Production and Evaluation of Flakes from Rice (*Oryza sativa*) and Kidney Bean (*Phaseolus vulgaris*) Flour Blends

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KEYWORDS

Flakes,
Kidney bean
Proximate composition,
Rice,
Sensory,

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ABSTRACT

This study evaluated breakfast flaked samples produced from rice and kidney bean flour blends. The rice grains were sorted, winnowed, washed, soaked, drained, dried, milled, and sieved, whereas, the kidney bean seeds were sorted, cleaned, boiled, drained, dehulled, washed, dried, milled, and sieved. The rice and kidney bean flours were blended in the ratio of 100:0, 90:10, 80:20, 70:30, 60:40, 50:50, 40:60, 30:70, 20:80 and 10:90 of rice and kidney bean. The blended flours were weighed, mixed, heated, aged, cut, toasted, cooled and packaged to obtain the flaked samples. The three best samples from the sensory evaluation of breakfast flake samples (60:40, 30:70, 10:90) were analysed for proximate composition using standard methods. The data obtained were statistically analysed using SPSS and means were separated at 0.05 level of significance. The sensory properties of the breakfast flake samples ranged from 6.07 to 7.53 for colour, 5.67 to 7.80 for taste, 6.20 to 7.13 for texture, 6.20 to 7.00 for flavour and 5.27 to 6.87 for overall acceptability. The breakfast flake samples produced were all acceptable, although sample A (60:40) was preferred most in terms of overall acceptability scores of 6.87±0.73. The results of the proximate composition of the samples showed that moisture ranged from 3.35 to 11.77%, protein 13.95 to 20.61%, ash 1.99 to 3.25%, fibre 1.66 to 4.67%, lipid 6.01 to 6.08% and carbohydrate 53.69 to 69.91%, respectively. It was observed, therefore, that the blends of the rice and kidney bean flour in breakfast flakes making should not exceed 50% of kidney bean flour substitution.

INTRODUCTION

The word “breakfast” is a compound of "break" and "fast" which literally means “breaking the fast” from the last meal or snack of the previous day. Breakfast is the nutritional foundation or the first meal of the day (Afeiche *et al*., 2017). In developing countries, particularly sub-Saharan Africa, breakfast meals for both adults and infants are based on local staple diets made from cereals, cassava and potato tubers. However, the most widely eaten breakfast foods are cereals (Baltar *et al*., 2018). Breakfast cereals can be referred to as foods obtained by swelling, grinding, rolling or flaking of any cereal (Sharma and Caralli, 2014). They can be categorized into traditional (hot) cereals that require further cooking or heating before consumption and ready-to-eat (cold) cereals that can be consumed from the box or with the addition of milk (Fast, 2000; Tribelhorn, 1991).

According to Jones (2023), instant and ready-to-eat (RTE) flakes facilitate independence because of their ease of preparation which means that children and adolescents can be responsible for their own breakfast or snacks. Such foods may need to be reconstituted, pre-heated in a vessel or allowed to thaw if frozen before consumption, or they may be eaten directly without further treatment (Usman *et al*., 2015). However, it is

still rare to find flakes made from legumes. Onweluzo and Nnamuchi (2009) indicated that most cereals are limited in some essential amino acids especially threonine and tryptophan. Though cereals are rich in lysine, they cannot effectively provide the nutrients required by the body, especially in the morning when the supply of nutrients from the previous day is exhausted. Cereals can however, be supplemented with most oil seeds and legumes which are rich in essential amino acids particularly the sulphur-containing amino acids (Kanu *et al*., 2017).

MATERIAL AND METHOD

Source of Raw Materials

The raw materials; rice grains, kidney bean seeds and other ingredients (sugar, salt, milk and vanilla) that were used in the study were purchased from Eke Market, Ekwulobia in Aguata Local Government Area of Anambra State, Nigeria.

Sample Processing

Preparation of Rice Flour

The rice flour was prepared following the method described by Eyenga *et al.* (2020) with modifications. One kilogram (1 kg) of rice grains were winnowed to remove the extraneous materials, washed, and soaked in distilled water for 8 h at room temperature (28°C**).** The rice was removed from water and dried at 60°C for 16 h to a moisture content of 20%. Then, the rice was milled in a regular disc attrition mill (dry milling) before completely drying the flour to 10% moisture and then pulverized to fine flour. The dried powder was sieved using a 60 mesh stainless sieve in order to bring the particle sizes to uniform at 60 mm, packaged and stored in a refrigerator until used.

