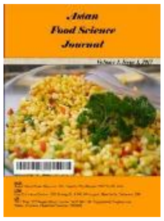

Asian Food Science Journal

4(2): 1-8, 2018; Article no.AFSJ.43677

Potentials of Pigeon Pea-wheat Flour Mixes in Bread Production

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Authors' contributions

This work was carried out in collaboration between all authors. Author BFO designed the study, supervised the project and wrote the first draft of the manuscript. Author VFA contributed to the literature search, method of the research and corrected the final manuscripts, author OJO contributed to the bread production, editing of the manuscript and general supervision of the study and author COO carried out the processing, laboratory analysis and wrote the first draft of the manuscript. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AFSJ/2018/43677

Editor(s):

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Complete Peer review History: http://prh.sdiarticle3.com/review-history/26181

Original Research Article

Received 10 June 2018
Accepted 25 August 2018
Published 11 September 2018

ABSTRACT

It is considered that pigeon pea (*Cajanus cajan)* has higher and more balanced protein than most of the other legumes. However, protracted cooking time, antinutritional constituents and dehulling constraints are responsible for its underutilisation in the developing countries. In this study, pigeon pea was processed into flour using different processing methods (Soaking, Sprouting, and Roasting), and subsequently used as a wheat flour supplement for baking bread. The bread was analysed for the proximate composition, physical and sensory attributes. The proximate composition analysis indicates more protein (17.73-18.51%) and ash (3.50-3.73%) contents in the bread produced with 20% substitution of the sprouted pigeon-pea-wheat flour than others. Loaf volume, specific volume, oven spring, crumb hydration and bread strength increased whereas a decreasing trend was observed for density with the increasing substitution percentage. Sensory results showed that substitution levels at 5 and 10% with soaked and roasted pigeon pea flour gave the highest rating while bread samples with sprouted pigeon pea flour had the lowest rating.

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The study has established that sprouted pigeon pea-wheat flour mixes have more nutritional potentials. As per the sensory analysis indices 5-10% substitution levels of the soaked and roasted pigeon peas are acceptable at $p<0.05$. Conclusively, utilisation of pigeon pea in the human diet as a source of plant protein has potentials of combating malnutrition problems especially among the vulnerable people of the developing countries.

Keywords: Pigeon pea; bread; flour; legumes; antinutrients; supplementation.

1. INTRODUCTION

Legumes are an important part of the traditional diets around the world but are often neglected in the typical Western diets. They are inexpensive, nutrient-dense sources of protein that can be substituted for dietary animal protein [1]. They are rich in protein and essential minerals but contain small quantities of fats that are mostly unsaturated. Despite the usefulness of legumes, they are limited by the presence of antinutrients. Therefore, it is essential that the anti-nutritional factors must be removed or reduced to improve the nutritional quality and provide effective utilisation of legume grains for human nutrition. In order to reduce anti-nutrients, and to increase its nutritional contents, various conventional, simple processing methods have been developed for legume seeds [2] and [3].

Pigeon pea (*Cajanus cajan* L.) is relatively cheap and contains a high amount of protein (23%) that is a rich source of lysine but is usually deficient in sulphur-containing amino acids especially methionine and cystine. It is therefore used as a supplement of the amino acids in *Kokoro* [4]. It is relatively high in protein and can be used to fortify bread. Since bread has relative general acceptance, it could be used as an excellent and convenient food item for protein fortification to improve the nutritional well-being/health of the people, and in nutritional programs which will enhance reduction in protein malnutrition that is prevalent in Nigeria as well as other developing countries. Since the legume is well adapted to tropical regimes and insufficient good quality protein is a limiting factor in developing countries, appropriate processing to improve the utilisation is of great importance. Attempts have been made to improve its utilisation in human diet due to increasing need for cheaper and available plant proteins, especially amongst Nigerian populace. Reduced cooking time and acceptability have been achieved for pigeon pea through the dehulling process [5]. Fermentation process had also been utilised to increase the protein and textural qualities of the seeds [6].

