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Optimisation of Nutritional and Anti-Nutritional Properties of Composite Flour Made from *Eleusine coracana* (Finger Millet) and *Manihot esculenta* (Cassava)

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Abstract

In this study, composite flour was formulated by blending *Eleusine coracana* (finger millet) and *Manihot esculenta* (cassava) to achieve optimal nutritional content tailored to different age groups. Various composites of roasted and unroasted finger millet and cassava flour were mingled into bread and analysed for nutritional and anti-nutritional values using AOAC International's Official Methods of Analysis. The composite (millet flour/cassava flour, 3:1; w/w) had the optimal content of nutrients for both roasted and unroasted samples. There was no significant difference in the nutrient content between roasted and unroasted samples ($p > 0.05$). The optimal sample meets the recommended carbohydrate Reference Nutrient Intake (RNI) for individuals aged 1 to 70 years and pregnant mothers aged 14 years to 50 years in a 200 g serving. Additionally, it meets the protein, iron and calcium RNI for children aged 0 to 6 years, 0 to 6 years, and 1 to 6 years respectively.

Subject Areas

Analytical Chemistry

Keywords

Finger Millet, Cassava, Mingled Bread, Nutritional Properties, Composite Flour

1. Introduction

Malnutrition continues to prevail around the globe and threatens to destroy generations, whereby about 149 million children under 5 years of age are stunted, 45 million are wasted while 38.9 million are obese, of which about 45% of these children die of undernutrition [1]. This problem is common in developing countries and particularly in African countries, where 24.8% of children are malnourished and of these more than 30% suffer the consequences of chronic malnutrition [2]. The prevalence of chronic malnutrition among children under five years in East Africa has been reported to be around 26% to 38%, with Uganda at 28.9% prevalence [3].

In Uganda, malnutrition is one of the leading causes of death especially in remote settings and amongst the urban poor [4]. For instance, more than 500,000 Ugandan children died between 2013 and 2015 and of these deaths, nearly half were associated with malnutrition. This was attributed to inadequate maternal and child care and household food insecurity [5]. Despite Uganda having fertile soils that favor the growth of various staple nutritious food crops, malnutrition still remains a concern because these foods are not properly utilized.

Finger millet and cassava are among the important staple foods consumed in various forms by all age groups in Uganda. One of the commonest modes of consumption is in the form of mingled bread which is prepared by mingling roasted composite flour of millet and cassava with boiling water. The composition of the composite flour and the degree of roasting are dependent on individual consumers' preference which mainly focuses on the texture, colour, viscosity, taste and sweetness. However, roasting and composition of the composite flour affect nutritional and anti-nutritional contents of the mingled bread. Previous studies have reported the effect of roasting finger millet on digestibility of protein, viscosity, mineral content and anti-nutritional contents in porridge [6]. However, there is paucity of data on the effect of roasting on finger millet-cassava composite flour for mingling bread. In this paper, we report on the nutritional and anti-nutritional content of bread prepared from varying ratios of roasted finger millet-cassava composite flour.

2. Materials and Methods

2.1. Finger Millet and Cassava Flour Preparation

Cassava root tubers of sweet variety at one year of maturity were harvested using a hand hoe from the garden in Nyeibingo parish, Ruhumuro sub-county in Bushenyi district southwestern part of Uganda. They were then peeled with a knife, grated, washed with clean water and sundried for 96 hours until they were completely dry. The dried tubers (10 kg) were crushed into small parts using a mortar and pestle and then ground into fine flour using a milling machine (hammer mill model) located in Bushenyi town, Bushenyi-Ishaka municipality in Bushenyi district.

2.2. Finger Millet Flour Preparation

Finger millet (*Eleusine coracana*) fingers (4 basins) were harvested from the garden and sun dried for two weeks. The dry fingers were put in a sisal bag and hit repeatedly with a piece of wood to obtain millet grains from the debris after thorough winnowing. The clean grains (10 kg) were ground directly using a milling machine (hammer mill model) located in Bushenyi town, Bushenyi- Ishaka municipality in Bushenyi district.

2.3. Composite Flour and Mingled Bread Preparation

Table 1. Composite flour formulation.

