

ORIGINAL ARTICLE

Quality evaluation of fermented Maize-based Complementary Foods as affected by amylase-rich mungbean malt

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Abstract

The effect of co-fermentation on proximate composition, invitro protein digestibility and amino acid profile of maize-mungbean malt complementary food was evaluated. Cereal-based complementary foods from non-malted local crops result in high viscous porridge and low nutrient availability. Inherent limitations like high viscosity, poor digestibility and low bio-availability of the macronutrients in cereal base infant formula can be improved using malted legume and subsequent fermentation of the mix. Mungbean grains were malted for 72 h, dried, dehulled, milled and sieved. Yellow maize grains were degermed after tempering in water for 15 min, dried, winnowed, milled and sieved. Complementary foods were formulated with varying ratios of maize:mungbean malt flours (0:100, 90:10, 80:20, 73:30, 60:40 and 50:50) and fermented by backslopping for 72 h, dried and milled. The formulated maize-mungbean malt complementary foods were evaluated for proximate composition, amino acid profile and invitro protein digestibility. Food blends with higher quantity of mungbean malt had high protein, ash, fiber and low carbohydrate content. Addition of mungbean malt increased the digestibility of the complementary food and the blends substituted with 30% mungbean malt had highest protein digestibility (84.71%), lysine (5.4 g/g protein), methionine (4.02 g/g protein), histidine (6.88 g/g protein) and Arginine (3.09 g/g protein) contents. The findings of this study established that supplementation of maize flour with mungbean malt flour improves the quality of protein digestibility and amino acid contents of end product and can find applications in a variety of products that can be of benefit for infants especially among rural dwellers, urban poor and industries.

Practical Applications

The complementary food produced in this work is made from locally available raw material, yellow maize and mungbean malt flours which are readily available. The addition of amylase rich malt flour could not only enhance the nutritional quality but reduce the high viscosity by which traditional complementary foods are known. Also the technology of processing (malting and fermentation) can easily be adopted at household level by majority of rural dwellers and urban poor. This will invariably reduce the cost implication of industrially made complementary food.

Keywords: Amino acid, complementary foods, invitro protein digestibility, malt addition, proximate composition.

1. Introduction

UNICEF (2018) defines complementary food as “any non-breast milk foods or nutritive liquids that are readily consumed and digested by the young child and that provide additional nutrition to meet all the growing child's needs during this period”. This process starts when breast milk

alone is no longer sufficient to meet the nutritional requirements of infants, and therefore other foods and liquids are needed, along with breast milk (WHO, 2018). Over the years, infants are commonly weaned on substitute for breast milk which is a well reconstituted infant

formula based on starchy, bulky gruels which have both low energy and nutrient density (mainly, maize, yam, millet, sorghum and other family diets) without adequate supplementation with high quality protein sources (Akintola *et al.*, 2014). Results from previous research (Onweluzo & Nnamchi, 2009), reported that most cereals are deficient in some essential amino acid, especially lysine and sometimes tryptophan, which are required for body maintenance by both infants and adult. Though cereals contain appreciable amount of nutrient, they cannot sufficiently provide the nutrients required by the infants. These breast milk complementary formulas are usually imported and/or obtained within the country, however, their retail price are high due to importation cost and the economic situation, respectively hence the average Nigerian nursing mother finds it overly expensive to purchase them (Sule, 2014). In addition over dependence on low and poor protein foods is the main cause for the widespread protein-energy malnutrition problem among infants (6-23 months). In recent times, legumes have been incorporated into traditional cereal formulation by food developers as an effort to reduce the problem of malnutrition and as nutrient diversification strategy among vulnerable groups (Usman, 2012). Cereals can be supplemented with legumes which are rich in essential amino-acids especially the sulphur-containing ones (Kanu *et al.*, 2007).