Preparation of Kidney Bean Flour

The preparation of kidney bean flour was done according to the method of Manonmani *et al*. (2014) with slight modification. Two kilograms (2 kg) of the kidney bean seeds were sorted out, washed and boiled for 30 min. It was drained, washed, and then soaked in clean portable water for 10 h. The kidney beans were drained and dehulled manually by the aid of rubbing between palms. The dehulled kidney bean was later dried in hot air oven at 60ºC for 20 h. Then, the dried seeds (1 kg) was finely mill in disc attrition mill, sieved with 60 mm mesh sieve and stored at 4ºC in air tight containers until needed for further use.

Formulation of Flour Blends

The rice and kidney bean flours were thoroughly mixed together in the ratios of 90:10, 80:20, 70:30, 60:40,50:50, 40:60, 30:70, 20:80, 10:90 in a Kenwood blender (specify model, country of origin and year) to produce composite flours while 100:0 of rice: kidney bean was used as control. The composite flours produced were separately packaged in covered plastic containers, labelled and stored in a refrigerator at about 10^0C until needed for the production of breakfast flakes.

Recipe for the Production

The ingredients used were 500 g of each flour samples, and in each case 30 g of sugar, 4 g of salt, 6 g of milk flavour, 10 ml of vegetable oil and 750 ml of water.

Production of Breakfast Flakes

The breakfast flakes samples were prepared using the method described by Mbaeyi-Nwaoha and Uchendu (2016). The composite flour was poured in a plastic bowel and small quantity of water (20 mL) was added so as to have a binding effect, sugar and salt were added to improve the taste. The mixture was heat-treated by steaming at 120°C for 10 min and cooled. Then the treated mixture was allowed to age at a temperature of 4°C for 6 h. The semi-dried products were cut with a sharp knife, placed back into the oven for further drying and toasted at 280°C. Thereafter, the flakes products obtained were removed from oven and allowed to cool at room temperature (28°C). On cooling, the toasted breakfast flakes were packaged individually in covered plastic containers labelled and kept in a refrigerator at 10^0C until needed for analysis. Breakfast flakes made from 100% rice flour was similarly produced and used as a control.

Proximate Composition of the Samples

The Standard procedures of the Association of Official Analytical Chemist (AOAC, 2012) were used for the analysis of moisture, ash, fat, and crude protein contents. The carbohydrate content was determined by difference (AOAC, 2012).

Sensory Evaluation

The rice and the composite flour breakfast flakes produced were cooled for 2 h at room temperature and evaluated sensorially by a panel of twenty (20) semi-trained consumer panellists consisting of staff and students of the Department of Food Science and Technology, Federal Polytechnic Oko, Anambra, Nigeria. The breakfast flakes samples were made into porridge, separately coded and served to the panellists in white plastic plates of similar sizes. The panellists were asked to taste, assess and score the samples using a Nine (9) Point Hedonic Scale where 9 represents extremely like and 1 represent extremely dislike for the following attributes; colour, texture, flavour, taste, and overall acceptability. A cup of drinking water was also provided to each panellist to rinse his or her mouth after testing each sample to avoid residual effect. The panellists were told to evaluate and score each of the samples based on their preference and acceptability.

Statistical Analysis

The data generated was subjected to One-Way Analysis of Variance (ANOVA) using Statistical Package for Social Sciences (SPSS, version 23) software (2015). Means were separated using Duncan New Multiple Range Test (DNMRT) at $p<0.05$. Values were reported in results as means ± standard deviation (SD).

RESULTS AND DISCUSSION

The Proximate Composition of Rice-kidney bean flour flaked samples

The result of the proximate composition of the breakfast flake samples produced from rice and kidney bean flour blends are as presented in Table 2.

Table 1: Proximate composition of the samples

Samples	Moisture (%)	Protein (%)	Ash (%)	Fibre (%)	Lipid (%)	Carbohydrate (%)
A	5.53^{b}±0.03	13.95^{b}±0.00	1.99^{c}±0.01	2.54^{b}±0.00	6.08^{a}±0.03	69.91^{a}±0.01
B	3.55^{c}±0.00	17.83^{c}±0.04	2.74^{b}±0.06	1.66^{c}±0.01	6.04^{a}±0.06	68.18^{b}±0.03
C	11.77^{a}±0.03	20.61^{a}±0.01	3.25^{a}±0.01	4.67^{a}±0.01	6.01^{a}±0.00	53.69^{c}±0.06

Data are mean ± standard deviation (SD) of duplicate determinations. Values in the same column bearing different superscripts differed significantly ($p<0.05$).

Keys: A = 60% Rice and 40% Kidney bean flours, B = 30% Rice and 70% Kidney bean flours and C = 10% Rice and 90% Kidney bean flours.

