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EVALUATION OF WHEAT-PIGEON PEA FLOUR BLENDS FOR NOODLE PRODUCTION IN NIGERIA

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ABSTRACT

Inclusion of legume flours/starches in food formulations such as pastas, noodles, among others, assists in enhancing structure, texture and nutritional quality of the final products. Pigeon pea as a legume is still underutilized in Nigeria and most places in Africa. In this study, the effect of addition of pigeon pea (*Cajanus cajan* L.) flour (PPF) in various proportions into wheat flour (WF) for noodle production was evaluated with respect to selected chemical, cooking and sensory properties of the formulated products. Pigeon pea grains (1 kg) were cleaned and boiled in 3 L of tap water for 15 min. Boiled seeds were de-hulled and sun-dried for 3 days (average ambient temperature of 33.0 ± 2°C), milled and sieved (mesh size: 300 µm). Flour blends (WF: PPF) for noodle production were 90:10, 80:20, 70:30, 60:40 and 50:50; and 100% WF was used as control. Selected functional properties (Water absorption, swelling, oil absorption capacities and bulk density) of the flours were determined, while the noodles were subjected to chemical, cooking and sensory analyses using standard laboratory methods. Results indicated that more inclusion of the pigeon pea flour (PPF) gave rise to increasing water and oil absorption capacities. The 50:50 noodle had significantly ($p<0.05$) higher crude protein (15.68%); Magnesium (109.23 mg/100g) and iron (6.88 mg/100g) than the other noodle samples, while all the noodles had low fat contents. This could be an advantage to prevention of rancidity in the food products during storage and availability of noodles suitable for obese and diabetes Miletus Type 2 individuals. The 90:10 noodles had lower values of cooking time and yield but its cooking loss was higher than others. This underscores the benefit of PPF on improvement of texture of the noodles as the amount increased in the mixture. The 90:10 noodle blend was also more acceptable in all the sensory attributes than others. Therefore, utilization of PPF in composite noodle production in Nigeria and other developing countries can be recommended as this could support the effort towards food and nutrition security of households and communities.

Key words: water absorption, cooking, flavour, flour, noodle blends, pigeon pea, product

INTRODUCTION

Nigeria is one of the third world countries where the issue of nutrient and food security including food sustainability will become risk factors if not sufficiently handled with respect to the rapid growing population. Consequently, utilization of local food crops and fortification processes in new food product developments for the purpose of nutrient diversification has been given attention. Instant noodles are quickly cooked foods commonly consumed and developed from unleavened durum wheat flour dough. They are among the most affordable and convenient foods to consumers who regularly use them as instant foods. However, wheat flour for noodle production has been shown to be deficient inessential micronutrients such as vitamins A, C, E, K and potassium, magnesium, iron, among others, unless blended or fortified with other food nutrients [1]. Otherwise, they are regarded as junk foods meant for the young populace. Most noodles were also noted to be limited in essential amino acids especially lysine, threonine and tryptophan [2]. Consequently, several researches had been carried out to address the problem depending on geographical location, raw materials for use, culture, ingredients added and method of consumption, among others [3]. In the findings, food materials such as Hungary rice, soybean, lupin, African yam bean, malted cow pea, millet and carrot flours or their starches, were incorporated into wheat flour for noodle making either in double or triple blended forms to enhance nutritional composition, cooking or sensorial qualities. In general, any well acceptable noodle should have yellow colour; it has to be firm and not sticky [4].

Legume flours/starches were shown to modify textures, enhance nutrients and add healthy phytonutrients to developed food products [5]. Pigeon pea is a legume utilized in some countries in the world (Japan, China and South Korea, among others) and was readily available for home and continental food preparations.
In Nigeria, most individuals including the diabetics use pigeon pea as staple food. Fortunately, it has ascertained nutritional and health benefits [6] without being enough developed into value-added food products. Hence, for nutrient diversification and food security, there is the need to blend pigeon pea and wheat flours to obtain noodle products that may be required by all end-users.

