Functional Properties, Nutritional and Sensory Qualities of Maize-Based Snack (Kokoro) Supplemented with Protein Hydrolysate Prepared from Pigeon Pea (Cajanus Cajan) Seed

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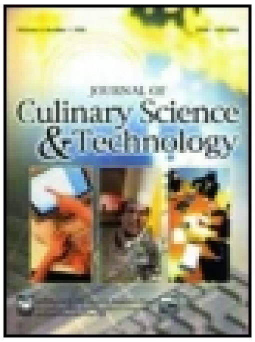
Sunday Samuel Akoja

Olalekan Jimi Adebowale
The Federal Polytechnic, Ilaro

Hafeez A. Salaam
federal polytechnic Ilaro



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Functional Properties, Nutritional and Sensory Qualities of Maize-Based Snack (*Kokoro*) Supplemented with Protein Hydrolysate Prepared from Pigeon Pea (*Cajanus Cajan*) Seed

Sunday Samuel Akoja, Olalekan Jimi Adebowale, Olakunle Moses Makanjuola, and Hafeez Salaam

Department of Food Technology, Federal Polytechnic, Ilaro, Nigeria

ABSTRACT
Kokoro is a popular maize-based snack in Nigeria, which is consumed by adults and children but characterized by low protein content. The snacks were produced from blends of maize flour supplemented with protein hydrolysate from pigeon pea at 100:0 (control), 95:5, 90:10, 85:15, and 80:20. Flour blends were evaluated for functional and pasting properties, while snacks were analyzed for proximate composition and sensory qualities. Proximate analysis results showed significant ($p < 0.05$) increase in protein (9.64–11.12%), fat (13.40–20.17%), ash (1.83–2.38%) content, and energy value (431.84–468.97 kcal/100 g), while fiber (1.19–0.96%) and carbohydrate (68.17–60.74%) content decreased with inclusion of protein hydrolysate. No significant difference ($p < 0.05$) occurred in the sensory qualities of products from 100% maize and 80:20 flour blend. Hence, acceptable *Kokoro* snacks from an 80:20 (maize: protein hydrolysate) blend have been formulated, which could enhance the nutritional wellness of the target consumers.

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KEYWORDS
Flour blends; *Kokoro*; maize-based snack; maize–hydrolysate

Introduction

Maize is a major staple food in developing countries, especially in Nigeria, where it serves as raw material for the production of some staple foods such as traditional fermented maize porridge (*Ogi*), fermented meal (*Agidi*), maize flour (*Tuwo*), and difference traditional snacks (*robo, adun, dankwa, Kokoro*). However, in the areas where maize is a staple, particularly among the rural dwellers and children, the incident of protein-energy malnutrition (PEM) is prevalent. This could be reduced through the availability of cheap, nutritious food based on a simple process such as supplementation and/or fortification. One approach to achieving this could be through the development of a more nutritious traditional snack such as *Kokoro*.

Kokoro is a ring-like, maize-based, ready-to-eat snack food whose origin has been traced to the *Egbado* people of Ogun-West district, Nigeria. The

CONTACT Sunday Samuel Akoja ss_akoja@yahoo.com Department of Food Technology, Federal Polytechnic Ilaro, P.M.B. 50, Ilaro, Nigeria.

snack is mainly produced in three towns: Imashayi, Joga, and Iboro of the district. Production of *Kokoro* snack in these areas is a family tradition from time immemorial. Though, the technologies involved still remain primitive, the processors guarded the trade secrets and know-how of the processing from any outsiders, be it non-indigenes, researchers, or governmental agencies. The production of the snack (*Kokoro*) is basically at a local level involving a three-day intensive process (Oranusi & Dahunsi, 2015) from a thick, coarse corn paste mixed with onion, salt, and deep-fried (Adegunwa, Adeniyi, Adebowale, & Bakare, 2015) in a two-stage pattern for color and aroma development.

The protein content of maize is low (9–12%) when compared with legumes. Maize is, however, known to be rich in methionine and cysteine but lacks lysine and tryptophan. Idowu (2015) noted that most snack foods do not provide nutrients in adequate amounts because of their composition or the production process they are passed through. The amino acids that are lacking can be supplied to the cereal-based snack by complementing or supplementing the maize with legumes like peanuts, soybeans, or pigeon peas, which are better sources of the missing amino acids.