However certain aspects like the digestibility and bio-availability of the macronutrients in these local diets need further investigations. Nutritional quality of legumes can be enhanced through processing (Uppal & Brains, 2012). Processing technologies aid in transforming raw grains into useful products with maximum nutritional value to ensure nutrient security of

population for developing countries. Such techniques include malting and fermentation. Malting is simple, easily adaptable, and inexpensive and a complex metabolic process during which the lipids, carbohydrates and storage proteins within the seed are broken down in order to provide energy and amino acids necessary for the plant development (Ziegler, 1995). The metabolic changes that take place in the malt influence and improve the bioavailability, palatability, and digestibility of certain essential nutrients (Colmenares De Ruiz & Bressani, 1990; Gernah *et al.*, 2011). Several enzymes become active; vitamins are increased, whereas there are reduction in phytates and tannins (Mehta & Bedi, 1993). Malting of legumes increases protein and carbohydrate digestibility, enhances some of their vitamin contents, reduces the antinutritional factors and improves their overall nutritional quality (Malleshi & Klopfenstein, 1996). Reduction of bulkiness and increasing shelf-life of cereal and legume based food formulations (Colmenares De Ruiz & Bressani, 1990) are among the advantages conferred by malting (Gernah *et al.*, 2011). It has also been shown to decrease anti nutritional factors and increase crude fiber content (El-Adawy *et al.*, 2003).

Fermentation process provides a means by which the protein content of high starch substrates can be increased (Wood, 2012) for the benefit of consumers needing higher protein intakes -a very significant improvement in nutrition to the consumer. Fermentation not only enriches the substrate with protein, the microorganisms also selectively enrich the substrate with lysine, the first essential limiting amino acid in cereals (Cronk *et al.*, 1977). Solomon (2005) reported that complementary food products formulated from locally available cereal-legume mix, can

meet the macro nutrient needs of infants and children. Co-fermentation of cereal-legume malt mix is yet to receive adequate research attention. Changes in the digestibility of complementary foods as affected by malt addition and subsequent fermentation hold significance in view of nutritional benefits of malted legume. This study seeks to evaluate the nutritional quality of complementary food made from fermented maize and mungbean malt flours.

2. Materials and methods

2.1. Materials

Mature dried seeds of mungbean (*Vigna radiata*) 'orarudi' and yellow maize (*Zea mays* L) were purchased from Ogige Market, Nsukka town, Enugu State.

2.2. Methods

2.2.1. Processing of mungbean seeds and yellow maize grain into flour

Mungbean seeds (1 kg) was processed into malt flour according to the methods described on Uvere *et al.* (2010) and the malt flour was stored in polyethylene bags at 4 °C until use. Three kilograms (3 kg) of yellow maize grains was processed into flour to get degermed maize flour as reported by Uvere *et al.* (2010).

2.2.2. Formulation and processing maize-mungbean malt complementary food

Complementary foods were formulated using graded level of maize and mungbean malt as follows: M100 (100% maize flour; M90MB10 (90% maize flour and 10% mungbean malt flour), M80MB20(80% maize flour and 20% mungbean malt flour), M70MB30(70% maize flour and 30% mungbean malt flour), M60MB40(60% maize flour and 40% mungbean malt flour), M50MB50(50% maize flour and

50% mungbean malt flour) and MB100(100% mungbean malt flour). The composite flours were each fermented by backslopping (Nout *et al.*, 1989) for 72 h (where 10% of the previous day slurry was used as a starter culture for the next day fermentation), dried at 50 °C in a convection Gallenkamp oven (Model IH-150) for 12 h, milled to get fermented product and packaged for analysis.

2.2.3. Analyses

2.2.3.1. Determination of proximate composition

Moisture, ash and fiber contents of the samples were determined by the method described in AOAC (2010). The crude protein content of the samples was determined using the Kjeldahl procedure described in AOAC (2010) and nitrogen value obtained was multiplied by 6.25 to obtain the protein content. The ether extract of the samples was determined using Babcock and Gambo methods (AACC, 2000). Carbohydrate content in each sample was obtained by difference by subtracting the percentage of moisture, protein, fat, ash and crude fiber from 100% (AOAC, 2010).

2.2.3.2. Energy value determination

Energy was determined using Atwater's conversion factors (4 x proteins, 9 x fats and 4 x carbohydrates) (Atwater conversion Factor, 2019).