Sample	Composition (w/w)	
	Finger millet flour (%)	Cassava flour (%)
F1	100	0
F2	75	25
F3	50	50
F4	25	75
F5	0	100

Five samples (F1, F2, F3, F4 and F5) were formulated from finger millet flour and cassava flour as shown in Table 1 above. Each sample was divided into two portions; one portion was mingled with boiling water (500 mL) into bread without roasting while the other was roasted in an open cast iron saucepan at a constant temperature of 150˚C maintained using a digital laboratory hotplate for 10 minutes before mingling into bread, giving a total of ten mingled breads. The bread was kept in well labeled clean beakers for analysis.

2.4. Determination of Nutrients and Anti-Nutrients in Samples

The nutrients and anti-nutrients that have been reported in finger millet and cassava were determined using three replicates of each sample. The nutrients include fat, carbohydrate, protein, iron, calcium, fiber content and the anti-nutrients include total phenolic content and total hydrogen cyanide.

2.4.1. Determination of Total Carbohydrate

Total carbohydrate concentration in the samples was determined by using phenol–sulphuric acid method. The bread sample (100 g) was weighed into a conical flask followed by a solution of 80% ethanol (100 mL) and mixture boiled in a water bath for 10 minutes while stirring. The sample mixture was then filtered through Whatmann filter paper (20 to 25 μm) and the filtrate was dried in an oven at 50˚C. The oven dried extract (0.1 g) was dissolved in deionized water (100 mL) and an aliquot (10 mL) was transferred into a test tube, followed by a solution of 5% phenol (5 mL) and a solution of 96% Sulphuric acid (1 mL). The absorbance of the resultant mixture was read at 490 nm in a UV-Visible spectrophotometer. Glucose was used to prepare the standard calibration curve for carbohydrate from which the concentration of the carbohydrate in each sample was determined [7].

2.4.2. Determination of Total Protein in Samples

The total protein content was determined using Biuret protein assay. The sample (0.5 g) was weighed into a conical flask followed by 10 colored glass beads and a solution of 0.5% sodium dodecyl sulphate (SDS) (10 mL). The mixture was rapidly shaken (vortexed) for one minute, allowed to stand at room temperature for 10 minutes and then filtered. Aliquots of the filtrate (10 mL) were pipetted into 3 separate test tubes (Pyrex) followed by Biuret reagent to form a blue complex whose absorbance was read at 550 nm in a UV-Visible spectrophotometer. The average absorbance was converted into concentration (mg/g) using the standard calibration curve obtained using albumin as the standard protein [8].

2.4.3. Determination of Iron in Samples

The total iron concentration was determined using spectrophotometric method. Mingled bread (2 g) for each sample was put in a 250 mL conical flask and shaken with distilled water (20 mL). A solution of 65% HNO_3 (18 mL) was then added to the contents of the flask followed by a solution of 37% HCl (6 mL) (aqua-regia) and the mixture was boiled on a water bath for 10 minutes after which it was filtered. The filtrate (10 mL) of each sample was pipetted into a test tube followed by ammonium thiocyanate solution (3 mL) to form a red complex whose absorbance was read at 490 nm in a UV-Visible spectrophotometer. The average absorbance measured was converted into concentrations by using calibration curve obtained using standard Fe^{3+} solution [9].

2.4.4. Determination of Total Calcium in Samples

Calcium content was determined by titrimetric method. Mingled bread (4 g) for each sample was put in a 250 mL conical flask containing distilled water (20 mL) and shaken. A solution of 65% HNO_3 (54 mL) was then added to the contents of the flask followed by a solution of 37% HCl (18 mL) (aqua-regia) and the mixture was boiled in a water bath for 10 minutes after which it was filtered. The Calcium in the extract was precipitated out by addition of ammonium oxalate solution. This precipitate was filtered off, washed with distilled water and dissolved in dilute acid (HCl). The amount of oxalic acid liberated was determined by titration with standard potassium permanganate solution (0.02 M) and was proportional to amount of calcium present in sample [10].