Pigeon pea (*Cajanus cajan*) is considered a most important grain legume for human nutrition in many protein deficient tropical countries, including Nigeria (Fasoyiro et al., 2010). Pigeon pea, with its protein content which ranges between 21 and 26% (Eltayeb, Ali, & Haran, 2010; Okpala & Okoli, 2011), is highly desirable as a protein supplement to cereal-based diets. However, utilization of this legume has been relegated to low-income families, despite its nutritive, high satiety value, unique good taste, and cheapness (Fasoyiro et al., 2010).

Food supplementation is the process of increasing the level of some specific nutrients previously identified as lacking using a source rich in that nutrient. This is normally done to prevent malnutrition in developing countries, particularly among children. The supplementation of cereal-based foods with legume proteins like hydrolysate could result in improved nutritional or protein quality and quantity. There have been considerable studies on supplementing *Kokoro* with different legumes and protein-rich sources (Adegunwa et al., 2015; Awoyale, Maziya-Dixon, Sanni, & Shittu, 2011; Ayinde, Bolaji, Abdus-Salaam, & Osidipe, 2012; Idowu, 2015; Oranusi & Dahunsi, 2015; Otunola, Sunny-Roberts, Adejuyitan, & Famakinwa, 2012; Uzor-Peters, Aris, Lawrence, Osondu, & Adelaja, 2008; Adeola, Olunlade, & Ajagunna, 2011), however information is scant on *Kokoro* snack supplemented with protein hydrolysate obtained from pigeon pea.

The aim of this work was to produce and evaluate the functional, nutritional, and sensory qualities of a maize-based ready-to-eat snack (*Kokoro*) supplemented with protein hydrolysate from pigeon pea (*Cajanus cajan*) seed.

Materials and methods

Matured, dried white maize (*Zea mays*) and pigeon pea (*Cajanus cajan*) were purchased from Oja-Odan market. Other ingredients include fresh onion, salt (Dangote Iodized brand), and vegetable oil (King's brand) and were obtained from a retail market at Sango, Ogun State, Nigeria.

Methods

Preparation of protein hydrolysate from pigeon pea

Pigeon pea flour was produced as described by Echendu, Onimawo, and Sontochi (2004). The pigeon peas were sorted, cleaned, and soaked in water for 5 hours, after which they were dehulled manually. The loosened seeds were washed and dried in a cabinet dryer at 50°C for 24 hours. The dried seeds were milled to pass through a 100 µm mesh sieve using a laboratory hammer mill. The flour was defatted using the cold extraction method with n-hexane 1:20 for 5 days. Protein hydrolysate was prepared using the procedure described by Muzaifa, Safriani, and Zakaria (2012) with little modification. The defatted sample was adjusted to pH 8.00 with buffer solution. The hydrolysis process was done in a water bath (Model W350, Memmert Schwabach, Germany) set up at 55°C. The enzymatic hydrolysis was started by adding a 2% papain enzyme. After 4 hours of hydrolysis, the enzyme was inactivated by heating at 90°C for 15 min in a water bath. The mixture was then put in a centrifuge at 3000 rpm at 4°C for 10 min and the supernatant was collected. Pigeon pea protein hydrolysate was freeze-dried using a Dura-Top freeze dryer (FTS system Inc. Stone Ridge, NY, USA). The protein hydrolysate was then packaged in an air-tight polyethylene bag, and stored in the refrigerator (−4°C) until use.

Production of maize flour

Maize flour was produced as described by Adegunwa et al. (2015). The maize grains were dried sorted and cleaned to remove stones, dirt, and infested grains. The cleaned maize was then milled using a laboratory hammer mill and allowed to pass through a 250-micrometer mesh.

Formulation and production of Kokoro with protein hydrolysate

Blends of maize flour substituted for protein hydrolysate were prepared at different proportions ranging from 5, 10, 15, 20, and 25% protein hydrolysate; using 100% maize flour as a control. Equal amounts of salt (1 g) and onion (2.5 g) were added to each of the blends for taste and then mixed thoroughly to be evenly distributed and a smooth texture. The blends were made into a thick dough by adding 100 ml of boiling water and then manually rolling on a cutting board into a ring-like shape with a 5 mm diameter. Next the dough was deep-fried in hot vegetable oil (King's brand) at 170 °C for 5 minutes. The fried pieces were removed and allowed to drain overnight, after which a second frying was done until the pieces were golden-yellow in color. They were then drained, cooled, and transferred to a basket lined with paper (Figure 1). Finally, they were packed in polyethylene bags and sealed.

