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Chemical, Functional and Sensory Properties of Pap (Gruel/Porridge) made from Fermented Maize *(Zea mays)* Starch Fortified with Red Kidney Bean (*Phaseolus vulgaris*) Flour

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Abstract

The study evaluated properties pap (gruel/porridge) produced from fermented yellow maize starch and red kidney bean. Specifically, this study determined: proximate and energy content of the pap; functional properties of the pap; mineral composition of the pap; the antinutritional composition of the pap and sensory evaluation of the pap. The fermented yellow maize starch and red kidney bean flour were mixed at the ratio of 90:10, 80:20, 70:30 and 60:40 respectively with 100:0 serving as control. The formulated samples were analyzed using mean, standard deviation and analysis of variance (ANOVA). Twenty panelists were involved in the sensory evaluation. A 9-point hedonic scale was used to collect data on the sensory properties of the samples. Results of proximate analysis showed that the values were significantly different ($P < 0.05$). Yellow maize fortified with red kidney bean at a ratio of 60:40 had the highest protein (25.80%), ash (1.84%), fibre (2.98%), fat (4.46%), energy (348.69Kcal) and lowest carbohydrate content (51.50%). Among all the samples analyzed, 60:40 had the highest copper, calcium, iron, zinc, and magnesium content. Antinutrient results showed that maize fortified with red kidney bean (60:40) had the highest value of tannin, phytate, saponin, trypsin inhibitor and hemagglutinin. Results of functional properties showed that except for water absorption capacity (WAC), that there was a decrease upon the addition of red kidney bean in the swelling capacity and bulk density of the sample. The values for appearance, taste, consistency for pap made maize pap fortified with 40 % red kidney bean flour were 6.65, 4.50 and 4.30 respectively. Sensory results showed that pap fortified with red kidney bean at the ratio of 60:40 was not accepted by the panelist.

Keywords: Pap, Yellow Maize, Red Kidney-Bean, Proximate, Antinutrient, Functional, Sensory, Analysis.

Introduction

Food fortification is the intentional increase of the macro- and micronutrient content of food initially present or absent in the food prior to processing, leading to improvement on the nutritive value and providing healthy benefit with low health risks to the people (Food and Agriculture Organization, 2010). Fortification of traditionally fermented food products is one of the major ways to enhance the concentration and bioavailability of the nutritional content of the food to the level that always exceeds the original contents (Itaman and Nwachukwu, 2021). Fortification of food with nutrients is an essential approach for reducing nutrient related diseases and deficiencies especially when the available foods cannot provide the ideal levels of the relevant nutrients required in the diet (John *et al*., 2017). Foods that are usually fortified include infant formular, roots and tubers, cereal, and cereal products. Cereals such as maize, sorghum, millet and rice are staple food grains used by most people in the world in making complementary foods.

A complementary food is a food intended to supplement the diet of infant after six months of age when breast milk is no longer sufficient to meet the nutritional needs of the growing infant. It is also known as weaning or supplementary food. A good processed complementary foods shall contain 75 percent milled cereals and/or legumes and 25 percent optional ingredients such as milk, low moisture content, manufactured and packaged under hygienic conditions, rich in energy content and other essential nutrients to ensure proper growth and development of children, soft, thin in consistency, easily digestible, not spicy and salty and the aroma and flavour should be fresh and sweet (Dutta and Sharma, 2020). Conventionally, fortified cereals are the first complementary foods introduced to the infant, followed by fruits and vegetables in most developed societies.