2.2.3.3. Amino Acid Analysis

Amino acid concentrations (except tryptophan) of each sample were determined by reverse phase high performance liquid chromatography using the Pico Tag method as described by White *et al.* (1986). Tryptophan was analysed by the ion exchange chromatographic method as described by AOAC (2010).

2.2.3.4. Amino acid score determination

The amino acid score was determined according to the method of [Pellet & Young \(1980\)](#).

$$\text{Amino acid score} = \frac{\text{mg of amino acid per g N in test protein}}{\text{mg amino acid per g N in reference protein}}$$

The essential amino acid profile of the complementary food was compared with the [FAO/WHO \(1991\)](#) essential amino acid requirement for children.

2.2.3.5. Determination of in-vitro protein digestibility

In vitro methods for the protein digestibility assay of different formula blends were conducted using the pH drop method ([Hsu *et al.*, 1977](#)).

2.3. Data Analyses

Data obtained were subjected to statistical analysis using one way analysis of variance (ANOVA) ([Steel & Torrie, 1980](#)). The mean separation was done by Duncan New Multiple Range Test using SPSS version 20.00 Software. Significance was accepted at $p < 0.05$ levels.

3. Results and discussion

3.1. Effect of malt addition on the proximate composition of maize-based complementary food

Table 1 shows the effects of mungbean malt addition on the proximate composition and energy value of maize-base complementary food. Addition of mungbean malt to maize flour had significant ($p < 0.05$) effects on the proximate composition of the blends. Supplementation of maize flour with mungbean malt led to reduction in moisture values (7.32 to 8.84 g/100 g) than unblended fermented maize flour (9.59 g/100 g)

which progressively decreased as the quantity of the mungbean malt was increased and the values significantly ($p < 0.05$) differed from each other. The higher moisture content observed in the unblended sample (M100) was expected because it does not contain as much hydrophilic constituent like protein as the blends. Hydrophilic constituents (protein) can absorb water molecules and hold the water as bound in food system. This bound water may not be easily released as free water to be determined as moisture content. However, the moisture content of all the samples were lower than critical moisture content of 10% and the maximum moisture content of 14% recommended by [Codex Alimentarius \(1991\)](#) and hence the sample can store for a long time.

Fermented maize flour (M100) also showed the least protein content (8.52 g/100 g) while supplementation of sample with mungbean malt increased the protein content of the products and the range was 9.80 to 14.92 g/100 g. Only the protein content of M70MB30, M60MB40 and M50MB50 met the RDA value of 14 mg/100 g protein recommended for complementary foods for 6-12 months old infants. The mungbean malt may have contributed appreciably to the observed high protein content. Ordinarily, mungbean malt ('orarudi') has a protein content of 31.47 g/100 g as reported by [Onwurafor *et al.* \(2013\)](#). The drastic reduction in protein content of blends relative to fermented mungbean malt sample could probably be due to the fact that maize and mungbean malt were co-fermented and the maize flour caused a dilution effect. The low protein content of maize flour and fermented maize flour 7.89 and 8.52 g/100 g, respectively may have reduced the protein content of co-fermented products. Protein values of 10.7% for

Table 1: Proximate composition (g/100 g) and energy (kcal) value of fermented maize-mungbean malt complementary foods