2.4.5. Determination of Total Fat in Samples

The fat content was determined by solvent extraction-gravimetric method. Each sample (5 g) was put in a 250 mL conical flask followed by diethylether (50 mL), covered tightly with foil paper and shaken vigorously for one hour. The contents of the conical flask were then allowed to settle for 24 hours. The mixture was filtered into an oven dried conical flask of known weight (w_1). The flask together with its contents was placed in an oven at 50˚C for 6 hours and then reweighed (w_2) after cooling to room temperature. The difference in weight ($w_2 - w_1$) was taken as the weight of total fat extracted from 5 g of sample. Triplicates of each measurement were made and the average difference was recorded [11].

$$\text{Percentage fat} = \frac{w_2 - w_1}{5} \times 100$$

2.4.6. Determination of Total Dietary Fiber in Samples

The total dietary fiber was determined by gravimetric method. The sample (5 g) was weighed into a conical flask and boiled with a solution of 50% sodium hydroxide solution (20 mL) for 20 minutes. The mixture was filtered using Whatmann filter paper and residue washed with a solution of 50% nitric acid (50 mL) and then with distilled water (50 mL). The filter papers used were weighed before and weight recorded (w_1g). The residue on the filter paper was kept in an oven at temperature of 50˚C for 24 hours. The filter paper was weighed again with its content and the weight recorded (w_2g). The difference in weight ($w_2 - w_1$) g was recorded as the total dietary fiber content in 5 g of the sample. Triplicates of each measurement were made and the average difference was recorded [12].

$$\text{crude fiber}(\%) = \frac{w_2 - w_1}{5} \times 100$$

2.4.7. Determination of Total Hydrogen Cyanide Content

The total hydrogen cyanide content of each of the samples was determined by spectrophotometric method. The sample (100 g) was immersed in water (100 mL) with in a distillation flask. The distillation flask was connected to the distillation unit and left to stand for two hours, then followed by reactive distillation. To the distillate (5 mL), 2% Na_2CO_3 (100 mL) followed by solution made by dissolving ninydrin (0.5 g) in a solution of 2% NaOH (100 mL) was added. The absorbance of the complex formed was read at 485 nm in a UV-Visible spectrophotometer. Potassium cyanide was utilized to prepare standard calibration curve from which the concentration of cyanide in the samples was determined [13].

2.4.8. Determination of Total Phenolic Content in Samples

The total phenolic content was determined by Folin-Ciocalteu method which utilizes UV-Visible spectrophotometry. The sample (100 g) was weighed into a conical flask followed by 80% ethanol (100 mL) and mixture boiled on a water bath for 10 minutes while stirring. The mixture was then filtered through Whatmann filter paper (20 to 25 μm) and the filtrate was dried in the oven at 50˚C. The dry extract (0.1 g) was dissolved in deionized water (100 mL) to form a solution. An aliquot (10 mL) was transferred into a test tube, followed by a solution of 5% Ferric Chloride (5 mL) and absorbance of the resultant mixture was read at 550 nm in a UV-Visible spectrophotometer. Tannic acid was used to obtain standard calibration curve from which total phenolic content of each sample was obtained [14].

2.5. Statistical Analysis

The means and standard deviations were derived for the nutritional and anti-nutritional properties using IBM SPSS Statistics (Version 20). One-way Analysis of Variance (ANOVA) was used to determine the significant differences among means generated. Turkey's test was used to separate means. Then after, paired samples t-test was applied on each sample to test if composition before and after roasting was significantly different. The differences in means were considered statistically significant at $p \leq 0.05$.

3. Results and Discussion

3.1. Nutrient Composition of Finger Millet-Cassava Composite Flour

Table 2. Proximate composition and mineral content of samples.

Samples		CHO (%w/w)	Protein (%w/w)	Fat (%w/w)	Fiber (%w/w)	Iron (mg/100 g)	Calcium (mg/100 g)
F1	Unroasted	**67.48 ± 0.66***	**9.29 ± 0.26**	**1.40 ± 0.02**	**3.45 ± 0.18**	**4.11 ± 0.10**	**301.33 ± 1.00**
	Roasted	72.45 ± 0.69*	8.73 ± 0.06	1.37 ± 0.02	3.27 ± 0.15	4.32 ± 0.23	306.43 ± 1.19
F2	Unroasted	**72.87 ± 0.12***	**7.62 ± 0.09**	**1.12 ± 0.01**	**3.10 ± 0.08**	**3.13 ± 0.06**	**229.50 ± 1.05**
	Roasted	76.14 ± 0.35*	6.71 ± 0.11	1.09 ± 0.03	2.89 ± 0.11	3.33 ± 0.06	236.11 ± 2.63
F3	Unroasted	**77.57 ± 1.13**	**5.06 ± 0.12**	**0.83 ± 0.02**	**2.71 ± 0.10**	**2.13 ± 0.12**	**159.19 ± 1.07**
	Roasted	80.45 ± 0.61	4.99 ± 0.15	0.81 ± 0.05	2.46 ± 0.11	2.18 ± 0.04	163.57 ± 1.06
F4	Unroasted	**80.83 ± 0.85**	**3.26 ± 0.07**	**0.57 ± 0.02**	**2.25 ± 0.10**	**1.25 ± 0.02**	**82.40 ± 1.15**
	Roasted	83.83 ± 0.38	3.08 ± 0.19	0.52 ± 0.01	2.06 ± 0.04	1.29 ± 0.04	85.63 ± 1.73
F5	Unroasted	**85.27 ± 0.75**	**1.32 ± 0.03***	**0.28 ± 0.01**	**1.90 ± 0.01***	**0.31 ± 0.02***	**14.94 ± 0.15***
	Roasted	87.04 ± 0.94	1.09 ± 0.03*	0.25 ± 0.01	1.54 ± 0.09*	0.44 ± 0.12*	20.01 ± 0.85*