MATERIALS AND METHODS

Collection of wheat and pigeon pea samples
Pigeon pea seeds and wheat flour (WF) were purchased from 'Ogige' market in Nsukka metropolis of the University, in March, 2018. The seeds were identifiedat the Department of Botany, University of Nigeria, Nsukka (UNN). Other materials such as extruding machine with all accessories were also purchased from the same market in a food store that sold equipment, while hygro-thermometer and chemicals of analar grade were obtained from the laboratories (Food Science and Technology, National Centre for Energy Research and Development; and Department of Microbiology laboratories,UNN) where various analyses were carried out.

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Processing of pigeon pea seeds into flour
Modified method described in [7] was used. One kilogram of pigeon pea seeds which were freed from dirt and other foreign particles such as sticks, stones and dried leaves, were thoroughly cleaned and boiled in 3 L of tap water at 100 ºC for 15 minutes. The boiled seeds were drained, cooled and de-hulled by abrasion (rubbing in-between palms). De-hulled seeds were then spread on stainless steel trays and sun-dried within three days at ambient temperature range of 33.0 ± 2ºC. The dried seeds (8.20% moisture content) were milled with an attrition mill and sieved (mesh size: 300 µm) to obtain pigeon pea flour.

Production of noodles
Noodles were produced using the method of Hou [8]. Two hundred grams of each flour complement (90:10, 80:20, 70:30, 60:40 and 50:50; WF: PPF, 100% WF as control) was mixed with 60 mL of water and 2 g of salt. No other additives were used to estimate the effect of pigeon pea flour on the formulated noodles. The salt was dissolved in the water and the entire mixture manually kneaded until crumbly dough was obtained which was rolled for three times and compressed from about 10 mm thickness to an average of 3 mm. The dough was rested for 30 minutes before extrusion using a pasta cutter. Extrusion of the noodles was done using 'Mercator' noodles cutter with model number; 1048536 (Italy). The extruded noodles were steamed for 90 seconds in a stainless steel vessel containing water with cover, heated at 100 ºC and filled with steam. The noodles were then placed in a stainless steel wire basket fitted with a lid and the basket dipped in hot palm olein vegetable oil at 150 ºC for one minute and cooled for 30 minutes at room temperature before packaging.

Analytical methods
Proximate and functional properties analyses were carried out on single flours, while instant noodles were subjected to proximate, sensory and cooking quality analyses.

Determination of proximate analysis
Moisture, crude fibre, ash, fat, crude protein (N×6.25) and total carbohydrate by difference contents of single flours and instant noodles were determined using the standard AOAC method [9].

Energy value /caloric content
The standard AOAC method [9] was applied in the calculation of caloric content as shown:

Calorie (kcal /100 g) = (4 × % carbohydrate) + (4 × % protein) + (9 × % fat).

Determination of Functional properties
Water absorption, swelling power and oil absorption capacities including bulk density of blended flour samples were evaluated based on the methods described in [10].

Bulk density
The bulk density was calculated as:

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$$Bulk\ density\ \left(\frac{g}{cm3}\right) = \frac{Weight\ of\ sample\ (g)}{Weight\ of\ sample\ after\ tapping\ (cm3)}$$

Swelling capacity
For the swelling power determination, the flour sample (0.1 g) was weighed into a test tube and 10 ml of distilled water added. The mixture was heated in a water bath at a temperature of 50 ^{o}C for 30 minutes with continuous shaking. In the end, the test tube was centrifuged at 1500 rpm for 20 minutes to facilitate the removal of the supernatant which was carefully decanted and the weight of the starch paste taken. This was carried out over a temperature range of 50-100 ^{o}C.

The swelling power was calculated as follows [10]:

$$\text{Swelling power (g)} = \frac{\text{Weight of starch paste}}{Weight\ of\ dry\ stach\ sample}$$

Iron and Magnesium contents
The iron and magnesium contents of the instant noodles were determined using method described in [9].

Noodles' width and length
Length and width of the noodles were measured manually using micrometer screw gauge and measuring rule [11], respectively.

