Evaluation of Amino Acid Profile, Protein Quality and Pasting Properties of Pap Made From Fermented Maize Starch and Red Kidney Beans

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Abstract

The study investigated amino acid profile, protein quality and pasting properties of pap made from fermented maize starch and red kidney bean. The samples were processed and made into five portions. One portion was used as the control while the remaining four portions of fermented maize starch were enriched with processed red kidney bean at the ratio of 90:10, 80:20, 70:30 and 60:40 percent respectively. Results of amino acid profile showed that the values were significantly different (P < 0.05). Fermented maize starch enriched at a ratio of 60: 40 showed the highest content of leucine (7.655g/100g), lysine (6.665g/100g), tryptophan (4.875), histidine (3.355g/100g), is oleucine (4.433g/100g), Phenylalanine (5.765g/100g) and valine (5.045g/100g) respectively. The results also showed that increasing the red kidney bean flour in the blends increased the amino acid quality. The biological value and nutritional index ranged from 76.0 to 81.6 and 5.1 to 6.1 % respectively and were significantly improved by increasing the red kidney bean flour. The control sample had the best breakdown viscosity (57.22 Rapid Visco Unit), setback viscosity (61. 15 Rapid Visco Unit), pasting time (5.56 min) and pasting temperature (91.85). The pasting properties of the samples was significantly (P < 0.05) affected by the blending ratio at each level of flour concentration. However, it is recommended that red kidney beans should be incorporated into fermented maize to enhance the amino acid profile, protein quality and quantity of pap.

Keywords: Amino Acid, Profile, Protein, Quality, Pasting, Properties, Maize, Red Kidney Bean

Introduction

Pap also known as *Akamu in Igbo, Ogi* in Yoruba and *Koko* in Hausa is produced from fermented maize, sorghum, or millet or a combination of the grains. The major reason why cereals grains are usually utilized in pap making is due to their high gelling capacity, availability, affordability and ease of Processing (James *et al.,* 2015).It is consumed by both adults and children. Pap is transformed into ready to serve diet by dissolving and diluting the fermented starch sediment in little amount of water, after which boiled water is added to form a semi liquid gruel. The gruel is usually sweetened with sugar, milk, ginger. The properties of the fermented starch, type of cereals and the manufacturing process give rise to varieties of Pap. Pap is made by steeping cereal grain in water for three days, the water drained, milled, filtered, bagged, dewatered with poor storage shelf life due to its high moisture content which of great concern as it reduces the quality of the food. Pap is produced mainly from maize because of its functional and sensory attributes (Bristone *et al.,* 2016).

Maize is high in carbohydrate, magnesium, and potassium but very low in lysine, tryptophan, small in oil and B-vitamins (Makanjuola and Olakunle, 2017).Several researchers have reported that pap is poor in protein quantity and quality (Bolaji *et al*., 2015; Bristone *et al.,* 2016). The quality of dietary protein is measured from the amino acid profile, protein efficiency ratio, net protein ratio, nitrogen balance index, net protein utilization and biological value. The major purpose of dietary protein is to provide amino acids for protein synthesis which should meet the physiological needs of the consumer. Amino acid is necessary for human but human can synthesis only ten out of the twenty naturally occurring amino acid. The remaining ten are called essential amino acid because they must be obtained from dietary sources (Aremu*et al.,* 2017). The absence of these essential amino acids can lead to disease such as morbidity, mortality, stunting and mental retardation (Aremu *et al*., 2011).

However, most of the consumers are not aware of the low quality of pap since most consumers assess the quality of food based on having good or sweet taste in the mouth which is always not true as food that is sweet may have low nutritional quality. It is because of these limitations that pap made from fermented maize need to be enriched with other rich protein sources such as red kidney beans.