Determination of functional properties of maize–hydrolysate flour blends bulk density

The functional property of maize–hydrolysate flour blends bulk density was determined using a standard laboratory method (AOAC, 2006). Sample blends were weighed (7 g) into a 50 ml graduated measuring cylinder. The cylinder was tapped gently against the palm of the hand until a constant volume was obtained. Bulk density was calculated as:

$$\text{Bulk density (g/ml)} = \frac{weiht\ of\ sample}{volume\ of\ sample\ after\ tapping}$$

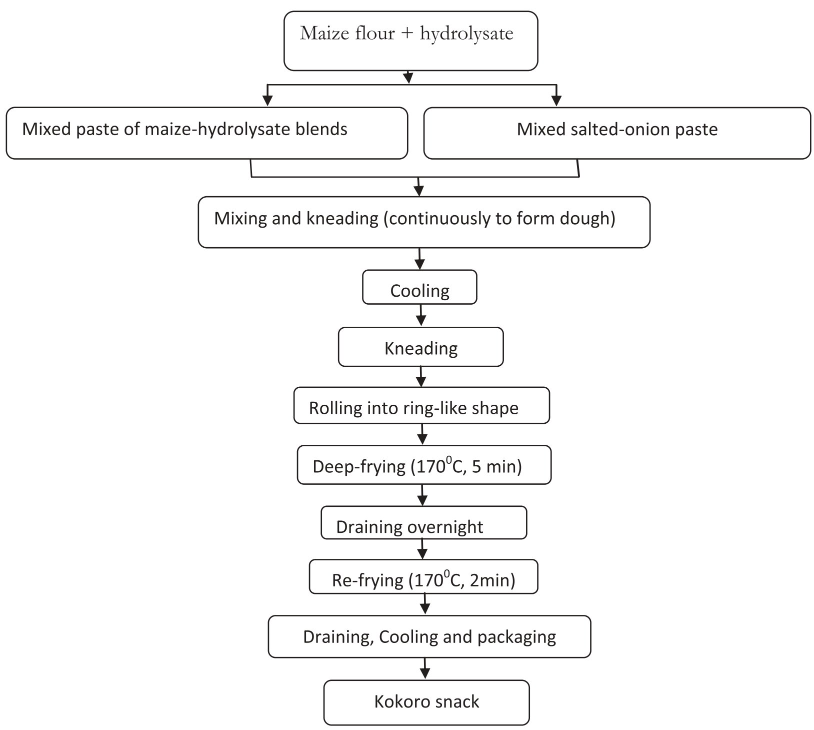

Figure 1. Flow chart for the production of *Kokoro* fortified with protein hydrolysate.

Water absorption capacity and oil absorption capacity

Water absorption capacity (WAC) and oil absorption capacity (OAC) were determined using the method reported by Awoyale et al. (2011). Exactly 10 ml of distilled water for WAC and 10 ml of edible oil for OAC were mixed with 1 g of flour each and blended for 30 seconds. The samples were allowed to stand for 30 minutes and centrifuged at 1303 g for another 30 min at room temperature (27 ± 2°C). The supernatant was decanted. The weight of water or oil absorbed by the flour was calculated and expressed as percentage WAC or OAC.

Swelling capacity

This was determined by using the method reported by Adebowale, Adeyemi, and Oshodi (2005). Flour samples (10 g) were placed in a washed, dried, and weighed graduated measuring cylinder. Distilled water (100 ml) was added, stirred and allowed to stand for 1 hour. The supernatant was discarded and the cylinder with its content weighed to obtain the weight of the net sample. The swelling capacity was calculated as:

$$\text{Swelling capacity }(\%) = \frac{\textit{final volume} - \textit{initial volume}}{\textit{initial volume}} \times 100$$

Dispersibility

The method reported by Adegunwa et al. (2015) was used. Exactly 10 g of flour was suspended in a 100 ml measuring cylinder and distilled water was added to reach a volume of 100 ml. The setup was stirred vigorously and allowed to settle for three hours. The volume of settled particles was recorded and subtracted from 100. The difference was reported as percentage dispersion.

Emulsification capacity

Emulsification capacity (EC) was determined using the method described by Klompong, Benjakul, Kantachote, and Shahidi (2007). Flour sample (2 g) was blended with 25 ml distilled water at room temperature for 30 seconds in a warring blender at 1,600 rpm. After complete dispersion, 25 ml vegetable oil was added gradually. The blending continued for another 30 seconds and the emulsion was transferred to a centrifuge tube and centrifuged at 1,600 rpm for 5 minutes. The volume of oil separated from the sample after centrifuging was read directly from the tube. Emulsion capacity was expressed as the amount of oil emulsified and held per gram of sample.