Determination of cooking quality
Optimum cooking time
The optimum cooking time of the noodles was determined according to the method of Yadav *et al.* [12]. In the procedure, 5 g of noodles were placed into a beaker (500 mL) containing 200 mL distilled water and one strip was crushed every 30seconds. The cooking was continued until white fraction in the central core of crushed noodles had disappeared when squeezed gently between two glass slides after cooking and the time taken was recorded as the optimum cooking time.

Cooking yield and cooking loss
Cooking yield and cooking loss were determined according to the method of AACC [13]. The noodles (10 g) were placed in a beaker containing 150 mL of boiling water. The beaker was covered and noodles cooked for 10 minutes with occasional slight agitation. The cooked noodles were allowed to drain for 5 minutes and then weighed. The yield/weight of cooked noodles was calculated. The gruel was poured into a 200 mL volumetric flask and adjusted to volume with distilled water. A 10 mL of the solution was pipetted into aluminum dish and dried to a constant weight at 105 ^{o}C. The cooking yield and cooking loss were calculated using the equations:

$$\text{Cooking yield (\%)} = \frac{\text{Weight of noodles after cooking} - \text{weight of noodles before cooking}}{\text{Weight of noodles before cooking}} \times 100$$

$$\text{Cooking loss (\%)} = \frac{\text{Weight of gruel and dish} - \text{weight after drying}}{\text{Constant weight after drying} \times 100}$$

Determination of microbial load

Total viable count

Total viable count was determined according to the method described by Prescott *et al.* [14]. The samples were inoculated using nutrient agar after the serial dilution of the sample had been obtained. Pour plate method was used. The colony count was done after 24 hours of incubation at 37 ^{o}C using a colony counter (Gallenkamp colony counter, CNW 330 – 010X) and the number of colonies calculated using the following formula:

$$Total\ viable\ count\ \left(\frac{CFU}{g}\right) = \frac{Number\ of\ colonies \times original\ concentration}{Dilution\ factor \times volume\ of\ inoculums}$$

CFU = colony forming unit

Mould count

Mould count was done using the method described in [14]. After the serial dilution of the samples, they were inoculated using Sabaroud dextrose agar. Pour plate method was used. The colony count was done after 24 hours on incubation at 37 ^{o}C, using a colony counter (Gallenkamp colony counter, CNW 330 – 010X) and the number of colonies calculated using the following method:

$$Mould\ count \left(\frac{CFU}{g}\right) = \frac{Number\ of\ colonies \times original\ concentration}{Dilution\ factor \times volume\ of\ inoculumns}$$

CFU = colony forming unit

Sensory evaluation

The noodles were evaluated by 20 untrained panelists made up of equal number of males and females (16-25 years) from Department of Food Science and Technology, University of Nigeria, Nsukka, for colour, flavour, taste, mouth-feel, after taste and general acceptability on a 9-point Hedonic scale as described in [15]; where 9 signifies ‘like extremely’ and 1 signifies ‘dislike extremely’. The samples were presented in coded plastic plates and order of presentation of samples to the judges was randomized. Clean portable sachet water was presented to the panelists for rinsing their mouths in between the evaluation.

Data analysis

The data collected were subjected to a one-way analysis of variance using IBM SPSS (Statistical Products for Service Solutions) version 23.0. Mean separation was done using Duncan’s new multiple range test. Significance was accepted at $p<0.05$ according to Obi [16].

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RESULTS AND DISCUSSION

Functional properties of the blends

Functional properties of wheat-pigeon pea flour blends are shown in Table 1. Values for water absorption capacity (WAC) ranged from 160.82-189.60% and swelling capacity (SC) varied between 8.31 and 89.97 mL. The values of both parameters increased with more incorporation of the PPF in the mixture and might be due to the presence of polar amino acids of the component proteins in the flour mixture. Also, the absorption could be dependent on the size of starch granules, amylose/amylopectin ratio and intra and intermolecular forces [17]. The WAC indicates amount of water available for starch gelatinization and amylose portion of the flour-starch leached into the system that could encourage hydrogen bonding. Experimental results agreed with those of Butt and Batool [18]. Findings of Ashogbon [19] showed that pigeon pea starch had required bond strength with limited brittleness and could help to support structure and texture of foods. The increase in SC could also be based on particle size and source of flour, including processing methods as noted by Suresh *et al*. [20]. Hence, 50:50 flour mixture had significantly ($p<0.05$) higher values for WAC and SC compared to others.

