14g	36.15d	30.78f	35.68d	31.51f	41.83a	40.2b
NEAA	24.92g	27.81e	22.54h	26.47f	26.85f	30.75d	28.21e	29.80e	27.12e	32.05c	24.04g	38.65b	54.5a
EAA/NEAA	1.09c	1.31ab	1.36a	1.45a	1.12c	1.12c	1.03c	1.21c	1.13c	1.11c	1.31ab	1.08c	1.00c
EAA/TAA (%)	0.52a	0.57a	0.58a	0.59a	0.53a	0.53a	0.51b	0.55a	0.53a	0.53a	0.57a	0.52a	0.50b
C.S/P.S (%)	64.85h	79.83cd	66.17h	80.73cd	70.81f	80.85cd	71.26f	81.94c	71.94f	84.16b	69.02g	100a	100a
EAAI	65.19j	87.19c	73.42f	92.04b	72.05h	82.05e	69.66i	86.42d	73.58g	85.29d	75.33f	100a	100a

Means of the same column followed by different letters are significant (p<0.05)
NOTE: FNM= Fermented normal maize; FQPM = Fermented quality protein maize; MNM= Malted normal maize; MQPM= Malted quality protein maize; SNM= Soy normal maize; SQPM= Soy quality protein maize; SFNM=Soy Fermented normal maize; SFQPM= Soy Fermented quality protein maize; SMNM= Soy malted normal maize; SMQPM= Soy malted quality protein maize

The total essential amino acids are the amino acids that are generally considered indispensable, and that cannot be synthesized in the body but must be provided in the diet.
According to Akuoma-Boateng (2002) quality protein maize supports adequate growth and healthy living in children in Ghana while Abiose *et al*. (20I5) shows that QPM based diets support adequate growth in experimental animals.
The Total Non-Essential Amino Acid (TNEAA) ranged between 22.54g/100g protein (malted NM) and 32.05g/100g protein (soy malted QPM). The total non-essential amino acid for commercial baby diet was 24.04 g/100g protein.
The ratio of essential amino acid to non-essential amino acid for all the formulated blends was higher than 1.0. These values compared favourably with the commercial diet and the reference point of the FAO/WHO Codex (1994).
The ratio of essential amino acids to total amino acid as presented in Table 3 shows that the values for all the formulated diets were higher than the reference point of 50% by FAO/WHO Codex (1994). This is particularly of advantage to the infants in that a reasonable percentage of the total amino acids are essential amino acid.
The Essential Amino Acid Indices (EAAI) for the formulated diets ranged between 65.19 % and 92.02 %. These values were lower than the EAAI of 100.00 recommended by FAO/WHO Codex (1994). The inclusion of soybean to quality protein maize further boosted the level of the essential amino acids.
In general, it was observed that the fermentation and malting processes improved the level of certain amino acids appreciably and increased the total amino acids.

The Mineral Content of the Complementary Diets

The result of the mineral content is presented in Table 4. It is evident that the levels of magnesium and calcium were high in all the samples. There was a significant difference ($p < 0.05$) in the mineral contents among the diets containing soybean and those without soybean. Also the malted diets had higher level of the mineral concentration in all the products compared with fermented products.
The increase in the minerals of the malted products agrees with the report of Hotz *et al*. (2001) who worked on sorghum malt. In addition, the results compared favourably with the mineral composition of control- a commercial complementary food.
The iron content of the samples ranged between 0.22 and 2.86 mg/100g. Iron is essential for the synthesis of haemoglobin. The amount of iron storage at birth depends on its adequacy in the mother's diet, the length of gestation, and the amount of blood received by the baby (Sajilata *etal*., 2002). Infant born by a healthy and well-fed mother will maintain good haemoglobin level at least up to 6 months of age. An infant receiving only the iron in milk will show a slow decrease in haemoglobin level during the second half of infancy and if the infant original iron store is poor, iron deficiency anaemia will occur in late infancy.
The calcium present in the diets ranged between 69.58 and 196.39 mg/100g. The potassium of the diets ranged from 56.26 to 106.21 mg/100g. The sodium and magnesium ranged between (68.50 -135.22 mg/100g) and (106.30 -161.30 mg/100g) respectively.
The RDAs for calcium, magnesium, sodium, potassium, iron and zinc for six month old infants are given as 600, 60, 200, 400, 10 and 5 mg/100g respectively (Sajilata *et al*., 2002). It was observed that the soy fortified diets will satisfy the RDA of infants in terms of Mg, Na, and Zn.

Phytate, Oxalate and Tannin content of complementary diets

The results presented in Table 5 show that the phytic acid ranged between 0.83-2.12mg/100g for the samples. There was increase in the soy fortified samples. The oxalate of the diets ranged from 0.83-2.55mg/100g,the addition of soy increased the level of the oxalate of the diets. The tannin ranged from 1.90-3.10mg/100g of the diets.