[1]Values are mean ± S.D, where S.D is the standard deviation (n = 3); [2]Values with *for the same sample in same column are statistically different.

Table 2 above shows the nutritional content of mingled bread made from formulated flour samples. The samples were analysed for proximate composition and mineral content.

3.1.1. The Total Carbohydrate in Samples

There were highly significant differences ($p = 0.001$) observed in the carbohydrate contents of roasted and unroasted samples for samples F1 and F2 (Table 2). Generally, the roasted samples had higher carbohydrate contents than the unroasted samples, suggesting that roasting enhanced the carbohydrate content of the flour. This is in agreement with studies which have shown that roasting of flour leads to caramelization and gelatinization of carbohydrates which account for the brown color, caramellic flavor and increased simple sugars such as maltose, fructose and glucose [15]. Thus, the carbohydrate content of cassava flour and millet flour composite can be increased by roasting. The Reference Nutrient Intake (RNI) has accordingly recommended the consumption of about 200 g/day of such composite flour samples to provide total carbohydrate content matching the RNI of all age groups [16].

Sample F1 (pure millet) had the least carbohydrate content on average while sample F5 (pure cassava) had the highest carbohydrate content. Addition of cassava flour to finger millet flour in increasing proportions (F2 - F4) resulted in a stepwise increase in carbohydrate content of mingled bread from the flour blends. These results were expected because cassava is one of the foods which are naturally rich in carbohydrates as compared to millet. The high carbohydrate content of cassava flour makes it a vital material to supplement low carbohydrate flours like finger millet flour for preparation and development of carbohydrate-enriched products. Past studies reported an a decrease in carbohydrate content of cassava as substitution with soy bean flour increased [17].

3.1.2. The Total Protein Content in Samples

Generally, roasted samples had non-significantly ($p > 0.05$) lower protein content than the unroasted samples. The decrease in protein during roasting could be attributed to Maillard reaction during which the reactive carbonyl group of carbohydrates reacts with the nucleophilic amino group of the amino acids (protein), forming mixtures of characterized molecules that are responsible for a range of aromas and flavors [18].

As expected, there was also a significant ($p < 0.05$) decrease in protein content with increase in degree of flour substitution with cassava flour. This was attributed to the low protein value of cassava flour. To this effect, the blend (F4) with the highest proportion of cassava had the lowest protein content (3.08 ± 0.19 g/100 g) while the blend (F2) with the lowest proportion of cassava had the highest (7.62 ± 0.09 g/100 g) protein content. Thus, sample F2 becomes the best optimal composite sample since it has the highest protein content.

3.1.3. The Total Fat Content in Samples

The data in **Table 2** shows that the roasted samples had lower fat content than the unroasted samples but the differences were non-significant ($p = 0.081 > 0.05$). The decrease in fat content upon roasting is attributed to the formation of starch-lipid complex which is resistant to lipid extraction. However, the low fat content found in the roasted samples is beneficial because of decreased possibility of rancidity resulting in increased shelf life [19].

Meanwhile, the total fat content in the samples decreased significantly ($p < 0.05$) with increase in degree of finger millet flour substitution with cassava flour, which was attributed to the low fat content of cassava flour. Among the blended samples, sample F2 had the highest fat content since it had the highest percentage of finger millet flour. Although previous studies have reported low fat content in finger millet, the grains are high in polyunsaturated fatty acids [20].