Maize is consumed in different forms like *pap* (gruel/porridge)*, tuwo, masa, waina, ibier, choko, Mumu couscous, gwate* and popcorn, used for medicine and as a raw material for industries (Oluwole,2022). It could be boiled, roasted eaten with pear or coconut, milled into flour used in preparation of traditional steamed gelled food product called *'moin-moin oka'*, cooked and turned into a stiff gel called *"agidi" or "eko"* prior to consumption. Pap is a gelatinized paste used as a conventional infant complementary food as well as breakfast meal for many adults in the tropics especially in Nigeria. Pap is a popular fermented cereal semi solid food product made from maize (*Zea mays*), sorghum (*Sorghum vulgare*) or millet (*Pennisetum typodenum*). Pap can be made from white or yellow maize. Yellow maize is rich in carbohydrates, low in fat, crude fibre and ash. It is also rich in carotenoids like *lutein* and *zeaxanthin* which act as antioxidants and help eye health. It also contains a lot of B- vitamins, minerals, and other essential amino acids such as lysine and tryptophan but low in sodium (Imtiaz et al., 2011). Conventionally, pap is produced by steeping cereals of preference (maize, sorghum, millet) in cold water for three days (72 hours), then wet milled and wet screened through muslin cloth. The filtrate is then allowed to sediment, supernatant discarded, the sediment bagged and further dewatered, and the resultant sediment described as pap which is often marketed as a wet cake wrapped in leaves or transparent polyethylene bags (Eke- Ejiofor and Beleya, 2017). During steeping and sieving of the maize paste, many nutrients including protein, vitamins, and minerals are lost which necessitates the need to improve the nutritional status of pap.

In Nigeria, breakfast meals for both adults and infants are made from cereals, legumes, roots, and tubers. However, results from previous studies note that most cereals are inadequate in essential amino acids such as threonine, tryptophan and lysine which are essential for the proper growth of infant. The essential amino acids are present in reasonable quantities in legumes (Abiose *et al.,* 2015; Dutta and Sharma, 2020). Therefore, the functionality and nutritional quality of pap can be improved by fortifying it with high protein legume such as red kidney bean.

Red kidney bean is one of the important tropical legumes usually consumed in Southeastern Nigeria. It contains 22.7 percent protein, 3.5 percent mineral, 1 percent fat and 57.7 percent carbohydrate (Shehzad *et al*., 2015). It also contains vitamin B group, essential minerals like potassium, calcium, magnesium, phosphorus, and iron (Yasmin et al., 2008). Despite these nutritional advantages of the crop, it has been neglected and not accorded large-scale breeding and necessary research attention.

Developing maize/red kidney beans based complementary foods would come at an affordable price to the less privileged in the society meeting the nutritional needs of infants, an extremely high priority in Nigeria.

Purpose of the study

The general purpose of the study was evaluate the chemical, functional and acceptability of pap made from fermented yellow maize starch fortified with red kidney beans flour. Specifically, the study determined the:

1. proximate and energy content of the pap.
2. functional properties of the pap.
3. mineral composition of the pap.
4. antinutritional composition of the pap.
5. sensory properties of the pap.

Methods and Materials

***Design of study*:** Experimental method was used for this research.

***Materials*:** The materials used in this study were yellow maize (*Zea mays*) variety and red kidney beans (*Phaseolus vulgaris*) grains purchased from Abakaliki main market, Ebonyi State, Nigeria.

***Production of flour*:** Two types of flours were produced thus: The following steps were followed in the production of the corn starch. The maize grains were sorted, washed, with potable water, 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 floated 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 oven.

***Red kidney bean flour*:** The red kidney bean grain was cleaned, soaked for six hours, boiled for 30 minutes and manually dehulled, washed and sundried using Dehyra tray oven. The dried seeds were milled into flour using an attrition mill and sieved using cheese cloth.

***Formulation of Composite Blends*:** The fermented maize (M) to red kidney bean (KB) flour blends were in the ratios of M: KB1 90:10%, M: KB2 80:20%, M: KB3 70:30%, and M: KB4 60:40%. The 100% maize pap served as the control sample. They were packaged in different airtight containers, labeled, and stored for further analysis.

