Characteristics of Whole Wheat, Red Kidney Bean and Defatted Coconut Flour Blends and its Application in Bread Production

ABSTRACT

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Aims: The aim of the study was to evaluate the functional properties, proximate composition and ani nutrient content of flour blends and sensory properties of bread produced from flour blends

Methodology: Flour was prepared from whole wheat (WW), red kidney bean (RKB) and coconut fruit (CF). It was then blend at the following levels: **S1** (100% refined wheat flour), **S2** (100% WW), **S3** (90% WW, 5% RKB and 5% CF), **S4** (85% WW, 10% RKB and 5% CF), **S5** (80% WW, 15% RKB and 5% CF), **S6** (75% WW, 20% RKB and 5% CF). The flour blends were subjected to functional properties, proximate composition and anti nutrient content analyses. Also the sensory attributes of breads produced from flour blends were determined.

Results: From the results, water absorption capacity increased from 0.62±0.06g/ml (S1) to 0.92±0.01 g/ml (S6), Oil absorption capacity increased from 0.96±0.02g/ml (S1) to 1.42±0.03 g/ml (S6), bulk density decreased from 0.84±0.01g/ml (S1) to 0.60±0.02g/ml (S6), swelling capacity increased from 1.05±0.01 (S1) to 1.73±0.01 (S6), foaming capacity increased from 11.47±0.02% (S1) to 13.20±0.05% (S6), foam stability increased from 50.93±0.01% (S1) to 53.47±0.01% (S6), emulsification capacity increased from 41.43±0.03% (S1) to 43.36±0.01% (S6). The results also showed that the moisture content ranged from 12.23±0.03% (S1) to 13.44±0.01% (S6), ash content increased from 0.66±0.01% (S1) to 1.66±0.02% (S6), fat content ranged from 0.22±0.3% (S1) to 2.57±0.01% (S6), fiber content increased from 0.67±0.26% (S1) to 4.34±0.02% (S6), protein content of the blends increased with increasing supplementation with red kidney bean flour from 10.70±0.12% (S1) to 13.06±0.03% (S6), while the carbohydrate decreased from 75.52±0.33% (S1) to 64.93±0.04% (S6) with red kidney bean addition. The phytate, oxalate and tannins content increased respectively from 0.03±0.00mg/100g (S1) to 1.09±0.01mg/100g (S6), 0.02±0.02mg/100g (S1) to 0.14±0.01mg/100g (S6), 0.01±0.01mg/100g (S1) to 0.09±0.01mg/100g (S6) with the addition of red kidney bean. The sensory analysis conducted showed that there was a significant difference ($p < 0.05$) between sample s1 bread and the other in the sensory qualities of appearance and texture. In terms of appearance, the panelists scored refined wheat bread (S1) highest. In term of overall acceptability sample S1 and S3 showed no significantly different ($p > 0.05$), thus bread of acceptable sensory quality can be produced from blends (sample S3), since it shows no significant difference with sample S1 (control 1).

Conclusion: The present study underscored the potential application of whole wheat, red kidney bean and coconut composite flour in the production of bread.

Keywords: *functional, proximate, anti nutrients, flour, blends,*

1. INTRODUCTION

wheat (*triticum aestivum*) is the world's third most important cereal crop after maize and rice that grows mostly in the temperate region [1]. Wheat is the major ingredient for the baking industries due to the presence of gliadins and glutenins collectively called gluten proteins wide variety of cereal[2]. The demand for the production of refined and whole meal flour has greatly increased during the last decades[3]. Whole wheat is rich in nutritive compounds in comparison with refined flour[4]. In addition to carbohydrate and protein whole wheat also contains minerals, fiber, B vitamins and bioactive compounds having high health-promoting properties[5]. Thus, it helps to reduce the risk of several diseases, such as cardiovascular disorders, type 2 diabetes and some cancers, as well as improving intestinal health[3]. wheat which is the major ingredient in bread production is not readily cultivated in the tropics hence most of the wheat flour in developing countries are imported[6][7]. This has resulted to high cost of production of baked products especial bread with low protein content in the tropic[8][7]. Substitutions of wheat with other local raw materials in the bakery can be undertaken in order to reduced the cost of production and improve the nutritional value of bread. research efforts have been geared towards finding a local and cheap substitute for wheat flour and this has led to the concept of composite flour[9][10].