Food enrichment refers to the addition of vital nutrients to a particular food to correct specific nutritional deficiencies such as minerals and vitamins (Okafor *et al*., 2017).Several authors have enriched *ogi* with legumes like cowpea (Ashaye et al., 2000),pawpaw (Ajanaku et al., 2010), soybean (Adeleke and Oyewole, 2010), groundnut seed (Ajanaku *et al.,* 2012), crayfish (Ajanaku et al., 2013), okra seed meal (Aminigo and Akingbola, 2004), kersting's groundnut (Kerstingiellageocarpah) flour (Aremu*et al*., 2011),among others. In their different studies, it was reported that one cheap method of enhancing the nutritive value of pap is by adding legumes to it.

Legumes are cheap sources of protein-rich foods that have been used in solving the problem protein malnutrition in Africa (Okafor *et al*., 2017). Legumes which include mung bean (*Vigna radiata*), soybean (*Glycine max*), pigeon pea (*Cajanus cajan*), (*Cicer arietinum*), lab lab bean (*Lab labpurpureus*) and red kidney bean (*Phaseolus vulgaris*) are good sources of protein, energy, vitamins, dietary fibre, minerals, and oil (Arawande and Borokini, 2010). Maize is deficient in lysine and tryptophan but high in methionine and cysteine while red kidney bean is rich in methionine, cysteine, and lysine which when combined will complement each other.

Red kidney bean (*Phaseolus vulgaris*) is an excellent source of both quality and quantity protein, starch, soluble and insoluble fiber, water soluble vitamins and minerals especially potassium, iron, zinc, magnesium, and manganese (Auduand Aremu, 2011) and very low in fat (Eknayake*etal*., 1999). Red kidney bean can be a potential ingredient in nutraceutical and functional foods (Shehzad *et al., 2015)*. Despite its industrial and nutritional potentials, it is widely underutilized. Loggerenberg (2004) observed that red Kidney beans are excellent source of lysine and can be used for the fortification of cereal-based products. In order to solve the problem of low nutritional quality of pap and deficiencies associated with it, it is important to enrich to meet the nutritional need of the people.

Objectives of the study

The general objective of the study was to evaluate the amino acid profile, protein quality and pasting properties of pap made from fermented maize starch enriched with red kidney beans. Specifically, the study determined:

1. amino acid profile of pap made from fermented maize starch enriched with red kidney beans.
2. protein quality of pap made from Fermented Maize Starch enriched with red kidney beans.
3. Pasting properties of pap made from fermented maize starch enriched with red kidney beans.

Materials and Methods

***Design of study*:** Experimental method was used for this research. Yellow maize and red kidney beans were purchased and separately sorted, washed, soaked, boiled, dehulled, washed, dried, and divided into four portions. The different portions were mixed separately.

***Procurement of materials*:** The materials used in this study were yellow maize variety and red kidney beans grains purchased from Abakaliki main market, Ebonyi State, Nigeria.

***Preparation of the materials*:** materials were prepared as follows:

Maize grains: These were sorted, washed, with potable water and steeped in clean water for three days. The grains were milled into slurry with an attrition mill. Water was poured into the slurry in excess and the floating germs were skimmed off. The slurry was manually sieved with cheese cloth. The starch which settled at the bottom of container was washed several times with clean water. The corn starch was sundried using Dehyra tray to moisture content of 10 percent using moisture meter.

Red kidney: These were cleaned, soaked for six hours, then boiled for 30 minutes and manually dehulled, washed and sundried to reduce moisture content below 10 percent. It was milled into flour using attrition mill and was sieved using cheese cloth.

Formulation of Composite Blends: The fermented maize starch and red kidney beans flour were blended to produce the following composite blends:

Code	Corn starch	Red kidney beans
Control	100	0
M: KB1	90	10
M: KB2	80	20
M: KB3	70	30
M: KB4	60	40

Where M = Maize, KB = Red kidney bean

***Amino Acid Determination*:** The method of Nwosu *et al.* (2008) was used. Exactly thirty milligrams (30mg) of the sample were dried to a constant weight, defatted with Soxhlet extractor for 15mins. The defatted sample was transferred into a glass ampoule and hydrolyzed using 7ml of 6N Hydrochloric. The glass ampoule was sealed using import sealer and place inside an oven set at 105^0C for 22hrs to affect hydrolysis. The sample was cooked and filtered. The filtrate was evaporated to dryness at 40^0C under vacuum in a rotary evaporator. The residue was liquefied with 5ml f acetic buffer and analyzed using multi-sample amino acid analyzer (TSM). Tryptophan content was determined calorimetrically after subjecting to alkaline hydrolysis as outlined by Miller, (1967).