***Proximate composition*:** The moisture, protein, fat, crude fibre and ash content of the samples were determined using the methods outlined in Association of Official Analytical Chemist (2010). Moisture content was determined by the air oven method. The protein content was determined using the micro-kjeldahl method and nitrogen content converted to protein using 6,25 as the conversion factor. Soxhlet extraction method was used to determine the fat content of the samples. Ash was obtained by weighing 2g of individual samples into porcelain crucible then charred and incinerated at 600^0 C for 12 hours in muffle furnace. Crude fibre was determined using diluted solution H_2SO_4 and NaOH solution, after the residue was ashed and the loss recorded as crude fibre. The carbohydrate was estimated by difference: %CHO = 100-(ash + moisture content + fat + fibre + protein). The energy content was estimated using the Atwater factor [Protein X 4] + [Carbohydrate X 4] + [Fat x9].

Antinurient composition: Phytate and saponin content of the sample was determined by double solvent extraction gravimetric method as described by (Harbone, 1973). Tannin was determined using the Folin-Dennis Spectrophotometric method described by Person (1976). The method of Awuchi, and Ebere (2016) was used to determine haemagglutinin.

***Mineral Content Analysis*:** Copper, Iron, Magnesium, Zinc, and Calcium were determined using the Atomic Absorption Spectrophotometer. The dry ash was reconstituted with 20ml of 6NHCl, heated, filtered into 100ml volumetric flask and made up to 100ml with deionized water. The supernatant was used in AAS to determine each microelement at set wavelength for detection.

***Functional Properties*:** Bulk density, water holding capacity and swelling index were determined by the method described Onwuka (2005). Exactly 1g of the sample was dispersed in 10ml of distilled water. The content was mixed every 30 seconds using a glass rod for 5 minutes. After mixing, the supernatant was decanted and measured. Swelling was achieved by weighing 2g of the sample into 50ml centrifuge tube, 30ml of distilled water was added and mixed gently. The slurry was heated in a water bath at 95^0 for 30 min. The supernatant was discarded, and the tube was dried and weighed. Centrifuge tube without was weighed alone. Bulk density was obtained by weighing 1g of the sample into 10ml measuring cylinder and tapped gently for 10 times on a laboratory bench after which the volume was recorded and calculated as mass over volume.

Sensory Evaluation This involved the following procedures:

***Selection of panelists*:** Twenty taste panelists drawn from students and staff of Faculty of Agriculture, Ebonyi State University who were nursing mothers and familiar with *"akamu"* were selected for the experiment. The panelist were dully trained before participate in the study.

***Instrument for Data Collection*:** A 9-point hedonic scale was used for data collection. The scale ranged from (9) representing "liked extremely (1) representing dislike extremely". It validated by five experts in food science.

***Data Collection Procedure*:** Sensory attributes tested were appearance, flavour, colour, taste, consistency and general acceptability. The sensory evaluation session was carried out in the Food Laboratory of the Department of Food Science and Technology Ebonyi state university. They were served the *"akamu"* samples in coded plates. Panelists rinsed their mouths with water after testing each sample before moving to the next sample.

Statistical Analysis: All data collected were analyzed using means and one-way analysis of variance. Duncan test was used to determine the significant differences ($P < 0.05$) between the variables.

Findings

Table 1: Proximate and Energy Content of Pap Made from Different Ratio of Yellow Maize and Red Kidney Bean Flour.

Composition	Control	MKB1	MKB2	MKB3	MKB4
Moisture	13.42^{c}±5.23	13.80^{a}±0.01	13.89^{b}±0.04	14.05^{C}±0.01	14.49^{c}±0.02
Ash	1.45^{b}±0.01	1.50^{a}±0.09	1.63^{b}±0.05	1.77^{c}±0.01	1.84^{c}±0.09
Protein	11.70^{e}±0.28	14.55^{d}±0.21	18.40^{c}±0.21	20.80^{b}±0.14	25.80^{a}±0.14
Fibre	2.02^{e}±0.03	2.31^{a}±0.02	2.57^{b}±0.01	2.73^{c}±0.03	2.98^{d}±0.01
Fat	3.59^{e}±0.01	3.79^{d}±0.02	4.01^{c}±0.01	4.21^{b}±0.01	4.46^{a}±0.08
Carbohydrate	67.40^{a}±5.5230	63.41^{ab}±0.10	59.34^{bc}±1.92	56.62^{bc}±2.82	51.50^{c}±2.06
Energy	1.65^{e}±8.4	306.27^{d}±0.66	311.54^{c}±9.22	315.97^{b}±1.35	348.69^{a}±2.19

Values are means and standard deviations of duplicate determinations. Means with the same superscript in the same row do not differ statistically (P>0.05).
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.