Foaming capacity and foam stability

Foaming capacity (FC) was determined by the method of Sze-Tao and Sathe (2000). A weighed sample (250 mg) was mixed with 250 ml distilled water, and the pH adjusted to 2, 4, 6, 8, and 10. This solution was whipped for 3 minutes in a stainless GS Blender (model 38 BL45, Dynamic Corporation, Auburn Hills, MI, USA). The whipped solution was then poured into a 100 ml graduated cylinder. The total sample volume was taken at 0 minutes for foam capacity and at 10 minutes intervals, up to 60 minutes for foam stability. Foam capacity and foam stability were then calculated thus:

$$\text{Foam capacity (FC)\%} = \frac{(volume\ after\ whipping - volume\ before\ whipping)\ ml \times 100}{(volume\ before\ whipping)\ ml}$$

$$\text{Foam stability (FS)\%} = \frac{(volume\ after\ standing - volume\ before\ whipping)\ ml \times 100}{(volume\ before\ whipping)\ ml}$$

Pasting characteristic

The pasting characteristics were determined by using Rapid Visco-Analyzer (RVA) (model 3D RVA, Newport Scientific Pvt. Ltd, Narrabeen, Australia). A suspension of 4 g (14% wet basis) sample in 25 ml was made of distilled water the RVA can and inserted into the tower, which was lowered into the system. The suspension was heated from 50 to 95°C and then cooled back to 50°C within 12 minutes, rotating the can at a speed of 160 rpm with continuous stirring of the contents with a plastic paddle. Parameters determined were peak viscosity, trough, breakdown, setback, final viscosity, peak time, and pasting temperature.

Determination of proximate composition of Kokoro *snacks*

Moisture, ash, fat, protein, and fiber contents were determined using the official methods (AOAC, 2006). Carbohydrate was determined by difference (100–[sum of moisture, ash, fat, protein, and fiber contents]). Atwater factor was used to estimate the energy values (4 x % carbohydrate + 4 x % protein + 9 x % fat) in kcal/100 g.

Sensory evaluation of Kokoro *snacks*

A 9-point hedonic preference scale and multiple comparison tests were used to test the acceptability of *Kokoro* samples. This was achieved by evaluating the samples with 40 panelists, comprising of 22 males and 18 females between the ages 15–31 who are staff, students, and members of the community. After seeking the consent of the panelist (including that of the teenagers and their parents), they were all screened with respect to their interest and ability to differentiate foods sensory attributes in three sections. The panelists were later presented with randomly coded samples each and were asked to score each attribute based on color, taste, aroma, shape, crispiness, and overall acceptability using a 9-point hedonic scale, where 1 corresponded to like extremely and 9 corresponded to dislike extremely.

Statistical analysis

Data generated were subjected to one-way analysis of variance (ANOVA). Means obtained from triplicate determinations were separated with the Fisher Least Significance Difference (LSD) at 0.05 significant levels using the Statistic Package for Social Sciences (SPSS version 17) for Windows.

Results and discussion

Functional properties of maize–hydrolysate flour blends

The mean values of the functional properties obtained for different flour blends containing maize and protein hydrolysate are shown in Table 1 below. There were significant differences ($p < 0.05$) in the functional properties of the maize and protein hydrolysate flour blends as shown in Table 1. The bulk density (BD), emulsification stability (ES), emulsification capacity (EC), swelling power (SP) and dispersibility (DP) values increased with an increase in the level of inclusion of protein hydrolysate in the maize flour. However, there was a decrease in values obtained for WAC, OAC, foam stability (FS), and foam capacity (FC), as the level of protein hydrolysate increased. The results obtained for bulk density revealed an increase in bulk density with an increase in protein hydrolysate flour; low bulk density will occupy more space if packed in a packaging material. Bulk density (BD) ranged from 0.645 to 0.769 g/ml, with the control sample (100:0) having the least while 80:20 flour blends had the highest. Values obtained for all of the flour blends were higher than those

Table 1. Functional properties of maize–hydrolysate flour blends.