***Protein Quality Determination*:** Protein quality was determined based on the amino acid profile, because protein quality is largely dependent on amino acid composition of the protein mixture. The content of the different acids was expressed as g/100g protein and was compared with FAO/WHO (2007) reference pattern.

***Determination of Essential Amino Acid Index*:** The essential amino acid index (EAAI) was calculated using the method of Labuda *et al.,* (1982).

Nutritional Index: The nutritional index was calculated using the formular below.

$$\text{Nut Index (\%)} = \text{EAAI} \times \frac{\text{\% Protein}}{100}$$

Where: EAAI= Essential Amino Acid Index.

Protein Efficiency Ratio: The protein efficiency ratio (PER) was estimated according to the regression equation developed by Alsmyer *et al.,* (1974) cited by Mune-Mune*et al.,* (2011).

Protein efficiency ratio (PER) = -0.468+0.454 (Leu) – 0.105 (Tyr).

Biological Value: The biological value was calculated from EAAI using the equation by Mune-Mune*et al.*, (2011)BV = (1.09 x essential amino acid index) – 11.7

Determination of Pasting Property: A Rapid Visco Analyzer (RVA) was used to determine the pasting property (Newport Scientific RVA Super 3, 1998). A portion of the sample (3g) was weighed into a vessel, and 25 ml of distilled water was poured into a new test canister. The sample was then transferred into the canister's water surface. The paddle was inserted into the canister, and the blade was vigorously jogged up and down ten times through the sample. The test went on for a while and then ended on its own. The slurry was heated to 95°C and then cooled to 50°C in 12 minutes while rotating the can at 160 rpm and stirring the contents continuously with a plastic paddle. Peak viscosity, setback viscosity, final viscosity, trough, breakdown value, pasting temperature, and time to reach peak viscosity were among the parameters estimated.

***Data Analysis*:** Data generated was analyzed using SPSS version 20. Data were presented as mean ± standard deviation. Analysis of variance (ANOVA) was used to compare means. Mean was separated using Turkey test ($P < 0.05$) to determine significant level.

RESULTS

Amino acid Profile of Fermented Maize Starch - Red Kidney Bean Pap

Table 1: Amino Acid Profile of Fermented Maize Starch Enriched with Red Kidney Bean

Amino Acid (g/100g)	Control	MKB1	MKB2	MKB3	MKB4	FAO/WHO (1991) (g/100g)FC
Arginine	0.778[e]	0.843[d]	0.878[c]	0.909[b]	0.911[a]	5.20
Cysteine	0.322[a]	0.311[b]	0.305[c]	0.304[d]	0.0303[e]	3.00
Methionine	0.868[a]	0.843[b]	0.823[c]	0.810[d]	0.808[e]	2.50
Histidine	2.985[e]	3.175[d]	3.190[c]	3.240[d]	3.355[a]	1.9
Isoleucine	4.250[e]	4.275[d]	4.280[c]	4.430[d]	4.435[a]	3.1
Leucine	7.265[e]	7.385[d]	7.440[c]	7.555[b]	7.655[a]	6.3
Lysine	6.355[e]	6.375[d]	6.445[c]	6.545[b]	6.665[a]	5.2
Tyrosine	1.275[e]	1.355[d]	1.450[c]	1.455[b]	1.680[a]	1.10
Phenylalanine	5.270[e]	5.365[d]	5.370[c]	5.435[b]	5. 765[a]	6.30
Threonine	3.170[e]	3.255[d]	3.275[c]	3.385[b]	3.450[a]	2.7
Tryptophan	3.765 [e]	4.055 [d]	4.545 [c]	4.560[b]	4.875[a]	0.7
Valine	4.225[e]	4.375[d]	4.655[c]	4.460[b]	5.045[a]	5.00
Glycine	3.360[e]	3.490[d]	3.555[c]	3.675[b]	3.975[a]	2.20