The Table 2 showed that the moisture content of the flaked samples ranged from 3.55±0.00 to 11.77±0.03%. The sample C had the highest value (11.77%), while sample B had the least value (3.55%). The results showed that the samples differed significantly ($p<0.05$) from each other. The moisture content of the flaked samples increased with corresponding increase in the percentage addition of kidney bean flour. This could be attributed to the differences in the composition of the individual raw materials. The values of 3.55 to 11.77% obtained in this finding were in agreement with the reported findings of 5.42 to 6.13 % by Edima-Nyah *et al*. (2020) in breakfast cereal made from maize, soybean and unripe banana. The breakfast flakes generally had low moisture content which implied that they could have an extended shelf-life except the sample C whose value was above 10%. Mbaeyi-Nwaoha and Uchendu (2016) also observed low moisture content of breakfast cereals made from blends of acha and fermented soybean to be within the range of 4.71 to 9.88%.

The protein content of the flaked samples ranged from 13.95±0.00 to 20.61±0.01%, with samples C (20.61%) having the highest value, while sample A (13.95%) had the least value. The results showed that the samples differed significantly ($p<0.05$) with each other. The protein content of the samples increased with increase in the percentage substitution of the rice with kidney bean flour. This increase could be attributed to the high protein content of kidney bean, as a legume grain compared to rice, a cereal grain. Kidney bean had been

reported to be a good source of protein and several researchers have also reported increase in the protein contents of a wide range of products-substituted kidney bean flour (Thani *et al*., 2018). The values 13.95% to 20.61% obtained in this research are within the range of of 15.68% to 18.26% recorded by Okafor and Usman (2013) for breakfast cereals made from maize, African yam bean and defatted coconut breakfast cereal. The high protein in sample C indicates the effect of supplementing legumes in breakfast cereals (Mbaeyi-Nwaoha and Uchendu, 2016).

The ash content of the samples ranged from 1.99±0.01 to 3.25±0.01%. It was observed from the results that that ample C (3.25%) had the highest ash content, while sample A (1.99%) had the least ash content. The ash content of the samples differed significantly ($p<0.05$) from each other. Furthermore, there was steady increase in the ash content of the breakfast cereal with increased substitution of the kidney bean flour. Okafor and Usman (2013) reported that the ash content of breakfast cereals made from maize, African yam bean and defatted coconut ranged from 1.97% to 2.05%. The ash content gives an overall estimate of total mineral elements present in the food (Adeyeye *et al.*, 2020). The high percentage of ash in sample C indicates that the product was possibly rich in mineral, maybe because of higher percentage of kidney bean that reportedly contain high mineral composition (Agustina *et al*., 2013).

The fibre content of the samples ranged from 1.66±0.01 to 4.67±0.01%, with sample C (4.67%) having the highest fibre content, while sample B (1.66%) had the least. The result showed that the samples differed significantly ($p<0.05$) from each other. The value (1.66-4.67%) of fibre content of the samples obtained in this study were in agreement with the value (2.11-4.25%) reported by Edima-Nyah *et al*. (2020) in breakfast cereal made from maize, soybean and unripe banana. Fibre is needed to assist in digestion and keep the gastro-intestinal tract healthy (Slavin, 2013).

The lipid content of the samples ranged from 6.01±0.00 to 6.08±0.08% with sample A (6.08%) having the highest value, while sample C (6.01%) had the least value. The result showed that there were no significant ($p>0.05$) differences in the lipid content of the samples. The value (6.01-6.08%) of fibre content obtained in this research are lower than the value (14.08-18.13%) reported by Usman *et al*. (2015) in breakfast cereal made from local rice, soybean and defatted coconut flour blends.

The carbohydrate content of the samples ranged from 53.69±0.06 to 69.91±0.01%. The result showed that sample A had the highest value (69.91%), while sample C had the least value (53.69%). There were also significant ($p<0.05$) differences in the carbohydrate content of the samples. The carbohydrate content of the samples decreased drastically with increase in the percentage substitution of kidney bean flour. This could be attributed to the low composition of carbohydrate in legume compared to cereals (Tujoo, 2020). The observed values (53.69-69.91%) of carbohydrate obtained in this research were in line with the values (62.44-66.48%) reported by Edima-Nyah *et al*. (2020) in breakfast cereal made from maize, soybean and unripe banana. Mbaeyi-Nwaoha and Uchendu (2016) stated that breakfast cereals made from acha and fermented soybean paste had carbohydrate content that ranged from 60.96% to 64.53%.

The Sensory Properties of the Samples

The results of the sensory properties of the breakfast flake samples produced from rice and kidney bean flour blends are presented in Table 1.

Table 2: Sensory results of the Rice-kidney bean flour flaked samples

Samples	Colour	Taste	Texture	Flavour	Overall acceptability
A	7.53^{a}±0.97	7.80^{a}±0.55	7.13^{a}±0.51	7.00^{a}±0.64	6.87^{a}±0.73
B	6.67^{b}±0.80	6.13^{b}±0.51	6.27^{b}±0.58	6.80^{b}±0.55	6.13^{b}±0.73
C	6.07^{c}±0.58	5.67^{c}±0.96	6.20^{b}±0.41	6.20^{c}±0.41	5.27^{c}±0.58

Data are mean ± standard deviation (SD) of duplicate determinations. Values in the same column bearing different superscripts differed significantly ($p<0.05$).