Parameter	100:0	95:5	90:10	85:15	80:20
BD (g/ml)	$0.645^b \pm 0.04$	$0.667^b \pm 0.02$	$0.690^b \pm 0.01$	$0.714^a \pm 0.01$	$0.769^a \pm 0.03$
WAC (g/g)	$240^a \pm 0.01$	$210^b \pm 0.04$	$200^b \pm 0.01$	$195^c \pm 0.01$	$170^d \pm 0.01$
AOC (g/g)	$163^a \pm 0.01$	$160^a \pm 0.02$	$152^b \pm 0.02$	$145^c \pm 0.04$	$141^c \pm 0.01$
FS (%)	$2.60^a \pm 0.04$	$2.40^b \pm 0.03$	$2.20^c \pm 0.03$	$1.80^d \pm 0.01$	$1.60^e \pm 0.01$
FC (%)	$4.60^a \pm 0.04$	$4.40^b \pm 0.06$	$3.40^c \pm 0.03$	$3.20^d \pm 0.01$	$2.80^e \pm 0.02$
ES (%)	$46.15^c \pm 0.01$	$46.30^c \pm 0.01$	$47.50^b \pm 0.01$	$45.30^d \pm 0.01$	$50.00^a \pm 0.01$
EC (%)	$46.90^c \pm 0.02$	$52.23^b \pm 0.01$	$54.10^a \pm 0.01$	$54.03^a \pm 0.01$	$54.80^a \pm 0.02$
SP (%)	$5.11^d \pm 0.03$	$5.75^c \pm 0.01$	$6.76^b \pm 0.03$	$8.55^a \pm 0.02$	$8.67^a \pm 0.02$
DP (g/g)	$4.40^c \pm 0.01$	$4.75^b \pm 0.02$	$5.10^a \pm 0.01$	$5.10^a \pm 0.01$	$5.20^a \pm 0.01$

Values are means of three replicates. Means in the same row with different superscripts are significantly different ($p < 0.05$). BD = bulk density; WAC = water absorption capacity; AOC = oil absorption capacity; FS = foam stability; FC = foam capacity; ES = emulsion stability; EC = emulsion capacity; SP = swelling power; DP = dispersibility.

reported for maize–pigeon pea (0.42–0.49 g/ml) and maize–beniseed (0.43–0.51 g/ml) flour blends by Adegunwa et al. (2015) and Ayinde et al. (2012), respectively. BD is an index of the heaviness of flour materials and expresses the relative volume of packaging material needed. The BD is generally affected by the particle size. It has relevant application in packaging, transportation, and raw material handling (Adegunwa et al., 2015). This is because higher BD is a packaging advantage, as a greater quantity of flour may be packaged within a constant volume (Yadav, Anand, Kaur, & Singh, 2012).

A similar expression was reported by Mempha, Luayt, and Niraojigoh (2007), suggesting that the BD values can be used to determine the packaging material requirement, material handling equipment, and application of the types of food in the food industry. Both the WAC and OAC decreased with increase inclusion of protein hydrolysate in the blends ranging from 240 ± 0.01 to 170 ± 0.01 and 163 ± 0.01 to 141 ± 0.01 g/g, respectively. The values for both WAC and OAC increased with the increasing inclusion of protein hydrolysate in maize flour. These findings were in agreement with some previous reports (Adegunwa et al., 2015; Ayinde et al., 2012; Otunola et al., 2012) Highest WAC and OAC values were recorded as 90:5 with 210 ± 0.04 g/g, while the lowest were in the 80:20 with 160 ± 0.02 g/g, respectively. The WAC values recorded were significantly higher than the values (5.071–5.688 g/ml) reported for maize–defatted groundnut (Otunola et al., 2012), (144–166 g/100 g) for maize–beniseed flour blends (Ayinde et al., 2012), and (2.25–3.15 g/ml) reported for maize–pigeon pea (Adegunwa et al., 2015). The water absorption behavior can be linked to the nature of the starch in the maize. The nature of the starch has been found to have an effect on WAC (Yadav et al., 2012). Similarly, high WAC may also be attributed to the loose structure of starch polymers while a low value indicates compactness of the starch structure. Hence, the high WAC of the flour blends obtained in this study has the potential to bind water. Therefore, Yadav et al. (2012) suggested that a higher WAC may be useful in products where hydration is required to enhance handling characteristics such as dough and pastes. OAC is the ability of a food or food ingredient to absorb oil or fat. The ability of proteins to bind fat is important, since fats act as flavor retainers and increase the mouth feel of foods, improve palatability, and extend the shelf life of bakery or meat products, meat extenders, doughnuts, pancakes, baked goods, and soup mixes. It is an indicator for flavor retention.