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Red kidney bean (Phaseolus vulgaris) a grain legume, is one of the neglected tropical legumes that can be used to fortify cereal-based diets especially in developing countries, because of its high protein content[11]. It is also a rich source of vitamin, minerals and relatively high in crude fibre[10]. Red kidney bean is one such protein source, which when used in the fortification or enrichment of cereal – based diets could go a long way in improving their nutritional status[10]. Low cost, protein-rich and high energy food formulation based on cereal legume mixtures have been suggested[3]. The enrichment or fortification of traditional cereal based diets with other protein sources such as oilseeds and legumes has received considerable attention. This is because oil seed and legumes proteins are rich in lysine, but deficient in sulphur containing amino acids[4]. Legumes generally contain relatively high amount of protein than other plant food stuffs. Cereals (wheat) have low protein content and are in general deficient in lysine but are adequate in sulphur containing amino acids. Legume proteins are mainly used in food formulations to complement the protein in cereal grains because of their chemical and nutritional characteristics[12].

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Coconut (Cocos nucifera) contains higher amounts of dietary fiber (60 g/100 g) and other nutrients[13]. Coconut contains low amount of digestible carbohydrates, and has no gluten[14]. The dietary fiber in coconut has significant health benefits. These include the inhibition of chronic diseases such as cancer, cardiovascular diseases and diabetes mellitus. Also, it has the ability to reduce weight [2]. Coconut has a glycemic lowering effect. Low glycemic index (GI: 35) food particularly such containing high dietary-fiber, has been demonstrated to moderate post-prandial blood glucose and insulin responses enhancing blood- glucose and lipid concentrations in humans and patients having diabetes mellitus[13]. Moreover, coconut is known for the production of coconut milk, coconut oil and flour. Coconut flour can be utilized to produce several delicious pies, cookies, cakes, breads, snacks and desserts[14] The use of coconut flour in food formulation does not only improve the nutritional value of the product but give unique aroma and taste[15].

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2. MATERIAL AND METHODS

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2.1 Materials procurement

Whole wheat grains and coconut fruits were purchased respectively from high- level and railway Markets Makurdi metropolis of Benue state Nigeria while red kidney bean was purchased from Ndop main market, North West region Cameroon.

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2.2 Preparation of Materials

2.2.1 Preparation of whole Wheat Flour

Whole wheat grains were processed into flour following the method described by Ndife *et al.* [4]. The grains were cleaned from dirt by sorting out contaminants such as sticks, leaves and sand, washed in potable water and dried at 55^{o}C for six hours in a conventional air oven. The grains were then milled in attrition mill, sieved to pass through 0.5mm mesh sieve, packaged in an air tight container.

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2.2.2 Preparation of red kidney bean flour

The method described by Ukeyima *et al*.[10], was followed in the preparation of red kidney bean flour. The kidney bean seeds were cleaned to remove foreign materials, defected seeds, insect etc. the

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healthy beans were washed and conditioned for 12 hours. After 12 hours of conditioning, the seeds were blanched at temperature of 85ºC for 30 minutes. The water was drained and allowed to cool to prevent further cooking. The beans were dehulled to remove the skin. It then was washed and placed in a hot air oven to dry at 55ºC for 20 hours. The dried beans were milled using an attrition mill into flour. It was then sieved using a 0.05 mm mesh sieve, packaged in an air tight container.