Parameter	Maize	M100	M90MB10	M80MB20	M70MB30	M60MB40	M50MB50	MB100
Moisture	(6.16±0.05) ^b	(9.59±0.5) ^a	(8.84±1.2) ^f	(7.73±0.04) ^e	(7.48±0.02) ^d	(7.34±0.11) ^c	(7.32±0.10) ^c	(5.81±0.14) ^a
Protein	(7.89±0.14) ^a	(8.52±0.02) ^b	(9.80±0.12) ^c	(11.42±0.20) ^d	(15.12±1.14) ^e	(15.40±1.4) ^e	(15.44±0.05) ^e	(22.68±1.11) ^f
Fat	(5.18±0.01) ^f	(4.79±0.5) ^e	(4.56±1.1) ^d	(4.03±0.02) ^c	(3.99±0.21) ^c	(3.90±1.12) ^b	(3.85±0.12) ^b	(2.24±0.13) ^a
Ash	(1.39±0.26) ^a	(2.27±0.01) ^b	(3.39±0.00) ^c	(3.26±2.1) ^c	(3.44±0.12) ^d	(3.48±0.03) ^d	(3.52±0.07) ^{cd}	(4.8±1.13) ^e
Fiber	(1.85±0.02) ^a	(2.10±0.5) ^b	(2.11±0.01) ^b	(2.28±1.2) ^c	(2.37±0.04) ^c	(2.39±0.13) ^c	(2.42±0.15) ^c	(2.66±0.14) ^d
CHO	(77.53±0.46) ^e	(72.73±0.1) ^d	(71.30±0.2) ^c	(71.28±1.2) ^c	(67.60±0.14) ^b	(67.49±0.09) ^{bc}	(67.25±0.05) ^{bc}	(62.81±0.15) ^a
Energy	(388.3) ^d	(360.11) ^c	(361.44) ^c	(359.07) ^b	(359.19) ^b	(359.4) ^b	(359.6) ^b	(340.84) ^a

Values are means of 3 replications ± SD; Means bearing different superscript in the same row are significantly ($p < 0.05$) different
 Key: M100= Fermented yellow maize (100%); M90MB10= Fermented Maize: Mungbean malt (90:10%); M80MB20 = Fermented Maize: Mungbean malt (80:20%); M70MB30= fermented Maize: Mungbean malt (70:30%); M60MB40 = Fermented Maize: Mungbean malt 60:40%; MB100 = Fermented Mungbean malt (100%)

co-fermented cowpea/sweet potato/ maize, 13.9% for co-fermented sorghum/cowpea and 13.4 g/100 g for co-fermented millet / cowpea has been reported by Oyarekua (2013) and Oyarekua & Adeyeye (2009), respectively. From the view point of protein content, the basis for advocating cereal-based complementation as a method of improving the protein content of cereal-based traditional foods was justified by the present study. Several workers have also reported marked improvements in the protein content of cereals when fortified with legumes (Lazou & Krokida, 2010; Fili *et al.*, 2012).

Fermented maize flour had fat content of 4.79% which was significantly ($p < 0.05$) lower than the value (5.18%) for unfermented maize. This could be attributed to the activities of lipolytic enzymes during fermentation (Uvere *et al.*, 2010) or due to their utilization by the growing microorganisms (Babalola & Giwa, 2012). The level of fat reported for the fermented maize in this study was higher than value of 2.30 g/100 g reported by Oyarekua (2013) and the difference could be in the preparation method and varieties. Fat content was significantly ($p < 0.05$) higher in fermented maize flour than in fermented mungbean malt substituted samples. Increasing the quantity of mungbean malt resulted to significant ($p < 0.05$) decrease in fat content of the samples attributable to low fat content of mungbean malt (1.55 g/100 g) and the effects of fermentation.

Supplementation of maize flour with mungbean malt flour increased the ash content of the samples and fermentation of maize flour increased the ash content from 1.39 to 2.27 g/100 g. Higher fiber content was observed as the level of mungbean malt increased in the formulation contrary to the observation of Uzopeters *et al.* (2008) who reported a reduction in the fiber

content of kokoro substituted with different level of defatted groundnut and soyabean cake flour. [Reihaneh & Mehdi \(2011\)](#) reported higher fiber values of 3.45 to 7.49 g/100 g for cereals-legumes composite and the disparity could be due to processing method and raw materials use and /or incorporation of dehulled legume flours. .

The highest energy content (388.3 Kcal) was observed in unfermented maize flour and this value was significantly ($p < 0.05$) higher than that of fermented maize flour attributable to reduction in fat content and carbohydrate content caused by fermentation. The energy values of the maize-mungbean malt blends observed in this work (359.07 to 361.44 kcal) were similar to values reported by pervious researchers ([Anuonye, 2012](#); [Itagi & Singh, 2012](#)) in cereal-legume mix. Expectedly, substitution with mungbean malt resulted to decrease in energy values of the food blends and this could be due to low fat and carbohydrate contents of the blends as both constitute major sources of energy. However, higher energy value was reported by [Solomon \(2005\)](#). The disparity could be due to use of fermentation process in the present work. Fermentation was reported to reduce fat and carbohydrate contents of mungbean malt flour which are major contributors of energy ([Onwurafor *et al.*, 2014](#)).