Formability is related to the rate of decrease in the surface tension of the air-water interface caused by absorption of protein molecules (Mempha et al., 2007). Foam stability (FS) and foam capacity (FC) decreased as the levels of inclusion of protein hydrolysate are increasing. The values were in the range 2.60 ± 0.04 to 1.60 ± 0.01% and 4.60 ± 0.04 to 2.80 ± 0.02%, respectively, for FS and FC. These results were significantly ($p < 0.05$) different between all the samples, with sample 80:20 having the lowest and 95:5 flour blends the highest within the fortified maize flour blends. The FC and FS have been related to the decreased surface tension of air-water interface caused by absorption of protein molecules (Mempha et al., 2007).

The values on emulsion stability (ES) and emulsion capacity (EC) decreased with increasing inclusion of protein hydrolysate into maize flour from 46.15–50.00% and 46.90–54.80%, respectively, which is a good indication that the samples have a greater tendency to form a better emulsion, particularly with sample 80:20 flour blends with the highest ES and EC of 50.0% and 54.80%, respectively, having better emulsion forming characteristics than other samples. The values for ES and EC increased with increase in the proportion of protein hydrolysate flour. The results showed that, there were significant differences ($p < 0.05$) in all the samples. Swelling power is the volume of expansion of molecules in response to water uptake, which it possessed until a colloidal suspension is achieved or until further expansion and uptake are prevented by intermolecular forces in the swollen particles (Houssou & Ayernor, 2002). Values obtained for the SP also decreased accordingly, with increasing substitution of the maize flour with protein hydrolysate. Highest values 8.67 and 5.75% were recorded as the highest and lowest for samples 80:20 and 90:5 flour blends, while the control (100:0) had 5.11%, which is much lower than the values obtained for flour blends. This value is higher than those reported earlier for maize–distillers' spent grain (Awoyale et al., 2011) and maize–pigeon pea (Adegunwa et al., 2015).

Dispersibility is an index of the ease of reconstitution of the flour samples in water. The percentage DP ranged from 4.40 ± 0.01 to 5.20 ± 001%, with sample 80:20 flour blends having the highest (5.20%) and 95:5 flour blends having the lowest. However, observed trends differ from what was reported for maize–beniseed (Ayinde et al., 2012) and maize–pigeon pea (Adegunwa et al., 2015) flour blends. This showed that the sample with 80:20 flour blends has the ability to disperse more easily and faster in aqueous solution or during food processing than other samples.

Pasting properties of maize–hydrolysate flour blends

The pasting property is an essential factor in predicting the cooking and baking qualities of flour. Usually, starch when heated increases in viscosity as a result of the swelling of the starch granules and the quantity of water absorbed depends on the duration of cooking and starch content (Yadav et al., 2012). Table 2 shows the pasting characteristics of the maize–protein hydrolysate flour blends. Peak viscosity ranged between 612.0 to 808.0 RVU (Rapid viscosity unit), where the 100% maize had the highest value while sample (90:10) had the least value of 612.0 RVU (Rapid viscosity unit). This is in agreement with the findings of Adegunwa et al. (2015). The peak viscosity is the highest viscosity attained during the gelatinization. It

Table 2. Pasting characteristics of maize–protein hydrolysate flour blends.

Parameters	100:0	95:5	90:10	85:15	80:20
Peak viscosity (RVU)	808.00	653.67	612.00	639.33	636.33
Trough (RVU)	698.00	574.67	548.33	580.67	586.33
Breakdown (RVU)	110.00	79.00	63.67	58.67	47.00
Final viscosity (RVU)	2227.00	1844.33	1629.33	1648.67	1573.33
Setback (RVU)	1529.00	1269.67	1081.00	1068.00	984.00
Peak time (minutes)	7.00	7.00	7.00	7.00	6.98
Pasting temperature (°C)	80.75	82.60	83.40	83.95	84.52

Values are means of three replicates.
RVU = rapid visco-analyser unit.

decreased with the increasing level of protein hydrolysate inclusion. This might be due to a higher content of protein, which has been reported to lower paste viscosity (Adebowale et al., 2005). Peak viscosity may be correlated with the final product quality and also used to ascertain the viscous load likely to be encountered by a mixer. Trough viscosity is the maximum viscosity at the constant temperature phase of the RVA profile and the ability of the phase to withstand breakdown during cooling. The trough or holding strength showed that there was a significant difference ($p < 0.05$) in all the samples. Similarly, 100% maize had the highest value of 698.0 RVU (Rapid visco-analyzer unit). The addition of protein hydrolysate in general lowers the trough of maize flour, which implies that the blends may not find good applications in the food system, where high paste stability during cooking is required (Adegunwa et al., 2015). The breakdown, which is the difference in the peak viscosity and trough, is an indication of the rate of gelling stability, which is dependent on the nature of the product. The breakdown in viscosity, also referred to as shear thinning, showed that there was a significant difference ($p < 0.05$) in all the samples. This is an indication of the ease with which the swollen granules can be disintegrated (Yadav et al., 2012). The phase of the pasting curve after cooling of the sample to 50°C is referred to as the setback region, a point where the retrogradation of starch molecules takes place, as high setback value is known to be associated with a cohesive paste, while a low setback value is an indication of a non-cohesive paste with less tendency to retrograde or syneresis upon cooling.