Control = 100% maize pap, MKB1 = 90% maize: 10% KB, MKB2 = 80% maize: 20% KB, MKB3 = 70% maize: 30% KB, MKB4 = 60% maize: 40% KB, FC = For children.

Table 1 shows that there were significant differences (P< 0.05) in the amino acid contents of the sample except in tryptophan were no significant difference (P > 0.05) existed among the sample. The variation in amino acid profile may be attributed to blending cereal and legumes. The most abundant amino acid in the samples was leucine (7.655 -7.265 g/100g) with 60% fermented maize and 40% red kidney beans having the highest value. Tryptophan an essential amino acid ranged from 3.765 to 4.875 mg/100g. The Arginine ranged from 0.778 to 0.911mg/100g. Histidine ranged from 2.985 to 3.355 mg/100g.

Amino acid quality of Fermented Maize Starch Enriched with Red Kidney Bean

Table 2: Amino Acid Quality of Fermented Maize Starch Enriched with Red Kidney Bean

Parameter	Control	MKB1	MKB2	MKB3	MKB4	Mean	SD	CV%
TAA	45.01	45.71	45.79	46.45	48.36	46.26	1.28	2.8
TNEA	5.99	6.02	6.10	6.21	6.80	6.23	0.33	5.4
%TNEA	13.10	13.13	13.38	13.57	14.07	13.45	0.39	2.9
TEAA with His	38.99	39.57	39.72	40.35	41.56	40.04	0.98	2.4
%TEAA (with HIS)	85.93	86.43	86.62	86.87	86.90	86.55	0.39	0.5
TEAA (without His)	35.63	36.33	36.53	37.37	38.38	36.85	1.06	2.9

%TEAA (WOH)	79.16	79.36	79.37	79.92	80.44	79.65	0.53	0.7
TArAA	10.81	10.88	11.19	10.36	11.99	11.24	0.47	4.2
TSAA	1.11	1.11	1.13	1.15	1.19	1.14	0.03	2.8
%TSAA	2.37	2.43	2.47	2.48	2.56	2.46	0.07	2.8
%CYSinTSAA	26.52	27.09	27.26	27.44	27.44	27.15	0.38	1.4
TAAA	-	-	-	-	-	-	-	-
TBAA	10.31	10.49	10.55	10.62	10.68	10.53	0.14	1.4
%TBAA	22.09	22.19	22.92	23.07	23.59	22.77	0.63	2.8
TNAA	34.39	35.16	35.29	36.14	37.68	35.73	1.25	3.5
%TNAA	76.41	76.93	77.08	77.81	77.91	77.23	0.63	0.8

TTA = Total amino acid, TNEA = Total non-essential amino acid, TEAA = Total essential amino acid, TArAA =Total aromatic amino acid, TSAA = Total Sulphur amino acid, TAAA = Total acidic amino acid, TBAA = Total basic amino acid, TNAA = Total neutral amino acid, Where Control = 100% maize pap, MKB1 = 90% maize: 10% KB, MKB2 = 80% maize: 20% KB, MKB3 = 70% maize: 30% KB, MKB4 = 60% maize: 40% KB., WHO = without, Coefficient of variation

Table 2 shows the total amino acids (TAA), total non-essential amino acid (TNEA), total essential amino acid (TEAA), total aromatic amino acid (TArAA), total Sulphur amino acid (TSAA), total acidic amino acid (TAAA), total basic amino acid (TBAA) and total neutral amino acid (TNAA) of samples. The results showed that most of the amino acids are essential. The total essential amino acids range between 35.63 – 38.38g/100g while the total non-essential amino acids range between 34.39 – 37.68 g/100g. The total essential amino acids were above the total non-essential amino acids (5.99 - 6.80g/100g). It was observed that essential amino acid with histidine which are known to be essential amino acid in children are lower than the total non-essential amino acid with histidine. Percentage of TEAA ranged from 85.63 – 86.55%. This is an indication that *ogi* produced from fermented maize and red kidney beans are rich sources of essential amino acids.