3.1.4. The Total Fiber Content in Samples

The data in **Table 2** shows that the roasted samples contained lower fiber content than the unroasted samples but the differences were non-significant ($p > 0.05$). The decrease in fiber content upon roasting may be attributed to structural changes in which there is break down of the complex carbohydrates present in fiber, making them more susceptible to degradation. Roasting also leads to the evaporation of moisture from the flour which then concentrates the remaining components, potentially giving the appearance of reduced fiber content when measured on a weight basis [19].

Meanwhile, the total fiber content in the samples decreased significantly ($p < 0.05$) with increase in degree of finger millet flour substitution with cassava flour and this was attributed to the low fiber content of cassava flour. Thus the blended sample F2 which had the lowest percentage of cassava flour had the highest fiber content and becomes the optimal sample.

The total fiber content of mingled bread from unroasted cassava flour and finger millet flour reported in this study was agreeable with the findings of past studies [12]. Moreover, the role of fiber in food has greatly attracted attention of nutritionists because of the vital physiological benefits of fiber such as prevention of diseases like colorectal cancer and inflammatory bowel disease. This dietary fiber helps the body to regulate the body's usage of sugars thus keeping the body hunger and blood sugar in check [21].

3.1.5. The Total Iron Content in Samples

Table 2 shows that the roasted samples generally had higher iron contents than the unroasted samples, suggesting iron content of the flour can be enhanced by roasting. However, this increase was not statistically significant. This is in agreement with past studies which have shown that roasting of flour leads to the migration of leached iron from the saucepan used for roasting into the samples and as well as increase in contact time with the iron saucepan. This iron increase after roasting could also be attributed to removal of complex polysaccharides of fibrous bran, reduction in phenolic content and decrease in phytate content during roasting all of which would enhance iron bioavailability [21].

Sample F5 (pure cassava) had the least iron content while sample F1 (pure finger millet) had the highest iron content. As cassava flour was added to finger millet flour in increasing proportions (F2 - F4), there was a stepwise decrease in iron content of mingled bread from the flour blends. This decrease in iron is attributed to the low iron content of cassava flour which is a starchy vegetable that is deficient in minerals including iron Due to this, sample F2 with the lowest percentage of cassava is the optimal sample since it has the highest total iron content among blended samples.

3.1.6. The Total Calcium Content in Samples

The data in **Table 2** shows that the total calcium content in roasted samples was higher ($p > 0.05$) than that of unroasted samples suggesting that flour roasting enhances calcium content. The increase in calcium was attributed to the effect of Maillard reaction that leads to changes in the structure of proteins and carbohydrates, potentially influencing the solubility of minerals like calcium and reduction in anti-nutrients like phytate and oxalates. Highest calcium content was found in pure finger millet (sample F1) but this significantly ($p < 0.05$) decreased with increasing percentage of cassava flour in the composite (F2 - F4). The decrease in calcium with increasing percentage of cassava is attributed to the low calcium content of cassava flour since cassava is a starchy vegetable deficient in minerals [23]. To this effect, the blended sample F2 which had the lowest percentage of cassava qualifies as the optimal sample because of its high calcium content.

3.2. Anti-Nutrient Composition of Finger Millet-Cassava Composite Flour

Table 3. Total phenolic content and HCN content of samples.

	Samples	TPC (mg/100 g)	HCN (mg/kg)
F1	**unroasted**	**41.44 ± 1.51***	**0.03 ± 0.00***
	Roasted	35.43 ± 2.65*	0.02 ± 0.00*
F2	**Unroasted**	**35.33 ± 0.61***	**1.41 ± 0.01**
	Roasted	28.64 ± 1.57*	1.35 ± 0.02
F3	**Unroasted**	**30.12 ± 0.73**	**2.72 ± 0.02**
	Roasted	26.93 ± 0.22	2.71 ± 0.02
F4	**Unroasted**	**24.27 ± 1.03**	**4.29 ± 0.08**
	Roasted	21.37 ± 0.70	3.89 ± 0.04
F5	**Unroasted**	**17.62 ± 0.53***	**5.51 ± 0.02***
	Roasted	12.26 ± 0.97*	4.67 ± 0.15*