Keys: A = 60% Rice and 40% Kidney bean flours, B = 30% Rice and 70% Kidney bean flours and C = 10% Rice and 90% Kidney bean flours.

The results of the sensory properties of the breakfast-flake samples made from rice and kidney bean flour blends are presented in Table 1. From the Table, the colour scores of the flakes ranged from 6.07±0.58 to 7.53±0.97. The sample A had the highest mean scores and rated by the panellists as very much acceptable

whereas sample C had the least mean colour scores of 6.07 and rated by the panellists as slightly acceptable. There were significant ($p<0.05$) differences among the samples. The results of this research are similar to the reported findings of 6.30-7.70 by Calderon *et al*. (2022) in breakfast cereal produced from wheat, amaranth and orange flesh sweet potato flour blends. The result showed that colour values decreased with increased addition of kidney bean flour in the samples. The values obtained were lower than the reported findings of 7.43-7.93 by Shrivastava and Chakraborty (2018) in breakfast cereal produced from fermented chickpea and wheat flour blends.

The taste scores of the breakfast cereals ranged from 5.67 to 7.80. The sample A had significantly ($p<0.05$) the highest mean score and rated by the panellists as very much acceptable. Conversely, the sample C had significantly ($p<0.05$) the least mean score and rated by the panellists as slightly acceptable. The values obtained for the taste was similar to the reported findings of 6.10-8.69 by Bibiana *et al*. (2014) in breakfast cereal produced from wheat, maize and orange flesh sweet potato flour blends. The taste values decreased with increases in quantity of kidney bean flour in the samples. This reduction in taste could be attributed to kidney bean beany flavour.

The texture scores ranged from 6.20 to 7.13. It was observed that sample A had significantly ($p<0.05$) the highest mean scores and rated by the panellists as moderately acceptable, while the sample C had the least mean texture scores of 6.20 and rated by the panellists as slightly acceptable. There were no significant differences ($p>0.05$) between samples B and C. The results of the textural score are similar to the reported findings of 6.10 to 7.29 by Chinma *et al*. (2015) in breakfast cereals produced from rice bran and wheat flour blends. The texture values also decreased with increased percentage levels of kidney bean flour in the samples. This reduction in texture can be attributed to the absence of gluten of kidney bean flour.

The flavour scores of the samples ranged from 6.20 to 7.00. The sample A had the highest flavour score of 7.00 and rated by panelists as moderately acceptable, whereas sample C had significantly ($p<0.05$) the least flavour score of 6.20 and rated by the panelists as slightly acceptable. The results of scores of flavour of this research are similar to the reported findings of 6.20 to7.00 by Bourre *et al*. (2019) in breakfast cereals produced from split yellow pear flour and wheat flour blends. The breakfast cereal produced with sample A was more acceptable in terms of flavour compared with other samples. This could be that higher percentage of rice flour than kidney bean in breakfast cereals production would be better.

The overall acceptability scores of the samples ranged from 5.27 to 6.87. The sample A had significantly ($p<0.05$) the highest overall acceptability score of 6.87 and was rated by the panellists as moderately acceptable, whereas sample C had significantly ($p<0.05$) the least overall acceptability scores of 5.27 and was rated by the panellists as neither acceptable nor unacceptable. The results of the overall acceptability scores decreased with increased percentage levels of substitution of kidney bean flour. The decrease in overall acceptability score could be attributed to beany flavour The findings of this research are in line with the reported findings of 5.17 to 7.23 by Fendri *et al*. (2022)in breakfast cereals produced from wheat, chickpea and broad bean pea flour blends.

CONCLUSION AND RECOMMENDATIONS

The incorporation of different proportions of kidney bean flour into rice flour in the formulation of breakfast flakes drastically influenced the proximate and sensory properties of the formulated breakfast cereal products. The proximate composition of the samples showed that the increase in kidney bean flour addition resulted to subsequent increase in moisture, protein, ash and crude fibre contents, while lipid and carbohydrate contents decreased drastically. The sensory properties revealed that sample A (Breakfast flake made with 60% rice and 40% kidney bean flour) was the most acceptable to the panellists. The result also showed that all the formulated breakfast flakes were equally acceptable because they were generally rated high by the judges. In effect, the use of these nutrient-dense food materials would help to increase their cultivation and utilization in formulation of a wide range of ready-to-eat breakfast cereals that could serve as cheap sources of nutrients in Nigeria and other developing nations of the world.

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