Oil absorption capacity (OAC) also increased as the amount of PPF increased and could be due to presence of non-polar side chains of proteins in the flour that would bind the hydrocarbon side chain of the oil during mixing. Similar trends were observed by Kaushal *et al*. [21]. However, increasing OAC within control has benefits [22]. Bulk density (BD) of the flour blends ranged from 0.88-1.56 g/cm^3.It is important for determining food packaging requirements and material handling [23]. Research reports of Plaami [24] showed that BD was affected by the structure of starch polymers. The blending of both flours gave rise to complements that relatively mixed well with water during dough preparation. Functional properties of flours usually affect the sensory quality of the final food product.

Proximate composition of the single flours

Table 2 shows the proximate composition of the pigeon pea and wheat flours. Moisture contents of WF and PPF were recorded as 10.10 and 11.0%, respectively, and indicated that the flours would store well without the problem of bacteria and mould growths as shown in [25], if properly packaged. Ash, crude fibre and protein contents were of higher values (3.61, 2.56 and 20.70%, respectively) for PPF than WF (0.66, 1.17 and 12.85%, respectively). Hence, results obtained for the parameters could indicate that combining wheat and pigeon flours in noodle production would give rise to nutritional enhancement in the final noodle products. Wheat flour required for instant noodle production should contain crude protein within the range of 8.5-13.0% according to research reports of Fu [26]. Protein content within this limit helps to produce noodles with firm structure due to visco-elastic properties of the gluten in wheat dough, while excess protein and ash might result to undesirable colour development. Both single flours also contained low fat which can benefit shelf stability of the noodles. There was a significant ($p<0.05$) difference in crude fat composition of pigeon flour (1.50.0%) and wheat flour (2.0%). Carbohydrate contents of the single flours indicated that they would be rich sources of energy. However, wheat flour had significantly ($p<0.05$)

higher value (73.630%) than pigeon pea flour (61.10%). Overall results showed that proximate composition of the flours compared relatively well with the values reported by other researchers [27].

Proximate composition of the instant noodles

Proximate composition of the noodles is presented in Table 3. Protein contents of the noodle blends ranged from 11.90-15.68%. Fat contents varied between 1.17 and 2.66%, while ash and crude fibre contents ranged from 3.41-3.96%; 1.94-3.26%, respectively. Moisture content of the noodle products ranged from 8.38-10.51%, while carbohydrate and energy contents varied between 68.16 and 72.96%; 330.10 and 347.89 kcal/g, respectively. The increase in protein content of the food products could be due to the high protein composition of the PPF in the blends. This might be used to reduce protein-energy malnutrition in developing countries such as Nigeria [28]. However, higher values of protein in the dough might encourage high fat absorption during the dehydration process [29] and can lead to rancidity. Undesirable colour development can also be a problem and might reduce colour preference. Cooked noodles are required to be clean, firm and free from surface stickiness [4]. Protein contents of most commercial noodles from WF in Nigeria were less than 1% and this highlighted the need to enhance nutritional quality of the noodles [30].

Crude fat contents of the products indicated low oil uptake during dehydration process [29] and underscore the benefits of complementing wheat-pigeon pea flours for instant noodle making. This might be due to a high concentration of fibre in the noodle blends during frying that might have acted as resistant starch [29]. Hence, the relatively low-fat content (1.17-2.60%) of the noodle blends may confer on them an excellent food for diabetic and obese individuals. Values for ash content was higher than those obtained for commercial noodles from WF (Indomie-1.80%, Honey-well-1.50% and Golden Penny-1.11%) and underscored the positive effect of the flour complementation [30]. The noodle blends contained significant ($p<0.05$) amounts of ash and can assist in the maintenance of healthy lifestyle of individuals that regularly consume the food. Ash content helps to estimate the amount of minerals in foods. Ash content increased in the noodle blends as more of the pigeon pea flour was added in the formulation.