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2.2.3 Preparation of defatted coconut flour

The method described by Afoakwah *et al*.[16], was followed in the preparation of red kidney bean flour. The coconuts were de-husked and the liquid drained. The meat was cut into smaller pieces using a paring knife. It was then transferred into a liquidizer containing 0.5 L of boiling water and was blended for 5 min, until the pulp was smooth. The milk was separated from the meal using cheesecloth. The meal was washed again in hot (100°C) water to reduce the oil content. The residue obtained was then weighed and dried using Hot Air Oven Dryer at 60°C until a constant weight was attained. The dried coconut was then milled into flour using plate mill. The coconut flour was sieved using a 0.5mm mesh sieve, packaged in an air tight container. All the flour were mix at different ratios to give composite as shown in chart 1

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Chart 1 Blend formulation of composite flour

Samples	Refined Wheat flour	whole wheat flour	Red kidney bean flour	coconut flour
S1 control	100	0	0	0
S2 control	0	100	0	0
S3	0	90	5	5
S4	0	85	10	5
S5	0	80	15	5
S6	0	75	20	5

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2.2.5 Preparation of bread

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The method used for the preparation of bread samples was the straight - dough method as described by Adelekan and Alamu,[17]. All the ingredients were weighed and poured into a mixing bowl of the mixing machine. The ingredients were mixed with the aid of a mixer using slow speed for 5 minutes. Little water was added as the mixing continued, using high speed for 15 minutes. The dough was then put on a moulding table and moulded into desired shape (by hand). After cutting and weighing, the moulded dough was placed inside a lubricated baking pan and covered with a lubricated lid. It was transferred into a proofing chamber for 1hour 30 minutes in order to enhance fermentation and dough development, it was then transferred into the oven at temperature 200-210^{0}C for 25 minutes. The bread was removed from the oven and cooled figure 1.

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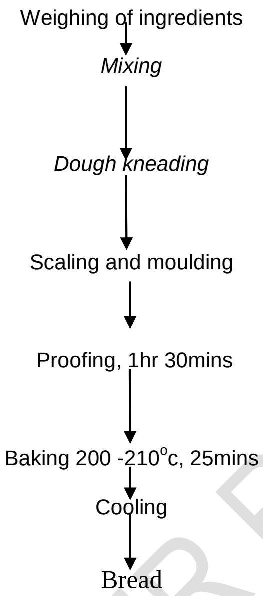

Figure 1: flow chart for preparation of bread Adelekan and Alamu[17]

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2.3 Methods of Analysis

2.3.1 Functional Properties of refined wheat, whole wheat, red kidney bean and defatted coconut flour Blends

2.3.1.1 Water Absorption Capacity (WAC)

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The water absorption capacity was determined using the method described by Chandra and Samsher, [18]; Horsfall *et al.*[19]; Ojo *et al*. [20]. 10mL of distilled water was added to 1g of the composite flour sample in a weighed centrifuge tube. The tube was agitated on a vertex mixer for two minutes and then centrifuged at 500 rpm for 30 minutes. The clear supernatant was decanted and discarded. The adhering drops of water are removed and then weighed. Water absorption capacity was expressed as the weight of water bound by 100 g of dried flour.

$$\text{Water absorption capacity (ml/g)} = \frac{\text{volume of water absorbed}}{\text{mass of sample (g)}}$$

Water absorbed (ml) = (Volume of water added - Volume of water obtained after centrifugation.

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2.3.1.2 Oil Absorption Capacity (OAC)

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The oil absorption capacity was determined using the method described by Chandra and Samsher [18]; Ojo *et al*. [20]. One gram (1g) of the composite flour sample was mixed with 10 millilitres (ml) of refined vegetable oil and allowed to stand at ambient temperature (30 ± 2^0c) for 30 minutes. It was then centrifuged for 30 minutes at 500 rpm. The oil and adhering drops of oil was decanted and discarded. Oil absorption capacity was expressed as percent oil bound per gram flour.

$$OAC = \frac{W2 - W3}{W1}$$

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W3= Weight of sample after centrifugation, W2= Weight before centrifugation, W1= Weight of original sample

2.3.1.3 Bulk density (BD)

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Bulk density of the flour blends was determined using the method described by ukeyima *et al*[10]. The flour blend sample (5 g) was poured into a (10 ml) dry measuring cylinder. The bottom of the cylinder was tapped 50 times (until a constant volume achieved) on the laboratory table and the volume was recorded for packed bulk density.