Table 1 shows the proximate composition of *ogi* the sample. Moisture content ranged from 13.41 to 14.49 % with 60%M40%KB having the highest moisture and the control having the least value. The ash increased with increase in red kidney bean. Ash content ranged from 1.45 to 1.84 %. The ash content increases with the addition of red kidney beans. The protein content ranged from 11.70 to 25.80% with sample 60%M40%KB having the highest value. The protein content showed significant difference ($P<0.05$) with the addition of red kidney bean, showing enhancement in the nutritional quality of the formulated pap samples. The crude fibre content ranged from 2.02 to 2.98 % with the control having the lowest value. There was a significant difference ($P< 0.05$) among the sample. The carbohydrate content of the sample ranged from 51.50 to 67.40 % with the control having the highest value. It was observed that inclusion of red kidney bean decreased the carbohydrate content of the formulated samples.

Table 2: Mineral Content of Pap Made from Different Ratio of Yellow Maize and Red Kidney Bean Flour (mg/100g)

Mineral	Control	MKB1	MKB2	MKB3	MKB4
Copper	0.231^{b}±0.06	0.326^{ab}±0.05	0.357^{a}±0.04	0.369^{a}±0.03	0.381^{a}±0.02
Calcium	35.32^{d}±0.07	37.89^{c}±0.18	38.33^{b}±0.16	38.48^{b}±0.00	38.89^{a}±0.18
Iron	8.11^{c}±0.10	8.30^{bc}±0.56	8.37^{bc}±0.05	8.84^{ab}±0.08	9.13^{a}±0.17
Zinc	23.12^{d}±0.05	24.13^{c}±0.06	25.57^{b}±0.14	25.93^{a}±0.07	26.00^{a}±0.02
Magnesium	50.02^{d}±0.21	50.46^{c}±0.09	50.94^{b}±0.21	51.20^{ab}±0.10	51.55^{a}±0.16

Values are means ± SD of duplicate measurements. Means with the same superscript in the same row are not statistically different (p>0.05). 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.

Table 2 shows the mineral content of fortified and unfortified pap samples are presented. The copper content ranged from 0.231 to 0.381 (mg/100g). It was observed that fortification of pap maize with red kidney bean increased the copper content. Calcium content of the samples ranged from 35.32 to 38.89(mg/100g). There was no significant difference (P < 0.05) among the samples. The zinc content ranged from 23.12 to 26.00(mg/100g). The zinc content slightly increased with incorporation of red kidney bean. The magnesium content ranged from 50.02 to 51.55mg/100g. The iron content ranged from 8.11 to 9.13 mg/100g with 60%M40%KB having the highest value.

Table 3: Antinutrient Composition of Pap Made from Different Ratios of Yellow Maize and Red Kidney Bean Flour

Antinutrient	Control	MKB1	MKB2	MKB3	MKB4
Tannin (mg/100g)	$8.43^{b}\pm0.06$	$8.53^{b}\pm0.06$	$8.62^{b}\pm0.07$	$8.80^{ab}\pm0.02$	$9.44^{a}\pm0.61$
Phytate (mg/100g)	$17.75^{b}\pm0.54$	$18.43^{a}\pm0.09$	$18.65^{a}\pm0.16$	$18.83^{a}\pm0.05$	$19.08^{a}\pm0.13$
Saponin (%)	$7.21^{e}\pm0.07$	$7.41^{d}\pm0.03$	$7.54^{c}\pm0.01$	$7.72^{b}\pm0.04$	$8.02^{a}\pm0.02$
Trypsin inhibitor (TIU/mg)	$86.52^{d}\pm0.04$	$87.73^{c}\pm0.05$	$87.97^{b}\pm0.003$	$88.09^{b}\pm0.11$	$88.87^{a}\pm0.14$
Hemagglutinin (HU/mg)	$119.0^{c}\pm1.1$	$126.5^{bc}\pm2.1$	$133.0^{b}\pm5.7$	$142.5^{a}\pm0.7$	$146.5^{a}\pm2.1$