The relatively high fibre values (1.94-3.26%) recorded for the noodle blends could be helpful in removing waste from the body preventing constipation and other health problems [31].

Standard moisture content for fried noodles in Nigeria is 10%, while that of non-fried noodles is 14% [32]. Hence, values obtained were within the limit except 50:50 noodles that was slightly above the required moisture content (10%) with its value as 10.51.0%. Moisture content after dehydration of the steamed noodles in oil increased relatively with increasing amount of PPF and could be due to water uptake by pre-gelatinized starches of the raw noodles during steaming. This scenario could be compared with the values obtained for the swelling power and water absorption capacity as the PPF was added in the flour mixture (Table 1). It must be noted that when starch in flour gelatinizes during heating in the presence of water, the water diffuses into starch granules which swell due to hydration of the amorphous phase.

Starches majorly made up with amylose structure imbibe more water due to hydrogen bonding than those that do not [33]. The WF had higher carbohydrate contents than PPF and complementing the flours might result to noodle blends of high-middle carbohydrate contents [34]. Carbohydrate composition of the noodle blends decreased significantly ($p>0.05$) as more PPF was included in the flour mixture. Values for energy contents of the instant noodle blends showed that the products can contribute to daily estimated energy requirement of different individuals [35].

Selected mineral composition of the instant noodles

Magnesium and iron contents of the noodles are shown in Table 4. Magnesium contents ranged from 86.33-109.23 mg/100g and indicated that the inclusion of more PPF in the flour mixture increased the magnesium composition of the noodle blends. Previous verifications by Adeyeye and Agesin [36] showed that magnesium assists in activating many enzymes in human systems and maintains electrical potential in the nerves. Other researchers such as Al Alawi [37] pointed out that calcium-magnesium interaction help in muscle contraction and assists in strong bone formation, among others. Similar trend was also observed for the iron contents. Iron as a trace mineral assists in carrying oxygen to the cells, among other functions [38].

Length and width of the instant noodles

Values for the length and width measured for the noodles are presented in Table 5. Values for the length ranged from 5.43-6.88 cm; and the width: 3.37-9.01 cm, for the noodle blends. The results were similar to that reported by Akubeze [11]. There were no significant ($p>0.05$) differences in the values of the control (100:00) and 90:10 noodles. Also, significant ($p>0.05$) differences did not exist among the widths of the control and other noodle blends. This could imply that the thickness of the noodles was negligibly affected during steaming and deep-frying and is an added advantage. All the noodle blends had low length and may depend on the amount of gluten in the flour complements [11]. Gluten is a component of wheat protein that forms continuous visco-elastic dough of noodles [8], [38]. Development of gluten structures and the networking between gluten and starches during kneading is very important to formation of dough, in addition to length and firmness of the noodles [8].

Cooking quality of the instant noodles

Cooking quality of the noodles is presented in Figure 1. Optimum cooking time (OCT) ranged from 6.18-12.18 minutes and increased with higher amounts of PPF in the mixture. Hence, the control had lower OCT of 5.36 minutes than others. The 90:10-A, 80: 20-B, 70:30-C, 60:40-D and 50:50-E; WF: PPF noodle blends had optimum cooking times of 6.18, 7.15, 8.21, 10.26 and 12.18 minutes, respectively. This might be due to starch-protein interaction with water and other molecules created during steaming. Cooking yield (CY) varied from 70.24-93.91% and increased as the quantity of PPF was increased in the flour mixture. The control had 60.37% CY, while 93.91% was recorded for the E noodles. Steaming process also positively affected the CY of the noodle blends. Cooking loss (CL) for all food blends varied between 6.13 and 8.47%. Values of the CL for all the noodle blends were significantly ($p<0.05$) different from that of the control (13.80%). The percentage loss from each of the product decreased as the amount of PPF increased. Hence, the A noodles had a loss of 8.47; B: 8.17; C: 7.89;