Table 3 above shows the anti-nutritional content of mingled bread made from formulated flour samples. The samples were analysed for total phenolic content (TPC) and hydrogen cyanide content

3.2.1. The Total Phenolic Content in Samples

The total phenolic contents of samples significantly ($p < 0.05$) decreased as a result of flour roasting for samples F1, F2 and F5 (Table 3). This is in agreement with studies which have shown that roasting of flour leads to the degradation, polymerization, Volatilization , oxidation and leaching of phenolics to form complexes with proteins and other macromolecules thus making them to be less extractable [24]. This decrease in total phenolic content upon flour roasting leads to a decrease in antioxidant activity but would result into bioavailability of mineral elements.

The highest total phenolic content was found in sample F1 (pure millet flour) but this decreased with increasing proportions of cassava flour in the composite (samples F2 - F4). This could be attributed to the low level of phenolic content in cassava flour [25]. For this reason, the blended sample F2 becomes the optimal sample since it has a high total phenolic content that would yield optimal antioxidant activity without reducing mineral bioavailability.

3.2.2. The Total HCN Content in Samples

The total hydrogen cyanide content of mingled bread samples significantly (p <

0.05) increased with increasing percentage of cassava flour in the formulation (Table 3). Therefore the mingled bread from cassava flour alone (sample F5) had the highest HCN content (5.51 ± 0.02 mg/kg) which decreased with increasing proportion of finger millet flour in the composite. This is in agreement with past studies which also reported a decrease in HCN levels of flours due to flour dilution with non-cassava flour [26]. This hydrogen cyanide content further significantly ($p < 0.05$) decreased in roasted flour samples F1 and F5 and this could be attributed to hydrogen cyanide degradation and volatilization that occurs at roasting temperatures. However, the levels of HCN determined in this study are within the guidelines of FAO/WHO on the level of cassava flour which was set at 10 mg/kg dry weight, suggesting that processing methods can be combined and be used for effective cyanide removal [17].

3.3. Formulation Ratios and Age Groups Whose RNI Is Met for 200 g Serving

Table 4. Formulation ratios and age groups whose RNI is met for 200 g serving [16].

Nutrient	Sample	Satisfied age group	RNI
Carbohydrate	F2, F3, F4	1 year to 70 years	100 g/day
		14 years to 50 years (pregnant mothers)	135 g/day
Protein	F2	0 to 6 years	12.5 g/day to 14.9 g/day
Iron	F2	0 to 6 years	1.7 mg/day to 6.9 mg/day except for (7 - 12) months
Calcium	F2	1 year to 6 years	350 mg/day to 450 mg/day
Fiber	NSR	NSG	15 g/day to 30 g/day
Fat	NSR	N/A	N/A

[1]NSR, no satisfying ratio; [2]NSG, no satisfied group; [3]N/A, not applicable.

Table 4 above shows the formulation ratios of finger millet flour to cassava flour, RNI and the age group for which their RNI are met by the formulated composite.

From Table 4, the carbohydrate, protein, iron and calcium requirements of the target groups could be met by consumption of only 200 g of mingled bread from optimal composite sample F2. Other groups would need more than 200 g of the same meal to obtain the RNI. Thus, according to reference to the Reference Nutrient Intake (RNI) (Table 4), the optimal blending ratios for finger millet flour to cassava flour is 3:1 (75% finger millet with 25% cassava flour) because the 200 g serving of mingled bread from such samples would meet the RNI for the vulnerable age groups of 0 to 6 years in terms of carbohydrate, protein, iron and calcium.

4. Conclusion

This study revealed the improvement in carbohydrate content, iron content and calcium of optimal sample (F2) as a result of roasting. On the contrary, the roasted samples had the lowest protein content, fiber, total phenolic content and hydrogen cyanide. Therefore, roasting can be employed in food processing especially cereals, to enhance nutrient composition and mineral bioavailability. However, a detailed study is recommended on the composite flour for determination of total amino acids, other minerals, vitamins, total energy density and physicochemical parameters such as bulk density, true density, porosity, water solubility index, foaming, capacity, foam stability, oil absorption capacity, viscosity. The texture analysis of mingled bread from composite flour is also recommended for future studies. Palatability and acceptability of formulated mingled bread products should be assessed to promote industrial production and increase consumption of mingled products.

Conflicts of Interest

The authors declare no conflicts of interest.

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