On further classification of the amino acids, it was found that TArAA was highest in the 60%M40%KB and lowest in the control, TNAA was highest in the 60%M40%KB and lowest in the control. The mean percentages of these amino acids in the samples were in the following order: %TNAA> %TArAA> %TBAA > %TSAA > %TAAA. The recommended TSAA value for infants is 5.8g/100g (FAO/WHO/UNU, 1991). None of the samples met this requirement and this could be explained by the fact that cysteine, a component of the TSAA was the limiting amino acid in all the samples.

Protein quality of Fermented Maize Starch Enriched with Red Kidney Bean.

Table 3: Protein Quality of Fermented Maize Starch Enriched with Red Kidney Bean

Parameter	100%M	90M10KB	80M20KB	70M30KB	60M40KB	Mean	SD	CV%
EAAI	80.5	81.3	81.4	82.9	85.6	82.3	2.02	2.5

BV (%)	76.0	77.0	77.0	78.7	81.6	78.1	2.23	2.9
PER(%)	2.7	2.8	2.8	2.8	2.8	2.8	0.06	2.1
NI (%)	5.1	5.3	6.0	6.1	6.1	5.7	0.46	8.0

EAAI = Essential amino acid index, BV = biological value, PER = protein efficiency ratio, NI = nutritional index, Where: Control = 100% maize ogi, MKB1 = 90% maize: 10% KB, MKB2 = 80% maize: 20% KB, MKB3 = 70% maize: 30% KB, MKB4 = 60% maize: 40% KB. CV= coefficient of variation.

Table 3 shows the results of the essential amino acid indices, biological value, protein efficiency ratio and nutritional index are shown in Table 3. The values ranged from 80.5 to 85.6 % with the 60%M40%KB blend recording the highest value, followed by 70%M30%KB and the least value was observed in the control. This indicates that blending fermented maize with 40 % red kidney bean produced pap of higher EAAI. The protein efficiency ratio is similar to 2.88 in whole hen egg, (Achidi*et al.*, 2016*)*, higher than 2.50 in reference casein (Oyarekua and Eleyinmi, 2004) as reported by Achidi*et al.* (2016). The biological value ranged from 76.0 – 81.6 with 60%M40%KB having the highest value. It was observed that inclusion of red kidney bean improved the biological value of the developed pap.

Essential Amino Acid Scores of White Maize-Red Kidney Bean Pap Based on FAO/WHO 2007 Reference Pattern.

Table 4: Essential Amino Acid Scores of White Maize-Red Kidney Bean Pap Based on FAO/WHO 2007 Reference Pattern.

Amino acid	FAO/WHO	Control	MKB1	MKB2	MKB3	MKB4	Mean	SD	CV %
Isoleucin	3.1	1.37	1.38	1.38	1.43	1.43	1.4	0.08	5.9
Leucine	6.3	1.15	1.17	1.18	1.20	1.22	1.2	0.02	2.0
Lysine	5.2	1.22	1.23	1.24	1.26	1.28	1.2	0.02	2.0
Meth+Cys	2.5	0.45	0.45	0.45	0.46	0.48	0.5	0.01	2.8
Phe+Tyr	4.6	1.44	1.48	1.48	1.53	1.55	1.5	0.04	2.9
Threonine	2.7	1.17	1.21	1.21	1.25	1.28		1.2	3.3
Tryptophan	0.7	5.38	5.790	6.49	6.51	6.96	6.2	0.63	10.2
Valine	4.1	1.03	1.07	1.09	1.14	1.23	1.1	0.08	7.0
Histidine	1.8	1.66	1.76	1.77	1.80	1.86	1.8	0.07	4.2