Table 4 Mineral Content of formulated complementary diets (mg/100g)

Sample	Sodium	Magnesium	Potassium	Calcium	Zinc	Iron
FNM	$78.05\pm10.00_e$	$106.30\pm6.45_f$	$66.25\pm6.67_e$	$118.50\pm9.04_e$	20.16±4.00e	$0.88\pm0.15_e$
FQPM	$68.50\pm6.25_f$	$101.20\pm4.70_g$	56.26±6.14f	$117.60\pm2.00_e$	$21.90\pm3.61_d$	$0.97\pm0.15_d$
MNM	$88.60\pm3.74_d$	$160.90\pm5.00_a$	$68.25\pm10.25_e$	$136.90\pm6.25_c$	$23.52\pm3.30_c$	$0.22\pm0.03_h$
MQPM	$87.80\pm9.00_d$	$161.30\pm10.00_a$	$70.25\pm9.75_e$	$125.60\pm2.00_d$	$31.60\pm3.60_a$	$0.24\pm0.30_h$
SNM	$123.22\pm15.00_b$	$116.70\pm8.91_d$	$106.21\pm10.32_a$	$104.70\pm4.00_f$	$21.02\pm3.48_d$	$2.86\pm0.02_a$
SQPM	$110.24\pm10.04_c$	$112.10\pm7.93_e$	$105.23\pm4.56_a$	$109.60\pm9.67_f$	$21.55\pm3.60_d$	$2.56\pm0.06_b$
SFNM	$134.40\pm14.74_a$	$109.90\pm7.94_f$	$87.58\pm10.10_c$	$167.50\pm9.00_b$	$21.06\pm3.60_d$	$0.86\pm0.10_e$
SFQPM	$135.22\pm10.67_a$	$107.80\pm8.96_f$	$90.55\pm7.10_c$	$196.30\pm7.71_a$	$22.85\pm3.00_c$	$0.63\pm0.06_f$
SMNM	$125.20\pm19.70_b$	$121.96\pm10.00_d$	$102.51\pm10.00_b$	$107.20\pm7.71_f$	$29.32\pm7.51_b$	$0.42\pm0.04_g$
SMQPM	$111.25\pm11.25_c$	$113.80\pm8.85_e$	$100.40\pm7.92_b$	$69.58\pm9.0_h$	$27.02\pm2.61_c$	$0.42\pm0.05_g$

Means of the same column followed by different letters are significant ($p < 0.05$)
NOTE: FNM= Fermented normal maize; FQPM = Fermented quality protein maize; MNM= Malted normal maize; MQPM= Malted quality protein maize; SNM= Soy normal maize; SQPM= Soy quality protein maize; SFNM= Soy Fermented normal maize; SFQPM= Soy Fermented quality protein maize; SMNM= Soy malted normal maize; SMQPM= Soy malted quality protein maize

Table 5: Phytate, Oxalate and Tannin (mg/100 g) content of complementary diets

Sample	Phytate	Oxalate	Tannin
FNM	$0.85\pm0.06_b$	$0.83\pm0.06_d$	$2.10\pm0.14_c$
FQPM	$0.83\pm0.06_b$	$0.90\pm0.06_c$	$2.20\pm0.07_c$
MNM	$0.90\pm0.06_b$	$0.97\pm0.06_{bc}$	$2.60\pm0.21_{bc}$
MQPM	$0.91\pm0.10_b$	$0.90\pm0.11_c$	$3.50\pm0.14_a$
SNM	$2.12\pm0.23_a$	$2.33\pm0.06_a$	$2.30\pm0.28_{bc}$
SQPM	$2.07\pm0.06_a$	$2.55\pm0.06_a$	$2.80\pm0.35_b$
SFNM	$1.94\pm0.06_a$	$1.43\pm0.06_{bc}$	$1.90\pm0.21_c$
SFQPM	$1.96\pm0.12_a$	$1.50\pm0.06_b$	$2.20\pm0.70_c$
SMNM	$1.96\pm0.12_a$	$2.03\pm0.12_a$	$2.55\pm0.35_b$
SMQPM	$1.95\pm0.56_a$	$2.02\pm0.06_a$	$3.10\pm0.35_{ab}$

Means of the same column followed by different letters are significant ($p < 0.05$)
NOTE: FNM= Fermented normal maize; FQPM = Fermented quality protein maize; MNM= Malted normal maize; MQPM= Malted quality protein maize; SNM= Soy normal maize; SQPM= Soy quality protein maize; SFNM= Soy Fermented normal maize; SFQPM= Soy Fermented quality protein maize; SMNM= Soy malted normal maize; SMQPM= Soy malted quality protein maize

Meanwhile the addition of soy did not increase the level of tannin in the samples.
Concentrations of anti-nutrients present in the diets as affected by the application of fermentation and malting processes. It was observed that the levels of the anti-nutritional factors reduced after fermentation and malting. This confirms the assertion of Hotz *et al.* (2001) that malting, fermentation and heating reduce the level of anti-nutrients. There was no significant difference ($p > 0.05$) in the levels of oxalate and tannin present in the two varieties of maize.

4. CONCLUSION

The quality protein maize based complementary food had better chemical and amino acids compositions than normal maize based diets. The addition of soybean improved the protein, amino acids and fat contents of the complementary diets. The study therefore concluded that QPM subjected to malting and fermentation were nutritionally better than normal maize subjected to similar treatments.

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