D: 6.86 and E: 6.13%. The strong bond forces within starch granules might also lead to low CL [33]. This highlights another advantage of the complementation. Studies of Neelam and Khatkar [39] indicated that CL could be related to surface properties of the cooked noodles which depended on the gluten quality of the wheat flour. Also, flours with good quality proteins assist in holding the starch molecules strongly preventing over swelling, rupture and leaching of starch during cooking. Hence, pigeon pea flour might have contributed to structure and texture formation of the blended noodles, reducing the CL and impacting high cooking quality to the noodles.

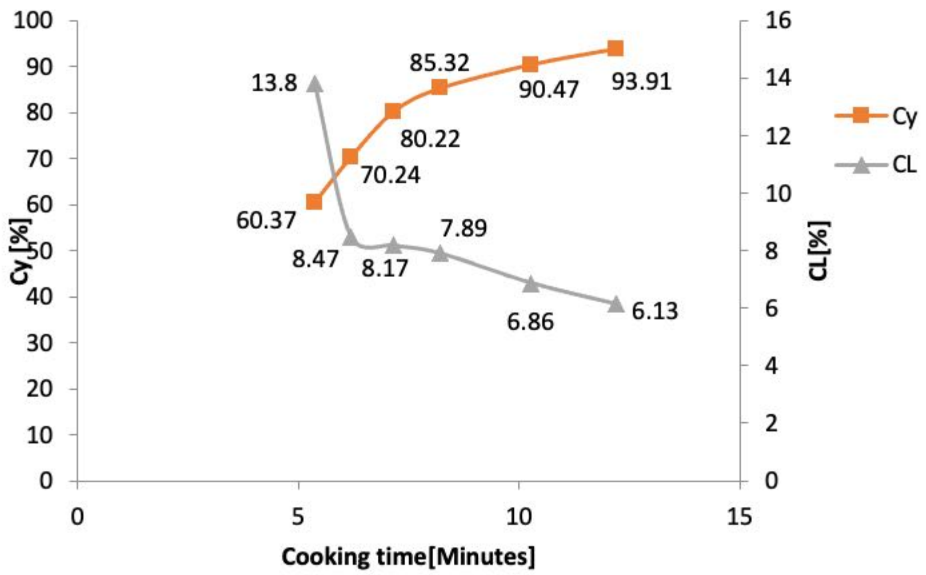

Figure 1: Cooking characteristics of the noodles without scent leaf extracts
Cy-cooking yield; CL-cooking loss

Microbial loads of the noodles

Total viable counts of the noodle blends ranged from 3.34-3.79 Log (cfu/g). The values were below the range that could make noodles unsafe for consumption which indicated 10^4 CFU/g (4.0) Log (cfu/g) as satisfactory [40]. The control, 90:10, 80:20, 70:30, 60:40 and 50:50 had values such as: 2.30, 2.68, 2.62, 2.52, 2.79 and 3.34 Log (cfu/g), respectively. Moulds were also not detected in almost all samples except in 50:50 ratios where very few counts (1.60) Log (cfu/g) were recorded. The total microbial counts for all noodles indicated hygienic condition and handling of the products after processing and hence, the products could be safe for consumption.

Sensory scores of the noodles

Spider web-plot for the sensory scores of the noodles is shown in Figure 2. Panelists' evaluation for the food blends indicated more preference to colour, mouth-feel and after taste for 90:10 noodles than others, while 50:50 products was least acceptable in the colour attribute and might be due to light brown colour that developed after processing of the products as physically observed. The colour development affected the noodle blends as incorporation of the pigeon pea flour increased in the formulation. The scores for flavour and taste were significantly ($p<0.05$) higher for 90:10 and 80:20 products than others. However, 90:10 noodle had the highest score (6.45) in overall acceptability among others which compared closely well with that of control score (6.57). There was no significant ($p>0.05$) difference in the flavour of 90:10 noodle and the control. Values slightly decreased with increasing pigeon pea flour. In mouth feel and positive aftertaste, no significant ($p>0.05$) differences existed between 90:10 noodles and the control.