Bread is universally accepted as a very convenient form of food that is important for population. It is a good source of nutrients, such as macronutrients (carbohydrates, protein, and fat) and micronutrients (minerals and vitamins) that are essential for human health [7]. In Nigeria, wheat production is limited and wheat flour is imported to meet local flour needs for bakery products. Thus, a huge amount of foreign exchange is used every year for importing wheat. Efforts have been made to promote the use of composite flours in which flour from locally grown crops and high protein seeds replace a portion of wheat flour for the use in bread, thereby helping in producing protein-enriched bread [8]. Supplementation with legumes is one way to meet the need of carbohydrate foods, particularly baked food. This research considered the effect of different processing methods on the quality attributes of pigeon pea used in bread production towards enhancing its utility.

2. MATERIALS AND METHODS

2.1 Materials Used for Bread Production

Pigeon pea (*Cajanus cajan* L.), Golden Penny (Nigeria) wheat flour and other ingredients used in the production of bread were obtained from a local market in Ogbomoso, Nigeria.

2.2 Methods

2.2.1 Preparation of pigeon pea flour

The pigeon pea seeds were sorted to remove bad ones and foreign materials and were divided into three portions. The first portion was soaked in clean water for 24 hours, dehulled and several washing with water was done, and then drained and dried in the cabinet oven dryer at 50°C for 48 h [9]. After cooling, it was milled, sieved and labelled as sample A. The second portion was roasted at 160°C for 10 minutes, dehulled, winnowed, milled into flour, sieved and labelled as sample B [10]. The third portion was washed thoroughly with cleaned water, soaked

Table 1. Formulation of wheat-processed pigeon pea flour mixes used for bread production

Sample	Processed pigeon pea flour (%)	Wheat flour (%)	Yeast (g)	Margarine (g)	Salt (g)	Sugar (g)	Water (ml)
A1	5	95	2.0	10	2.0	30	100
A2	10	90	2.0	10	2.0	30	100
A3	15	85	2.0	10	2.0	30	100
A4	20	80	2.0	10	2.0	30	100
B1	5	95	2.0	10	2.0	30	100
B2	10	90	2.0	10	2.0	30	100
B3	15	85	2.0	10	2.0	30	100
B4	20	80	2.0	10	2.0	30	100
C1	5	95	2.0	10	2.0	30	100
C2	10	90	2.0	10	2.0	30	100
C3	15	85	2.0	10	2.0	30	100
C4	20	80	2.0	10	2.0	30	100
D	0	100	2.0	10	2.0	30	100

inside a glass jar for 10 h then removed according to Hallen et al. [11]. It was poured back into the glass jar and resealed, thereafter placed in a dark cupboard for it to grow. The sprouting process was monitored for 5 days. Sprouted seeds were dried in the cabinet oven dryer (kilning), milled into flour, sieved and labelled sample C. The flour samples were kept in airtight containers until analysis.

2.2.3 Bread production

The bread loaves were prepared by mixing different proportions of wheat- processed pigeon pea flour mixes using 0, 5, 10, 15 and 20% processed pigeon pea flour, respectively (Table 1). Thereafter, the method described by Adebowale et al. [12] was used for baking. The dough in each case was scaled to 190 g before being moulded and placed in a well-greased baking pan. It was left to proof for about 55 min at 30°C in a proofing cabinet, with a relative humidity of about 40%. It was then transferred into baking oven operating at a temperature of 220-230°C for 15 min. The baked loaves were depanned, cooled and packaged.

2.3 Analyses

2.3.1 Proximate analysis of bread

Protein, fat, ash, moisture and crude fibre contents of bread loaves were determined through the use of AOAC [13] procedures. Carbohydrate content was determined by differences and analyses were performed in triplicates.

2.3.2 Physical attributes of bread loaves

Loaf volume, specific volume and density of bread loaves were determined using the procedures of Otunola et al. [14], while oven spring and crumb hydration capacity were determined as reported by Adebowale et al. [12]. The bread strength was determined using the procedure of Pyler [15].

2.3.3 Sensory evaluation

This was carried out on bread made from 100% wheat and bread made from composite flour (wheat-pigeon pea blends) using a 25 member semi-trained panellists drawn from the staff of the Ladoke Akintola University of Technology, Ogbomoso, Nigeria. The panellists were asked to score samples in terms of taste, colour, texture, aroma, appearance and overall acceptability using a 9 point hedonic scale [5]