Control = 100% maize pap, MKB1 = 90% maize: 10% KB, MKB2 = 80% maize: 20% KB, MKB3 = 70% maize: 30% KB, MKB4 = 60% maize: 40% KB. CV = Coefficient of variation

Table 4reveals that is oleucine of the enriched samples was higher than the control (1.37 -1.43). The tryptophan content increased with increase in red kidney bean when compared with the control (5.38 -6.96). Histidine increased with increase in red kidney bean (1.66 - 1.86). the amino acids in all the samples except for Tryptophan and histidine were lower than the amino acids in the reference pattern as indicated by essential amino acid scores (EAAS).The low value recorded for meth+Cys in all the samples shows that the first limiting amino acids in the samples were meth+Cys.

Pasting Properties of Fermented Maize Starch Enriched with Red Kidney Bean

Table5: Pasting Properties of Fermented Maize Starch Enriched with Red Kidney Bean.

Properties	Control	MKB1	MKB2	MKB3	MKB4
PV(RVU)	164.92^{e}	165.3^{d}	169.42^{c}	190.08^{b}	268.17^{a}
Trough	100.33^{e}	108.08^{d}	109.08^{c}	131.33^{b}	205.83^{a}
Breakdown	57.22^{e}	58.75^{d}	60.34^{c}	62.33^{b}	64.59^{a}
Final viscosity	198.67^{e}	227.33^{d}	230.57^{c}	236.42^{b}	338.92^{a}
Setback	61.15^{e}	62.41^{d}	67.34^{c}	71.12^{b}	133.03^{a}
Peak time(min)	5.56^{e}	6.28^{d}	6.35^{c}	6.48^{b}	6.28^{a}
Pasting temp	91.85^{e}	92.44^{d}	93.65^{c}	93.75^{b}	93.11^{a}

Control = 100% maize pap, MKB1 = 90% maize: 10% KB, MKB2 = 80% maize: 20% KB, MKB3 = 70% maize: 30% KB, MKB4 = 60% maize: 40% KB

Table 5 shows the result of the pasting characteristics of enrich
ed samples. The peak viscosity ranged from 164.92 to 268.17 RVU. Significant difference exists (P < 0.05) between samples. The trough viscosity ranged between 100.33 and 205.83 RVU with 60%M40%KB possessing the highest trough viscosity (205.83 RVU). The break down viscosity ranged from 57.22 to 64.59 RVU. Final viscosity ranged from 198.67 to 338.92 RVU. Pasting time ranged from 5.56 to 6.28 RVU. Setback viscosity ranged from 61.15 to 133.03 RVU. Pasting temperature ranged from 91.85 to 93.75 RVU. The sample differ significantly (P<0.05).

Discussion

Amino acids are important components for healing and protein synthesis process, any deficiency in these important components will hinder the recovery process. Leucine remained the highest amino acid in all the samples and met the recommended requirement for infant (6.3). This was followed by lysine, phenylalanine, and valine. Lysine is essential as it is crucial for bone formation, lowers serum triglyceride levels and involved in hormone production. This result agrees with the report of other researchers (Aremu*et al.*, 2017)for amino acid composition of some leguminous seeds grown in Nigeria; Oluwole, (2022)macronutrient composition, amino acid profiles and acceptability of maize-based complementary foods enriched with defatted white melon seed and *moringa oleifera* leaf powder and Okafor *et al.* (2017) for nutritional composition and antinutritional properties of maize pap cofermented with pigeon pea. The result revealed that the essential amino acid in the samples were higher than the FAO/WHO (1991) reference pattern except for arginine, cysteine, and methionine. This shows that the samples are good sources of essential amino acids which are important in the nutrition of children and adults. Furthermore, the result revealed that cysteine was the least concentrated amino acid in the samples. This was expected as legumes are known to be low in sulphur-containing amino acid *(*Amarakoon, *2012;* Adeyeye, 2010;Ijarotimi and Keshinro, 2013*)*. This implies that red kidney bean cannot serve as cysteine supplement in food formulation.