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$$Bulk\ density\ \left({}^{g}/_{ml}\right) = \frac{weight\ of\ sample}{volume\ of\ sample\ after\ trapping}$$

2.3.1.4 Swelling Capacity (SC)

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The swelling capacity was determined using the method described by Ukeyima *et al.*[10]. Five (5) gram of the sample was weighed into a clean and dry graduated measuring cylinder. Fifty (50) ml of boiled distilled water was added and stirred with a glass rod. It was then allowed to stand for 15 minutes and change in volume of the sample was recorded. The ratio of the initial volume to the final volume as swelling Index was calculated as:

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$$swelling\ capacity\ = \frac{change\ in\ volume\ of\ sample\ (ml)}{original\ volume\ of\ sample(ml)}$$

2.3.1.5 Foaming capacity (FC) and Foaming stability (FS)

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The foam capacity (FC) and foam stability (FS) were determined as described by ukeyima *et al.*[10] . The 1.0 g flour sample was added to 50 mL distilled water at 30 ± 2°C in a graduated cylinder. The suspension was mixed and shaken for 5 minutes to foam. The volume of foam at 30 sec after whipping was expressed as foam capacity using the formula:

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$$Foaming\ capacity\ (\%) = \frac{volume\ of\ foam\ AW - volume\ of\ foam\ BW}{volume\ of\ of\ foam\ BW} X\ 100$$

Where, AW = after whipping, BW = before whipping.
The volume of foam was recorded two minutes after whipping to determine foam stability as per percent of initial foam volume.

2.3.1.6 Emulsion Activity

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The emulsion activity was determined using the method described by Horsfall *et al.*[19] The emulsion, 1g of the composite flour sample, 10 ml refined vegetable oil and 10 ml distilled water is prepared in a calibrated tube. The emulsion was centrifuged at 200 rpm for 15 minutes. The ratio of the height of the emulsion layer to the total height of the mixture was calculated as the emulsion activity expressed in percentage.

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$$Emulsion\ activity\ = \frac{height\ of\ emulsion\ layer}{height\ of\ mixture}\ x100$$

2.4 Proximate Composition of whole wheat, red kidney bean and defatted flour Blends

2.4.1 Moisture content determination

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Moisture content (MC) was determined by oven method described by Ukeyima et al.[10]. Two 2g of each sample was weighed into a weighed dried dish (moisture cans). It was then placed in an oven at 103ºC for three hours. Then it was removed and transferred into desiccators at room temperature to cool. After cooling, the samples were weighed and replaced in the oven for another 1 hour. After this, the dish containing the sample was removed and cooled in desiccators and reweighed. The procedure was repeated until a constant weight was obtained. The loss in weight was reported as moisture content and calculated as:

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$$\%MC = \frac{initial\ mass\ of\ sample - mass\ after\ drying}{initial\ mass\ of\ sample} X\ 100$$

2.4.2 Ash content determination

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Ash was determined by the method outlined by Ukeyima *et al*[10]. The crucible was weighed and dried in an oven and cooled in the desiccators. 5g of the each sample was weighed in the empty porcelain crucible. The crucible containing the samples were placed in the muffle furnace and ignited at 550ºC. This temperature was maintained for three hours after which the crucibles were then transferred into the desiccators, cooled and weighed. The ash content was calculated as follows;

$$\%\, ash = \frac{weight\ of\ crucible + ash - weight\ of\ empty\ crucible}{weight\ of\ sample}\ x\ 100$$

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2.4.3 Crude Fibre content determination