The setback value decreased with an increase in the protein hydrolysate inclusion, with 100% maize flour having the highest value of 1529.0 RVU (Rapid visco-analyzer unit) and the sample (80:20) had the lowest value of 984.0 RVU. The peak time ranged between 6.98 and 7.00 minutes. There was no significant difference ($p < 0.05$) between the samples. The peak time gives an indication of ease of cooking. More so, the shorter the peak time, the better the ease of cooking (Adegunwa et al., 2015). The pasting temperature ranged from 80.75 to 84.52°C. Sample (80:20) had the highest pasting temperature of 84.52°C, while the 100% maize flour sample had the lowest value of 80.75°C. The pasting temperature gives an indication of the minimum temperature required to cook a sample, which also has implication on the energy cost of preparing a food product. The final viscosity decreased with increasing protein hydrolysate in the flour blends, with 100% maize flour having the highest value of 2,227.0 RVU and the sample (80:20) with the lowest value of 1,573.33 RVU. The pasting properties in general reduce as the inclusion of protein hydrolysate increases. This may be connected with the higher protein content of the hydrolysate.

Proximate composition of Kokoro *from maize–hydrolysate flour blends*

Proximate composition of *Kokoro* samples produced from varying proportions of maize flour and protein hydrolysate blends are presented in Table 3. Significant variation ($p < 0.05$) was obtained in each of the *Kokoro* samples with varying proportions of the protein hydrolysate. The protein (9.64–11.12%), crude fat (13.40–20.17%), ash (1.83–2.38%), and energy value (431.84–468.97kcal/100 g) contents increased, while moisture (5.77–4.91%), crude fiber (1.45–0.96%), and carbohydrate (68.17–60.74%) contents decreased with increasing proportion of protein hydrolysate in the product. The increase in the protein content could be attributed to high protein contents reported earlier for pigeon pea (Adegunwa et al., 2015; Akande, Abubakar, Adegbola, Bogoro, & Doma, 2010). Protein content is one of the most important qualities of any food. Hence, the recommended value for any food commodity is 20% according to the Food Agricultural Organization (FAO) (1996). The sample (80:20) had the highest protein content of 11.12%, while 100% maize *Kokoro* had the lowest value of 9.46%. This is because pigeon pea from where the hydrolysate was obtained is higher in protein than maize flour. This is in agreement with previous studies by Adegunwa et al. (2015) and Idowu (2015) on *Kokor*o produced from pigeon pea and African yam bean respectively. The fat content ranged from 13.40 to 20.17%.

The values of the fat contents were similar to the fat content obtained by Adegunwa et al. (2015) in whole maize *Kokoro*. The ash content indicated that incorporation of protein hydrolysate from pigeon pea may enhance the

Table 3. Proximate composition of *Kokoro* produced with maize–hydrolysate flour blends.

Parameter	100:0	95:5	90:10	85:15	80:20
Moisture (%)	$5.77^{b} \pm 0.62$	$5.06^{c} \pm 0.28$	$6.06^{a} \pm 0.12$	$5.90^{a} \pm 0.46$	$4.91^{d} \pm 0.23$
Crude protein (%)	$9.64^{c} \pm 0.10$	$9.81^{b} \pm 0.09$	$9.96^{b} \pm 0.23$	$11.09^{a} \pm 0.14$	$11.12^{a} \pm 0.21$
Crude fat (%)	$13.40^{e} \pm 0.07$	$14.26^{d} \pm 0.57$	$15.70^{c} \pm 0.06$	$19.17^{b} \pm 0.09$	$20.17^{a} \pm 0.38$
Crude fibre (%)	$1.19^{b} \pm 0.01$	$1.02^{c} \pm 0.01$	$1.45^{a} \pm 0.01$	$1.28^{b} \pm 0.02$	0.96 ± 0.01
Ash (%)	$1.83^{b} \pm 0.02$	$1.99^{b} \pm 0.01$	$2.38^{a} \pm 0.02$	$2.15^{a} \pm 0.03$	$2.10^{a} \pm 0.01$
Carbohydrate (%)	$68.17^{a} \pm 0.68$	$67.86^{a} \pm 0.46$	$64.53^{b} \pm 0.37$	$60.41^{c} \pm 0.47$	$60.74^{d} \pm 0.80$
Energy value (kcal/100 g)	431.84^{c}	439.02^{b}	439.26^{b}	458.53^{a}	468.97^{a}