Values are means ± SD of duplicate measurements. Means with the same superscript in the same row are not statistically different (p>0.05). 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.

Table 3 shows that pap produced from 60%M40%KB recorded the highest amount of tannin (9.44mg/100g), Phytate (18.83mg/100g), saponin (8.02%), trypsin inhibitor (88.87TUI/mg) and Hemagglutinin (146.5HU/mg) respectively while pap produced from the control had the least values. It was observed that there was no significant difference (P < 0.05) between the fortified and control sample expect for 60%M40%KB which differed significantly (P < 0.05) in tannin content.

Table 4: Functional Properties of Pap Made from Different Ratio of Yellow Maize and Red Kidney Bean Flour.

Property	**Control**	**MKB1**	**MKB2**	**MKB3**	**MKB4**
WAC (%)	$180.0^{e}\pm0.0$	$190.0^{d}\pm141$	$200.0^{c}\pm14.1$	$217.5^{b}\pm27$	$250.0^{a}\pm56.6$
SI (ml/g)	$1.34^{a}\pm0.01$	$1.17^{b}\pm0.02$	$0.91^{c}\pm0.02$	$0.72^{d}\pm0.01$	$0.71^{d}\pm0.01$
Bulk density (g/ml)	$0.65^{a}\pm0.09$	$0.64^{a}\pm0.05$	$0.62^{a}\pm0.13$	$0.62^{a}\pm0.05$	$0.57^{a}\pm0.16$

Values are means ± SD of duplicate measurements. Means with the same superscript in the same row are not statistically different (p>0.05). 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, WAC = Water absorption capacity, SI = Swelling index.

Table 4 shows the functional properties of pap made from different ratios of yellow maize and red kidney bean flour. The water absorption capacity (WAC) ranged from 180.0 to 250.0%. The water absorption capacity increased with the addition of red kidney beans. The swelling index ranged from 0.71 to 1.34 ml/g. The bulk density ranged from 0.57 to 0.65 g/ml. The result revealed that significant differences (P < 0.05) existed between the samples expect for bulk density which was statistically same (P > 0.05).

Table 5: Sensory Properties of Pap Made from Different Ratio of Yellow Maize and Red Kidney Bean Flour.

Characteristics	Control	MKB1	MKB2	MKB3	MKB4
Appearance	$8.15^{a}\pm0.99$	$7.90^{b}\pm1.00$	$7.65^{c}\pm0.79$	$7.50^{d}\pm0.93$	$6.65^{e}\pm1.50$
Flavour	$6.85^{a}\pm1.97$	$6.60^{b}\pm1.50$	$6.60^{b}\pm1.64$	$6.10^{c}\pm1.89$	$5.20^{e}\pm2.48$
Colour	$8.05^{a}\pm0.76$	$7.79^{b}\pm1.10$	$7.55^{c}\pm0.95$	$7.45^{d}\pm1.10$	$6.55^{e}\pm1.88$
Taste	$7.75^{a}\pm2.34$	$6.05^{b}\pm1.61$	$5.70^{c}\pm1.81$	$5.45^{d}\pm2.46$	$4.50^{e}\pm1.96$
Consistency	$7.85^{a}\pm1.23$	$5.85^{b}\pm1.92$	$5.50^{c}\pm1.57$	$4.65^{d}\pm2.61$	$4.30^{e}\pm2.25$
General acceptability	$7.65^{a}\pm1.27$	$6.95^{b}\pm1.05$	$6.40^{c}\pm1.93$	$6.35^{d}\pm1.95$	$5.35^{e}\pm1.98$