3. RESULTS AND DISCUSSION

3.1 Proximate Composition of Bread Loaves Produced from Mixes of Wheat –pigeon Pea Flour

The result of the proximate composition of bread produced from wheat-pigeon pea flour mixes is shown in Table 2. The moisture content of the various breads from the soaked, sprouted and roasted peas ranged from 29.03-32.67, 31.50-34.00 and 29.60-33.67%, respectively. The control sample had the value of 30.17%. Sample B4 had the highest value of 34.00% while sample A1 had the least value of 29.03%. These findings are in agreement with the finding of Udeme et al. [16] in which the bread produced from wheat-potato flour mixes showed an increasing trend with increasing supplementation levels. Increase in moisture content has been associated with an increase in fibre content [17] and [18]. Protein content increased with values ranging as 15.83-17.27, 17.73-18.57 and 11.87- 13.67% for soaked, sprouted and roasted samples, respectively. The control sample showed the value of 9.67%. The highest value was obtained in sample B4 whereas, sample C4 had the least value. Significant differences were recorded in all the samples except samples B3 and B4 (*p* <0.05). The protein content of the samples increased with increase in the substitution level with pigeon pea flour. As the percentage of substitution with pigeon pea increases, increasing trends were observed in the fat content with values ranging as 5.00-5.90, 4.00-4.67 and 4.03-4.70%, respectively for the soaked, sprouted and roasted samples. The control sample had the value of 4.39%. The highest value was obtained in sample B4 whereas sample C4 had the least value. The results are in conformity with the findings of El-Adawy et al. [19] who reported that supplementation of wheat flour with cowpea flour to levels of 15% increased the fat content. The high-fat content of the composite bread affects the shelf stability [20].

Ash content of the bread increased as the percentage of substitution increased and the values ranged from 3.40-3.63, 3.50-3.73 and 3.43-3.63%, respectively from the soaked, sprouted and roasted samples. The control sample showed the value of 3.30%. The highest value was obtained in sample B4 whereas sample C4 had the least value. No significant differences occurred in all the samples except sample B4 and C1 at p <0.05. Sprouted pigeon pea bread had the highest value for ash probably because of the fat reduction during the sprouting process. Shah et al. [21] found an increase in ash content during the germination of two Mung bean varieties and suggested that such an increase was as a result of the reduction in fat and carbohydrate contents. Based on the results, supplementation with pigeon pea flour in the product formulation is encouraged to improve intake of minerals through the consumption of the products.

The crude fibre content of the bread produced from the blends of pigeon pea seeds that were soaked, sprouted and roasted showed an increasing trend as the percentage of substitution increased with values ranging from 1.13-1.40, 1.37-1.50 and 1.20-1.30%, respectively. The control sample had the value of 0.87%. The highest sample was obtained in sample B4 whereas sample C4 had the least value. These results are in conformity with the findings of [19] that supplementation of wheat flour with debittered Fenugreek flour increases the fibre content. The increased fibre and decreased carbohydrate contents of composite bread have

Table 2. Effect of pre-treatment on the proximate composition of bread using pigeon pea-wheat flour mixes

Sample	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Crude fibre (%)	Carbohydrate (%)
A1	29.03^{a}	15.83^{f}	5.00^{bc}	3.40^{a}	1.13^{bc}	45.34^{g}
A2	30.73^{d}	16.33^{g}	5.30^{cd}	3.50^{abc}	1.20^{bcd}	42.94^{f}
A3	31.07^{de}	16.67^{h}	5.51^{d}	3.57^{bcd}	1.30^{cde}	41.88^{e}
A4	32.67^{gh}	17.27^{i}	5.90^{e}	3.63^{cde}	1.40^{ef}	39.13^{c}
B1	31.50^{ef}	17.73^{j}	4.00^{a}	3.50^{abc}	1.37^{def}	41.90^{de}
B2	31.67^{f}	18.13^{k}	4.50^{a}	3.57^{bcd}	1.40^{ef}	40.73^{cd}
B3	33.00^{h}	18.50^{l}	4.57^{a}	3.60^{cde}	1.53^{f}	38.80^{b}
B4	34.00^{i}	18.57^{l}	4.67^{a}	3.73^{e}	1.50^{f}	37.53^{a}
C1	29.60^{b}	11.87^{b}	4.03^{ab}	3.43^{ab}	1.20^{bcd}	49.87^{i}
C2	32.30^{g}	12.60^{c}	4.50^{a}	3.50^{abc}	1.10^{b}	46.00^{h}
C3	32.37^{g}	12.90^{d}	4.60^{a}	3.57^{bcd}	1.23^{bcde}	45.33^{gh}
C4	32.67^{i}	13.67^{e}	4.70^{ab}	3.63^{cde}	1.30^{cde}	43.03^{f}
D	30.17^{c}	9.67^{a}	4.39^{a}	3.30^{a}	0.87^{a}	51.60^{j}