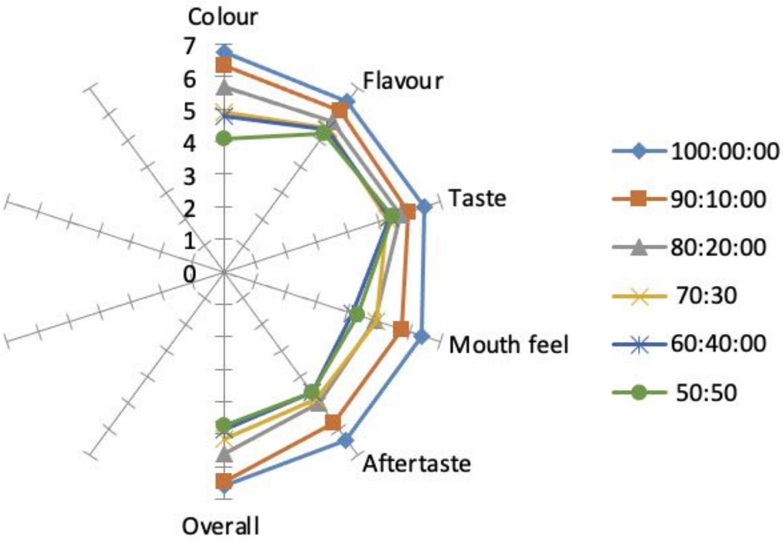

Figure 2: Spider web-plot for the sensory scores of the noodles

CONCLUSION

The study showed that noodle blends of enhanced protein, crude fibre and ash with low-fat contents were developed and contained magnesium and iron that could nutritionally help to maintain the health of individuals that would regularly consume them. The 50:50 noodle blends had higher protein, fibre, ash and mineral contents than others. This cooked blend may also benefit those who are under health management. Enhancement of texture of the blended noodles as pigeon pea flour increased in food matrix underscores the role of pigeon pea flour on the cooking quality of the noodles. The cooked 90:10 noodle was preferred to other product blends in colour, mouth-feel and aftertaste and was the most acceptable product. Hence, the instant noodle blends can assist on improvement of food security of households in addition to reduction of nutritional-hunger prevalent in developing countries.

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Table 1: Functional properties of flour blends and control

Functional properties	WF: PPF 100:00	WF: PPF 90:10	WF: PPF 80:20	WF: PPF 70:30	WF: PPF 60:40	WF: PPF 50:50
Water absorption capacity (%)	141.1^{f} ±0.85	164.63^{d} ±0.74	160.82^{e} ±0.98	170.72^{c} ±0.85	189.60^{a} ±0.14	187.44^{b} ±2.09
Swelling capacity (mL)	8.26^{c} ±0.07	8.31^{c} ±0.01	8.86^{d} ±0.06	9.17^{c} ±0.21	9.21^{b} ±0.01	9.97^{a} ±0.21
Oil absorption capacity (%)	135.95^{d} ±0.35	148.46^{c} ±0.36	147.66^{c} ±0.21	150.82^{b} ±0.70	152.17^{f} ±0.91	153.91^{a} ±0.83
Bulk density (g/cm^3)	0.73^{d} ±0.72	0.88^{d} ±0.87	1.13^{c} ±1.12	1.47^{a} ±1.42	1.32^{b} ±1.31	1.56^{a} ±1.55

Values are means ± standard deviation of three replications. Means within a row with the same superscript were not significantly (p>0.05) different.
Key: WF-wheat flour; PPF-pigeon pea flour