3.2. *Effect of malt-addition on the amino acid content of maize-mungbean malt complementary food blends*

Table 2 shows the amino acid profile (g/gp) of maize-mungbean malt complementary foods. The lysine content of fermented maize was 0.82 g/gp and tryptophan 0.5 g/gp. [Mbata *et al.* \(2009\)](#) in earlier study reported lysine values of 0.5 gp and tryptophan value of 0.5 g/gp in fermented ‘ogi’. The differences in lysine

content could be due to differences in variety. The lysine value for mungbean malt substituted samples increased as the amount of mungbean malt flour increased. The value of lysine content (5.49 g/gcp) of 30% mungbean malt substituted blend was within the range (6.6 g/100 gp) of lysine reported by [Filli *et al.* \(2012\)](#) in 36.8% cowpea level substitution in millet-cowpea blends and but higher than the value (4.2 g/gcp) reported by [Mbata *et al.* \(2009\)](#) in co-fermented maize and bambara-nut blends. Methionine and cysteine content of the sample increase as the quantity of mungbean malt increased in the complementary food blends. Methionine and cysteine are the limiting amino acids in legumes but their levels in this formulation are higher than the RDA value of 42 mg-1cp required for complementary foods. Cysteine has been reported to act as sparring partner in methionine synthesis and has positive effect on zinc absorption thus making consumption of these products desirable for children. The values of phenylalanine, leucine, isoleucine, valine, arginine, and histidine are higher in mungbean malt substituted samples than in fermented maize flour. The values observed in this study are higher than values reported for co-fermented maize/cowpea/sweet potatoes. Histidine content of M70MB30 was 6.88g/gp. Arginine and histidine are essential for child’s growth ([Adeyeye & Faleye, 2004](#)) when present in small quantities. Glutamic acid was the most abundant amino acid in maize-mungbean malt blends. The amino acid values in this study are of nutritional importance. The major constituents of maize flour used in this study are carbohydrate and a protein content of 7.89 g/100 g. Most cereals are low in protein and some essential nutrients; hence blending with legume rich in protein and essential amino acids could improve their

nutrient content of complementary foods (Mbata *et al.*, 2009; Filli *et al.*, 2012).

Table 2: Amino acid profile (g/gp) of maize-mungbean malt substituted blends

Amino acid Profile	M100	M90MB10	M80MB20	M70MB30	M60MB40	M50MB50
Threonine	0.61	7.09	9.16	10.96	9.75	10.23
Leucine	1.75	1.40	2.40	2.93	2.03	1.73
Iso Leucine	1.01	1.33	3.24	4.03	3.33	3.02
Lysine	0.82	2.59	2.84	5.49	5.39	5.44
Methionine	0.36	1.13	3.04	4.03	3.49	3.73
Phenylalanine	1.29	1.13	3.99	3.51	4.99	4.61
Tyrosine	0.5	0.31	0.31	1.43	1.51	1.51
Valine	0.61	1.15	1.14	1.54	1.33	1.22
Arginine	1.89	0.73	0.86	3.09	1.87	1.41
Histidine	0.85	0.36	3.46	6.88	6.03	6.64
Alanine	0.80	0.99	1.03	4.03	1.92	1.68
Aspartic acid	3.57	0.43	0.39	1.83	1.09	0.63
Asparagine	ND	0.67	1.54	3.13	3.45	3.88
Glutamic acid	9.54	12.91	12.80	13.50	13.30	13.45
Glutamine	ND	1.85	1.41	8.25	5.31	2.3
Glycine	1.15	0.35	0.37	2.05	2.29	2.26
Proline	0.51	0.62	0.71	0.92	1.42	1.62
Serine	0.41	0.15	0.09	1.23	0.68	0.29
Tryptophan	0.50	1.17	1.11	1.07	1.55	1.23
Cysteine	0.33	4.01	4.52	7.89	7.31	7.11
Total AA	26	26.46	41.89	75.64	66.77	60.99