Values are means of three determinations, and values with same superscripts in the same column are not significantly different (p<0.05)

A1:5% soaked pigeon pea flour; A2: 10% soaked pigeon pea flour; A3: 15% soaked pigeon pea flour; A4: 20% soaked pigeon pea flour; B1: 5% sprouted pigeon pea flour; B2: 10% sprouted pigeon pea flour; B3: 15% sprouted pigeon pea flour; B4: 20% sprouted pigeon pea flour; C1: 5% roasted pigeon pea flour; C2:10% roasted pigeon pea flour; C3: 15% roasted pigeon pea flour; C4: 20% roasted pigeon pea flour; D: 100% wheat flour several health benefits, as it will aid in the digestion of the bread in the colon and reduce constipation often associated with bread produced from refined wheat flour [22] and [18].

The carbohydrate content of the bread showed a decreasing trend. The percentage of substitution increased with values ranging from 45.34-39.13, 41.90-37.53 and 49.87-43.03%, respectively. The control sample had the highest value (51.60%) while sample B1 had the least. Significant differences were recorded in all the samples except samples A1, C1, C2 C3 and C4. The carbohydrate content of the samples decreased with increase in the level of substitution of wheat flour. Generally, the carbohydrate content reduced from 51.60% (control) to 37.53% (B4). These results are in close agreement with what [23] observed, where inclusion of 0-25% mushroom powder in wheat bread reduced the carbohydrate content. Ndife et al. [24] similarly reported that carbohydrate reduced considerably with increasing supplementation level of soybean flour in wheat bread.

3.2 Physical Properties of Bread Produced from the Composite Flour of Pigeon Pea and Wheat

3.2.1 Loaf volume

The data obtained for loaf volume produced from blends of wheat-pigeon pea flour are shown in Table 3. The loaf volume of bread produced from blends of pigeon pea that were soaked, sprouted and roasted showed a decreasing trend as the percentage of substitution increases with values ranging from 691-583 cm^3, 690-576 cm^3 and 1160-736 cm^3, respectively. The control sample had the highest value of 2060 cm^3 while sample B4 had the lowest value probably because of the increased weight of the samples. Significant differences occurred in all the samples (p<0.05).

Generally, the addition of pigeon pea flour into wheat flour significantly affected the volume of the bread in all processes probably due to the reduction of gluten which is responsible for the viscoelastic property of bread. The reduction of the bread volume due to the addition of pigeon pea flour is due to the increased weight of the composite bread samples which occur as a result of less retention of carbon-dioxide gas in the blended dough, hence providing dense bread texture [25]. This result is in accordance with the report of [26] and [27] that showed a decreasing trend in loaf volume as a proportion of composite flours increases. The specific loaf volume of bread produced from blends of pigeon pea that were soaked, sprouted and roasted showed a decreasing trend as the percentage of substitution increased with values ranging from 2.70-2.22 g/cm^3, 2.63-2.07 g/cm^3 and 4.31-2.83 g/cm^3, respectively. The control sample showed the highest value of 5.41 g/cm^3 while sample B4 had the least value probably because of the increased weight of the samples. The specific loaf volume decreased with the increase in pigeon pea flour in the formulation. This corroborates with the reports of Ukpabia et al. [28] on Chinese yam (*D. esculenta*) flour for bread production. The density of bread produced from blends of pigeon pea recorded an increasing trend as the percentage of substitution increases with values ranging from 0.37-0.47 g/cm^3, 0.38-0.48g/cm^3 and 0.23-0.35 g/cm^3, respectively. The control sample exhibited the lowest value of 0.18g/cm^3 and the sample B4 recorded the highest value probably because of the increased weight of the samples resulting in the hardness of the loaf. Significant differences were noted in all the samples at p>0.05 except samples A2, B1, C2 and C3. Moreover, increase in the fibre content of the composite flour, particularly in the sprouted pigeon pea flour may have pronounced effects on the dough properties yielding higher density, mixing tolerance, and tenacity, and smaller extensibility in comparison with those obtained without fibre addition [18]. The oven spring of bread produced from blends showed a decreasing trend as the percentage of substitution increased with values ranging from 0.21-0.08 mm, 0.10-0.05 mm and 0.25-0.21mm, respectively. The control sample had the highest value of 0.31 mm while sample B4 had the least probably because of the increased weight of the samples. Significant differences occurred in all the samples (p<0.05) except for samples D, B1, A3 and A2. The low oven spring recorded by the composite bread samples is attributed to low gluten content which is a direct contribution to the viscoelastic properties of wheat flour dough [12]. The bread strength of breads produced from blends of pigeon pea decreased as the percentage of substitution increased with values ranging from 35.93 mm-34.60 mm, 41.03-39.07 and 38.50-37.47 mm, respectively. The control sample had the highest value of 47.50 mm while sample B4 had the lowest as the bread loaves became hard which made it difficult for the penetrometer to penetrate the loaves. The crumb hydration capacity of bread decreased as the percentage of substitution increased with values ranging from 139.7-134.0 ml, 139.63- 141.20 ml and 143.0 ml-136.0 ml except for the uses of soaked pigeon pea that increased. The control sample recorded the highest value of 147.0 ml while sample A4 had the least value which serve as an indication that the increase of pigeon pea flour in the blend made the bread loaves hard, thereby making it difficult for the loaves to absorb water. Significant differences occurred in all the samples at $p<0.05$ except samples D, C1, C2, A1 and A4.