Table 2: Proximate composition of the wheat and pigeon pea flours

Proximate composition (%)	Moisture content	Ash content	Crude fat content	Crude fibre	Crude protein	Carbohydrate by difference
Wheat flour (WF)	10.10^{b} ±0.13	0.66^{b} ±0.01	2.0^{a} ±0.0	1.17^{b} ±0.34	12.85^{b} ±0.78	73.63^{a} ±1.22
Pigeon pea flour (PPF)	11.02^{a} ±0.08	3.61^{a} ±0.16	1.50^{b} ±0.04	2.56^{a} ±0.22	20.70^{a} ±0.78	61.10^{b} ±0.43

Values are means ± standard deviation of three replications. Means within a column with the same superscript were not significantly (p>0.05) different
Key: **WF-wheat flour; PPF-pigeon pea flour**

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Table 3: Proximate composition and energy contents of the instant noodles

Parameters (%)	100:00 (WF:PPF)	90:10	80:20	70:30	60:40	50:50
Protein	9.17^{e}± 1.00	11.15^{d}± 1.00	11.82^{c}± 0.01	13.11^{b}± 1.00	12.24^{c}± 0.30	15.68^{a}± 0.33
Fat	1.19^{e}± 0.12	1.17^{d}± 0.22	1.81^{d}± 0.16	2.17^{b}± 0.21	2.66^{ac}± 0.08	2.60^{c}± 0.21
Ash	2.17^{c}± 0.22	3.41^{ab}± 0.44	3.46^{c}± 0.07	3.49^{c}± 0.31	3.67^{b}± 0.22	3.96^{a}± 0.08
Fibre	1.41^{c}± 0.15	1.94^{b}± 0.06	3.15^{a}± 0.07	3.15^{b}± 0.07	3.10^{a}± 0.14	3.26^{a}± 0.07
Moisture	6.53^{e}± 0.38	8.38^{d}± 0.12	9.39^{c}± 0.53	10.19^{b}± 0.19	10.17^{c}± 0.21	10.51^{a}± 0.35
Carbohydrate	79.05^{a}± 0.35	72.96^{b}± 0.79	71.08^{b}± 0.81	68.16^{c}± 0.12	67.67^{c}± 0.78	61.00^{d}± 1.04
Energy value	363.29^{a}± 3.36	346.97^{b}± 0.86	347.89^{b}± 1.29	344.69^{b}± 0.86	343.58^{b}± 2.69	330.10^{c}± 0.94

Values are means ± standard deviation of three replications. Means within a row with the same superscript were not significantly (p>0.05) different
Key: **WF-wheat flour; PPF-pigeon pea flour**

Table 4: Selected mineral composition of the instant noodles

Noodle Blends (WF:PPF)	100:00	90:10	80:20	70:30	60:40	50:50
Magnesium (mg/100g)	82.72^{f}±0.01	86.33^{e}±0.04	88.01^{d}±0.05	99.32^{c}±0.03	103.11^{b}±0.05	109.23^{a}±0.04
Iron (mg/100g)	4.87^{d}±0.06	5.43^{c}±0.04	5.81^{c}±0.07	6.32^{a}±0.03	6.67^{a}±0.11	6.88^{a}±0.04

Values are means ± standard deviation of three replications. Means within a row having the same superscript were not significantly (p>0.05) different.
Key: WF-wheat flour; PPF-pigeon pea flour

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Table 5: Length and width of the instant noodles

Noodle Blends (WF:PPF)	100:00	90:10	80:20	70:30	60:40	50:50
Length (cm)	8.68 ^{a}±0.68	9.01 ^{a}±0.01	8.12^{b}±0.13	5.20^{d}±0.14	3.66 ^{e}±0.47	3.37 ^{e}±0.21
Width (cm)	0.42 ^{a}±0.01	0.38^{a}±0.01	0.32^{b}+0.01	0.41a+0.01	0.36^{a}±0.01	0.37^{a}±0.01

Values are means ± standard deviation of three replications. Means within a row having the same superscript were not significantly ($p>0.05$) different.
Key: WF-wheat flour; PPF-pigeon pea flour

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