Values are means of 3 replications

Key: M100= Fermented yellow maize (100%); M90MB10= fermented Maize: Mungbean malt (90:10%); M80MB20 =Maize: fermented mungbean malt (80:20%); M70MB30= fermented maize: mungbean malt (70:30%); M60MB40 = fermented maize: mungbean malt (60:40%); M50MB50 = fermented maize: mungbean malt (50:50%); MB100 = fermented mungbean malt (100%); ND = not determined

3.3. Chemical scores of Essential Amino acid content of maize-mungbean malt blends

The essential amino acid score of the maize-mungbean malt complementary food are presented in Table 3. All the essential amino acids are present in the substituted samples. But quite a good number of them are below the RDA for infant. The percent ratio of amino acid to the

total amino acid in maize-mungbean malt substituted blends are slightly lower than the RDA of the AAs, hence further fortification is necessary to improve the protein and amino acid content of the sample. However, the values observed in most samples in this study are higher than 26 and 11% reported by Oyarekua & Adeyeye (2009) for maize-cowpea and maize-sorghum composite, respectively. These values are also comparable to that of egg (50%) (FAO/WHO, 1991).

Table 3: Percentage chemical scores of essential amino acid (g/gp) content of maize-mungbean malt blends

AA	M100	M90MB10	M80MB20	M70MB30	M60MB40	M50MB50	FAO Ref value
Lysine	0.82(19.52)	1.59(37.86)	2.84(43.81)	5.49(130.71)	4.29(102.14)	3.94(93.81)	4.2
Threonine	0.61(21.79)	3.93(140.36)	2.47(88.21)	8.03(286.79)	5.89(210.36)	4.03(143.93)	2.8
Valine	0.61(14.52)	0.15(3.57)	0.14(3.33)	0.54(12.86)	0.33(7.86)	0.22(5.24)	4.2
Cysteine	0.33(16.5)	4.01(200.5)	2.52(126)	7.89(396.5)	6.31(315.50)	4.11(205.5)	2.0
Methionine	0.36(16.36)	1.13(51.36)	1.04(47.27)	4.03(183.18)	3.49(158.64)	2.73(124.09)	2.2
Iso Leucine	1.75(41.67)	1.33(31.67)	1.24(29.52)	4.03(95.95)	3.33(79.29)	2.02(48.10)	4.2
Leucine	1.01(24.05)	0.33(7.86)	0.45(10.71)	1.93(45.95)	1.03(24.52)	0.73(17.38)	4.2
Tyrosine	0.5(17.86)	0.31(11.07)	0.31(11.07)	1.43(51.07)	1.1(39.29)	0.51(18.21)	2.8
Phenylalaline	1.29(92.14)	1.13(80.71)	0.99(70.71)	3.51(250.71)	1.99(142.14)	1.61(115)	1.4
Trptophan	0.5(35.71)	0.17(12.14)	0.11(7.86)	1.07(76.43)	0.55(39.29)	0.23(16.43)	1.4

Values are means of 3 replications

Key: M100= Fermented yellow maize (100%); M90MB10=Maize:mungbean malt (90:10%); M80MB20 =Maize:mungbean malt (80:20%); M70MB30= Maize:mungbean malt (70:30%); M60MB40 =Maize:mungbean malt (60:40%); M50MB50 =Maize: Mung bean malt (50:50%); MB100 = fermented Mungbean malt (100%); Values in parenthesis = amino acid score value