3.3 Sensory Evaluation

The results of bread produced with different levels of substitution with soaked, sprouted and roasted pigeon pea flour are presented in Table 4. The crust colour of bread produced from blends of pigeon pea that were soaked, sprouted and roasted showed a decreasing trend as the level of substitution increased and the values ranged from 8.40-6.15, 5.30-3.20 and

Table 3. Effect of pre-treatment on the physical properties of bread using pigeon pea-wheat flour mixes

Sample	Loaf volume cm^3	Specific loaf volume cm^3/g	Density g/cm^3	Oven spring mm	Bread strength mm	Crumb hydration capacity ml
A1	691^{e}	2.70^{d}	0.37^{de}	0.21^{f}	35.93^{c}	139.7^{e}
A2	672^{d}	2.62^{d}	0.38^{e}	0.18^{e}	35.63^{c}	138.0^{de}
A3	589^{a}	2.13^{ab}	0.47^{gh}	0.15^{d}	35.47^{c}	136.0^{bd}
A4	583^{a}	2.22^{b}	0.45^{g}	0.08^{a}	34.60^{b}	134.0^{c}
B1	690^{e}	2.63^{d}	0.38^{e}	0.10^{c}	41.03^{h}	139.63^{a}
B2	654^{c}	2.45^{c}	0.41^{f}	0.07^{b}	39.83^{g}	140.43^{a}
B3	635^{b}	2.15^{ab}	0.46^{gh}	0.07^{b}	39.37^{fg}	140.90^{b}
B4	576^{a}	2.07^{a}	0.48^{h}	0.05^{a}	39.07^{f}	141.20^{b}
C1	1160^{i}	4.31^{g}	0.23^{b}	0.25^{g}	38.50^{e}	143.0^{g}
C2	1020^{h}	3.68^{f}	0.27^{c}	0.24^{g}	38.47^{e}	141.0^{f}
C3	1000^{g}	3.59^{f}	0.28^{c}	0.22^{f}	37.83^{d}	138.0^{de}
C4	736^{f}	2.83^{e}	0.35^{d}	0.21^{f}	37.47^{d}	136.0^{bd}
D	2060^{j}	5.41^{h}	0.18^{a}	0.31^{h}	47.50^{h}	147.0^{h}

Values are means of three determinations, and values with same superscripts in the same column are not significantly different (p<0.05)

A1: 5% soaked pigeon pea flour; A2: 10% soaked pigeon pea flour; A3: 15% soaked pigeon pea flour; A4: 20% soaked pigeon pea flour; B1: 5% sprouted pigeon pea flour; B2: 10% sprouted pigeon pea flour; B3: 15% sprouted pigeon pea flour; B4: 20% sprouted pigeon pea flour; C1: 5% roasted pigeon pea flour; C2: 5% roasted pigeon pea flour; C3: 10% roasted pigeon pea flour; C4: 15% roasted pigeon pea flour; D: 100% wheat flour

Table 4. Result of sensory evaluation of composite bread from wheat and pigeon pea flour