Values are means ± SD of duplicate measurements. Means with the same superscript in the same row are not statistically different (p>0.05). 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

Table 5 shows the sensory characteristics of pap made from different ratio of yellow maize and red kidney bean flour. The appearance of the samples ranged from 6.65 to 8.15. The colour ranged between 6.55 and 8.05. The colours of the fortified samples were the lowest while the control was the highest. The variation in colour was expected because the colour red kidney bean is naturally dark. The flavour ranged from 5.20 to 6.85 with the control sample having the highest value. The taste ranged from 4.50 to 7.75 with the fortified sample having the least values. The consistency ranged from 4.30 to 7.85 with the unfortified sample having the highest value. The general acceptability ranged from 5.35 to 7.65 with the supplemented sample having the least value. There was significant difference (P < 0.05) among the samples.

Discussion of Findings

Table 1 shows the proximate composition of pap made from different ratio of yellow maize and red kidney bean flour blends. The result showed that the fortified samples and the control were significantly different (P < 0.05) in their moisture content. It was observed that the moisture content increased slightly with the inclusion of red kidney beans. The result is in consistent with the report of Okoye et al. (2008) who reported that addition kidney beans in the kidney bean-wheat flour blend increased the moisture content. Ash content gives an indication of the mineral content of foods. The ash content of the blends improved significantly (P<0.05) when compared with the control. The values are within the range for complementary food from maize and soybeans (Offiah et al., 2017).

The protein content of the samples was significantly different (P < 0.05) from each other. The protein content is similar to the value for yellow maize reported by (Bristone *et al.*, 2016). The recommended dietary allowance (RDA) for crude protein in foods is ≥ 16.0 % (FAO/WHO, 1998) and the pap produced from 100 percent maize was below this range (11.70 %). The protein content of *ogi* fortified with red kidney bean is far above the recommended value. This could be attributed to inclusion of red kidney bean as legumes are known to be a rich source of protein compared to cereals. Several researchers have reported that addition of legume to ogi increased the protein content (Audu and Aremu, 2011; Oko *et al., 2018*).

The crude fibre values were found to be higher in the fortified samples. The recommended dietary allowance (RDA) for crude fiber in foods for infants (6–12 months) is 4.0 mg/100 g (FAO/WHO, 1998), implying that the crude fiber contents of the fermented products in this study did not meet the recommended allowance for infants. The fat content of the fortified pap was significantly higher (P < 0.05). The high fat content could be credited to boiled red kidney bean, which was reported to contain 10.3 percent fat (Audu and Aremu, 2011) as yellow maize has been reported to be low in Fat 5.96 percent (Bristone *et al.*, 2016). The addition of red kidney bean to the blends resulted in a reduction in the carbohydrate content of the pap.

The mineral composition of pap produced from maize and red kidney bean reveals that the most abundant mineral in both the fortified and unfortified pap was magnesium. Magnesium levels increased significantly (P <0.05) as kidney bean proportions increased. The variation in magnesium contents of the control and blends may depend on the initial contents of this mineral in maize and kidney bean as yellow maize has been reported to be low in magnesium (22.73 and 44.13 mg/100g) respectively (Edet *et al., 2017*) compared to kidney bean which is very rich in magnesium (820.9 mg/100g) (Audu and Aremu, 2011).

Pap produced from yellow maize had the lowest concentration of calcium while the fortified increased with an increase in red kidney bean inclusion. Calcium and phosphorous play important roles in the formation of bones in children (Ijarotimi, and Kenshinro, 2021).

For copper, there was a statistically significant difference (P < 0.05) between the samples. The values are higher than the 0.034-0.242mg/100g reported for African yam bean- maize blends (Atinuke, 2015). The samples were high in zinc content as indicated in Table 2. There was a significant difference between the samples (P < 0.05). The values are higher than the 2.45mg/100g reported for complementary meal made from rice with banjara beans and sesame seeds (Shuaibu et al., 2015).