3.2. Effect of malt addition in invitro-protein digestibility of maize-mungbean malt blends

The final pH ranges 6.25 – 7.30 were recorded for the samples (Figure 1). The low final pH observed in this study can be translated to high protein digestibility of the product. Final pH change value of 7.81, 7.67 and 7.38 has been reported for soybean meal; polish rice and mustard oil cake (Sarwar *et al.*, 2012). Sample substituted with 30 % mungbean malt had the lowest final pH (6.25) while M50MB50 had the highest final pH (7.30). Incorporation of mungbean malt into maize flour resulted to lowering of pH; an indication of improvement in the in-vitro protein digestibility of maize flour and the effect was significant ($p < 0.05$) until 30% substitution. Substitution of maize flour with mungbean malt may have caused increased in protein digestibility which was contrary as

cereals had been reported to have higher digestibility than legumes (Sarwar *et al.*, 2012); the observed effect here could be due to combined effect of malting of legume and co-fermentation on cereal-legume mixture. However, substitution of maize flour with greater than 30% mungbean malt was found to have marginal decrease in in-vitro protein digestibility. This could be due to increase in residual anti nutritional factor in the malt and the effect may have become obvious as the quantity of malt increased. Figure 2 shows the protein digestibility (PD) of maize-mungbean malt blends. The highest PD (84.71%) was observed in 30% level of mungbean malt substitution and the lowest value was for 10% malt substitution. The value of PD (84.71%) of fermented mungbean malt was higher than the value reported by Ali *et al.* (2009) for soybean (76.08%) and a lower value (67.39%) for

mustard oil cake. Higher PD for oil seed (81.88 to 95.60%) has been reported in literature (Mohanta *et al.*, 2006). The variation could be due to difference in processing treatments given to such oil seed. M70MB30 had the highest digestibility and is more suited for further use in complementary food formulation.

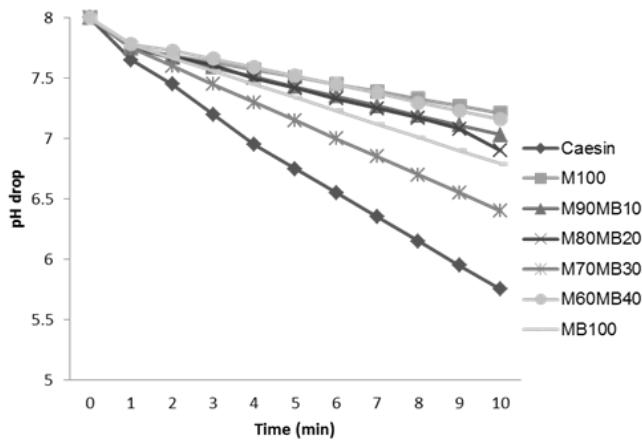


Figure 1: pH change of caesin and effect of mung-bean malt substitution on the pH drop of the blends

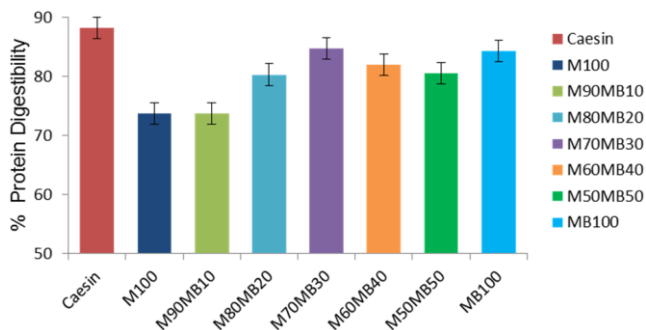


Figure 2: Effect of mungmalt addition on the PD of of maize-mungbean malt composite. Key: M100 = Fermented yellow maize (100%); M90MB10 = Fermented Maize: Mungbean malt (90:10%); M80MB20 = Fermented Maize: Mung bean malt (80:20%); M70MB30= fermented Maize: Mung bean malt (70:30%); M60MB40 =Fermented Maize: Mungbean malt (60:40%); M60MB40 =Fermented Maize: Mung bean malt (50:50%)

4. Conclusion

This study has shown that substitution of maize flour with graded levels of mungbean malt flour

in complementary food formulation and fermentation generally increased the protein, ash and fiber and amino acid contents of the complementary food. Highest protein content, lysine and protein digestibility were seen in the 70:30 maize-mungbean malt complementary. For enhanced protein quantity and quality mungbean malt should be used to substitute maize flour at the level of 30 % in complementary food production.

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Conflict of interest

The authors declare that there are not conflicts of interest.

Ethics

This Study does not involve Human or Animal Testing.

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