The arginine is lower than the value recommended by FAO/WHO (1991) which is 5.20g/day for infant. The histidine is higher than the recommended value by FAO/WHO (1991) which is 1.9for infant. Histidine and arginine are essential amino acid for infants because the gut of infants cannot synthesize this amino acid. The histidine value increased as the red kidney beans flour content increased. This because red kidney beans have more protein than maize.

It was observed that red kidney bean is rich in essential amino acids than non-essential amino acid. The increase in amino acid quality was observed with increase in red kidney bean. The results suggest that the pap blends can meet the essential amino acid requirement of people of all age groups since the value is greater than 39 % considered to be ideal protein food for infants, 26 % for children and 11 % for adults (FAO/WHO 1991).

Generally, a protein is said to be of good nutritional quality when its essential amino acid indices is above 90 % and to be useful as food when the values are around 80 % and inadequate for food material when the value is below 70 percent (Ijarotimi and Keshinro, 2012)for amino acid, fatty acid, mineral and nutritional quality of raw, germinated and fermented African locust bean (*Parkia biglobosa*) flour. In this present study, it was observed that EAAI for all the formulations were above 80 percent considered useful and adequate for food. Biological value (BV) is an index for the measurement of the proportion of the absorbed protein from a food which becomes incorporated into the proteins of the organism's body (Abiola, 2018). This implies that the enriched samples protein can be absorbed when consumed. The protein efficiency ratio was higher in pap produced from enriched flour than the control and was within the recommended value of 2.7g/100g (Ijarotimi and Keshinro, 2012). The greater the essential amino acid indices, the more balanced amino acid composition and the higher quality and efficiency of the protein (Fang *et al.*, 2018).

The pasting properties are essential in predicting the performance of food during and after cooking. The peak viscosity value increased with increase in red kidney bean. The highest value was recorded in enriched samples while the least value was observed in control sample. Breakdown viscosity is the ability of starch or mixture to withstand heating and shear stress during cooking (Adebowale *et al.*, 2005). The higher breakdown viscosity recorded in the enriched sample implies that it will be less stable to withstand heating and shear stress. The trough is the minimum viscosity value in the constant temperature phase of the RVA profile and measures the ability of paste to withstand breakdown during cooling. The final viscosity shows the ability of the sample to form a viscous paste or gel after cooking and cooling (Maziya-Dixon *et al*., 2007). The final viscosity value of enriched sample indicated the ability to form a firm visco-elastic paste or gel after cooking and cooling. The setback shows that the unsubstituted sample will be more susceptible to retrogradation after cooking and cooling but will be desirable in a system where enzyme hydrolysis is undesirable. Peak time is the minimum time taken to cook food product and it was observed that unsubstituted sample will require more time to cook. Pasting temperature is the minimum temperature needed to cook a given food sample and the time required for gelatinization to occur during food processing. It was observed that enrichment increased the pasting temperature which implies that the enriched sample will take longer time to cook.

Conclusion

This study has shown that inclusion of red kidney beans improved the amino acid profile, amino acid quality, essential amino acid score, protein quality and pasting properties of fermented maize starch. It was observed that enriched pap samples were nutritionally superior when compared with the traditional pap and would produce a more nutritionally balanced and acceptable food products which will be cheaper and readily available. Hence, it can be concluded that inclusion of red kidney bean to fermented maize starch enhanced the nutritional quality of the developed pap.

Recommendation

Based on the results of the study, it is therefore recommended that:

1. Red kidney bean is a good of amino acid profile and should be incorporated into diets.
2. Pap should be blended with processed red kidney bean as an alternative protein and energy sources for infant and adults since animal protein is now very expensive.

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