Values are means of three replicates. Means in the same row with different superscripts are significantly different ($p < 0.05$).

amount of minerals in food products made from maize–protein hydrolysate flour blends (Oyetoro et al., 2007). The moisture contents ranged from 4.91 to 6.06% with the sample (90:10) having the highest value of 6.06% while the sample (80:20) had the least value of 4.91%. Moisture content is used as a quality parameter of food products, as it influences the shelf stability of foods; the lower the moisture the better the storage potential of the food product (Adegunwa et al., 2015). The moisture content of any food is an index of its water activity (a_w). High water activity encourages the growth of fungi. This is an indication that the *Kokoro* sample will store for a longer time due to its low moisture content.

The carbohydrate content decreased from 68.17 to 60.74% as the percentage of the protein hydrolysate is increased from 0 to 20%. This was due to the relatively low carbohydrate content of pigeon pea (Adegunwa et al., 2015; Akande et al., 2010) from where the hydrolysate was produced. Similar findings have been reported with the inclusion of soybean, beniseed flour, distillers' spent grain, and defatted groundnut (Otunola et al., 2012; Ayinde et al., 2012; Awoyale et al., 2011; Uzor-Peters et al., 2008).

Sensory evaluation of Kokoro *from maize–hydrolysate flour blends*

The results obtained for the multiple comparison tests is presented in Table 4. There were significant differences ($p < 0.05$) between the color, taste, aroma, texture, and overall acceptability of the control (100% maize *Kokoro*) and the maize–protein hydrolysate based *Kokoro* snack. The color of the control was most preferred by the panelists having the highest score of 8.50 followed by the 95:5 formulation (8.00) while the 80:20 formulation was the least preferred with a mean sensory score 6.50.

Kokoro snack food containing 80% maize and 20% protein hydrolysate was the least preferred in terms of all the sensory attributes under investigation. However, substitutions up to 15% with protein hydrolysate into the maize flour were still acceptable in terms of the entire sensory attribute without affecting the acceptability by the panelists. The panelist's comments did not in any way reveal the presence of the hydrolysate except the perceived off-flavor by one panelist in the sample blends containing 80% maize and 20% protein hydrolysate flour blends.

Table 4. Mean* scores of sensory evaluation of *Kokoro* from maize–hydrolysate flour blends.

Sample	Colour	Aroma	Taste	Texture	Crispiness	overall acceptability
100:0	8.50^{a}	8.25^{a}	8.65^{a}	8.45^{a}		8.55^{a}
95:5	8.00^{ab}	8.50^{a}	8.25^{ab}	8.15^{ab}		8.35^{a}
90:10	7.25^{c}	7.60^{b}	7.75^{b}	7.50^{b}		7.55^{b}
85:15	7.05^{c}	7.35^{b}	7.55^{b}	7.15^{b}		7.15^{b}
80:20	6.50^{d}	6.45^{c}	6.55^{bc}	6.15^{bc}		6.35^{c}

*Means within the same column not followed by the same superscripts are significantly ($p < 0.05$) different.

Conclusion

The present study has revealed that consumption of the maize-based snack (*Kokoro*) by the target group (Children and adults) may improve their protein in terms of the essential amino acid intakes in such a way that it may eventually contribute to the reduction of PEM, although an increase in the level of substitution of the maize flour with the protein hydrolysate resulted in a reduction of the acceptance level in all the sensory attributes considered. *Kokoro* with a higher nutritional content can be made with composite blends of maize flour and protein hydrolysate from pigeon pea. The maximum levels of replacement which were acceptable are from 5 to 15% protein hydrolysate blends.

In addition to the aforementioned, there would be an increase in demand and utilization for pigeon pea by the processor of *Kokoro* snack; hence this would eventually encourage the cultivation of more hectares by the farmers for the crop and more income on returns. The cultivation of more farmland will require additionally capable hands and thus create job opportunities. More so, planting of more pigeon pea will improve the soil fertility because the crop is a cover crop and prevents the arable land from excessive and prolonged sun rays. Pigeon pea, being a leguminous crop, will also encourage nitrogen fixation activities in the soil by bacteria.

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