Sample	Crust colour	Texture	Aroma	Appearance	Taste	Overall acceptability
A1	8.40^{g}	7.80^{e}	7.55^{e}	7.85^{e}	7.95^{d}	8.10^{g}
A2	6.90^{ef}	6.80^{d}	5.95^{cd}	6.35^{d}	6.15^{c}	6.55^{f}
A3	6.85^{ef}	6.15^{cd}	5.50^{c}	6.20^{d}	5.75^{c}	6.30^{f}
A4	6.15^{de}	5.70^{c}	5.45^{c}	5.95^{d}	5.50^{c}	5.85^{ef}
B1	5.30^{cd}	4.65^{b}	4.40^{b}	4.90^{c}	4.50^{b}	4.90^{de}
B2	5.10^{c}	4.55^{b}	4.30^{b}	4.60^{bc}	4.40^{b}	4.55^{cd}
B3	4.15^{b}	4.05^{ab}	3.90^{ab}	3.90^{ab}	3.70^{ab}	4.05^{bcd}
B4	3.20^{ab}	3.30^{a}	3.25^{a}	3.10^{a}	2.90^{a}	2.85^{a}
C1	7.20^{f}	6.75^{d}	6.45^{d}	6.45^{d}	6.20^{c}	6.55^{f}
C2	6.60^{ef}	5.75^{c}	6.00^{cd}	6.00^{d}	5.65^{c}	5.80^{f}
C3	4.55^{bc}	3.75^{ab}	4.15^{ab}	4.00^{ab}	4.30^{b}	3.60^{ab}
C4	3.95^{ab}	3.55^{a}	3.60^{ab}	3.50^{a}	3.55^{ab}	3.40^{ab}
D	8.25^{g}	7.70^{e}	7.90^{e}	8.35^{e}	8.35^{d}	8.25^{g}

Mean with the same superscript in the same column are not significantly different (p<0.05) from each other

A1: 5% soaked pigeon pea flour; A2: 10% soaked pigeon pea flour; A3: 15% soaked pigeon pea flour; A4: 20% soaked pigeon pea flour; B1: 5% sprouted pigeon pea flour; B2: 10% sprouted pigeon pea flour; B3: 15% sprouted pigeon pea flour; B4: 20% sprouted pigeon pea flour; C1: 5% roasted pigeon pea flour; C2: 5% roasted pigeon pea flour; C3: 10% roasted pigeon pea flour; C4: 15% roasted pigeon pea flour;D: 100% wheat flour

7.20-3.95, respectively. The control sample had a value of 8.25. Sample A1 recorded the highest value while sample B4 had the least. Dhingra and Jood [29] reported that as amino acid reacts with reducing sugars, Millard reaction takes place which results in the reducing quality level for the colour of the bread. Also, the texture value of bread produced from blends of pigeon pea that were soaked, sprouted and roasted showed a decreasing trend as the percentage of substitution increased with values ranging from 7.70-5.70, 4.65-3.30 and 6.75-3.60, respectively. The control sample had the highest value of 7.80, which was preferred than the other samples while sample B4 (3.20) showed the least value because it had a very hard texture due to the dilution of the gluten in wheat. Samples A1 and C1 were comparable to the control sample in terms of texture. Increase in the substitution levels of pigeon pea flour affected the overall acceptability of bread. The highest score (8.25) was obtained in the control sample (D) while the minimum was recorded for sample B4 (2.85). Soaked pigeon pea flour at 5% inclusion (Sample A1) and sample D(control) had no significant difference at $p<0.05$. It could be recommended that inclusion of pigeon pea flour up to 10% with samples A1, C1 and C2 can be acceptable for bread production.

4. CONCLUSION

The current study on the Potentialility of pigeon-flour as a component of the composite flour for bread making, indicates that bread produced from wheat- pigeon flour mixes are more nutritious with respect to protein, ash and crude fibre contents, compared to the control sample. The bread baked using 5-20% substitution level of roasted pigeon pea flour level showed the best physical attributes. The 10% level substitution of soaked and roasted pigeon pea flour scored best on sensory attributes. The outcomes of the study, therefore, have the potential of enhancing the cultivation of pigeon pea as an underutilised legume and invariably boost the economy of the crop growers. The information generated also encourage the consumption of the legume as a cheap source of essential nutrients such as protein, and could be an index for further studies towards addressing issues of malnutrition in the developing countries, and invariably promote global food security.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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