Tannin content increased as the amount of kidney beans increased (Table 3). This is to be expected, given that kidney beans belong to the legume family, which is known for its tannin content. However, the tannin contents of the blends were not significantly different (P>0.05) from the control except the MKB4 blend. This could be attributed to the soaking and boiling treatments received by the kidney bean as studies have shown that soaking and fermentation reduces tannin content by 35% (Devi *et al.*, 2018).

Although there was no significant difference (P >0.05) in the phytate content of the samples, the values increased as the amount of red kidney bean was increased. The major antinutritional role of phytate in diets is that they influence bioavailability of minerals, digestibility, functionality and solubility of carbohydrates and proteins (Popova and Mihaylova, 2019). The result revealed that pap saponin content was low. The high value observed in this study may be due to insufficient heat treatment since heat treatment has been recommended as the easiest method of reducing trypsin inhibitor (Popova and Mihaylova, 2019). The result revealed that inclusion of red kidney bean increased haemagglutinins values significantly ($P < 0.05$) in the samples.

The result of the functional properties of pap produced from maize and red kidney bean is shown that water absorption capacity (WAC) was high for all the samples and significant difference ($P < 0.05$) existed among the samples. The WAC increased with an increase in red kidney beans. The values are lower than the value reported for kidney bean-wheat flour blend (Asaam *et al.*, 2018). The higher WAC of the fortified samples may be accredited to the proportion of hydrophilic and hydrophobic amino acids in the protein and carbohydrate. The more hydrophilic amino acids and polysaccharide constituents, the more water the diet will absorb and bind (Adepeju *et al.*, 2014). This implies that the unfortified diet with the highest swelling index will produce a thick viscous paste compared to the fortified sample. Fortification significantly ($P < 0.05$) decreased the bulk density. The reduction in bulk density may be due to breakdown of complex compounds such as starch and protein because of modification that occur during fermentation and boiling. The lower bulk density of the formulated complementary diet will imply lower dietary bulk. This is desirable as high bulk density reduces the quantity that the infant will consume thereby reducing their nutrient in take requirement (Adepeju *et al.*, 2014).

The findings on sensory properties in Table 5 showed that all the samples were significantly ($P < 0.05$) different in the attributes measured (appearance, flavour, colour, taste, consistency, and general acceptability). Blends containing processed red kidney bean compete favourably with the control in all the parameters measured. The control, MKB1and MKB2 were found more acceptable in all the attributes analyzed. Sample MKB3 and MKB4 containing higher proportion of red kidney bean was not well accepted. This could be due to the fact the red kidney bean impacted unpleasant properties to the diet. Omemu (2011) reported that fortification of fermented cereal gruel with protein-rich food in a bid to increase their nutrient content most times brings about undesirable change in the sensory properties of the formulated with legumes. It was observed that the unfortified sample was preferred by the panelists.

Conclusion

In this study, blending kidney bean with maize flour to produce pap significantly improved the nutritional value of the samples. Findings showed that the pap blends were rich in minerals. Antinutrients increased as proportion of kidney bean increased and trypsin inhibitor and haemagglutinin were present in high amounts in both control sample and the blends. The control and blends recorded good functional properties. The pap blend with 30 percent kidney bean compared well in pasting properties as the control and both samples had good pasting properties. All the blends had acceptable sensory properties as the control except the blend with 30 and 40 percent red kidney bean. The study concludes that substitution of maize with up to 20 percent red kidney bean is necessary to produce pap of good nutritional, functional, pasting, and sensory properties.

Recommendations

1. About 20 percent red kidney bean should be included in the regular maize pap in order to improve its nutritional value as a cheap means of meeting the nutritional deficit of many developing countries such as Nigeria.
2. Further study on the use of other processing methods such as toasting, fermentation, germinating should be employed to ascertain the best that will reduce the antinutrient to the safest value.

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