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The crude fibre of the flour samples was determined according to the method describe by. Ukeyima *et al*.[10]. Two grams each of the samples were boiled under reflux for thirty minutes with 200 mL of the solution containing 1.25 g of H_2SO_4 per 100 ml of solution. The solution was filtered through linen on a flaunted funnel and washed with water until the washing is no longer acidic. The residue was then transferred to a beaker and boiled for 30 minutes with solution containing 1.25 g of NaOH per 100 ml of solution. The final residue was filtered through a thin but closer pad of washed and ignited asbestos in a Gosh crucible. The residue was then dried in an electric oven and weighed; the residue was ashed in a muffle furnace at 550 ^{0}C for 3hours, cooled and weighed.

$$\%\, of\ crude\ fiber = \frac{(W2 - W3)}{W1}\ X\ 100$$

Where: W1 = weight of sample used, W2 = weight of crucible plus sample, W3 = weight of sample crucible + ash.

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2.4.4 Fat content determination

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The fat content of the flour samples was determined using the method describe by Ukeyima *et al*.[10]. Five (5) grams each of the flour samples in a filter paper and placed in a soxhlet reflux flask which is connected to a condenser on the upper side and a weighed oil extraction flask full with two hundred ml petroleum ether. The ether was brought to its boiling point, the vapour condensed into the reflux flask immersing the samples completely for extraction to take place on filling up the reflux flask siphons over carrying the oil extract back to the boiling solvent in the flask. The process of boiling, condensation, and reflux was allowed to go on for four hours before the defatted samples were removed. The oil extract in the flux was dried in the oven at 60ºC for 30 minutes and then weighed.

$$\%fat = \frac{mass\ of\ fat\ obtained}{dry\ mass\ of\ sample\ used} X\ 100$$

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2. 4. 5 Protein content determination

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Crude protein of the sample flours was determined using the Kjeldahl method as describe by Ukeyima *et al*.[10]. One gram of the sample was introduced into the digestion flask. Kjedahl catalyst (Selenium Tablets) was added to the sample. Twenty ml of concentrated sulphuric acid was added to the sample and fixed to the digester for eight hours until a clear solution was obtained. The cooled digest was transferred into one hundred ml volumetric flask and made up to the mark with distilled water. The distillation apparatus was set and rinsed for ten minutes after boiling. 20ml of 4% boric acid was pipetted into a conical flask. Five drops of methyl red were added to the flask as an indicator and the sample was diluted with seventy-five ml distilled water. Ten ml of the digest was made alkaline with twenty ml of NaOH (20%) and distilled. The steam exit of the distillatory was closed and the change of color of the boric acid solution to green was timed. The mixture was distilled for fifteen minutes. The filtrate was then titrated against 0.1 N HCl. The percentage total was calculated:

$$\%\, of\ total\ nitrogen = \frac{(Vb - Va)x0.1Nx\ 0.0142}{W}x100$$

Where: Va = Volume of acid used in titration, Vb = Volume of base, W =weight of sample used.

$$\%\text{Crude protein} = \%\text{ of total Nitrogen X } 6.25$$

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2.4.6 Carbohydrate content determination

Total carbohydrate was determined by differences between 100 and total sum of the percentage of fat, moisture, ash, crude fibre and protein content[21].
%CHO = 100 – (%Protein + %Moisture + %Fat + %Ash + %Fibre)

2.5 Anti-Nutritional Properties of whole wheat, red kidney bean and defatted coconut Flour blends

2.5.1 Phytate content determination

The phytate content was determined using the method described by Marolt and Kolar[22]. Two grams of composite flour sample was weighed into a 250ml conical flask and 100ml of 2% concentrated HCl was added. It was allowed to stand for 3hr and filtered. After filtration, 50ml of the filtrate was pipetted into a 250ml beaker and 107ml of distilled water was added to improve acidity. Ten millimetre of 0.3% ammonium thiocynate solution was added as an indicator. The solution was titrated with standard iron III chloride ($FeCl_3$) which contains 0.00195g iron/ml until a brownish yellow colour appear and persist for 5minutes. The phytic acid content was calculated using the formula below:

$$\text{Phytic acid (g/kg)} = \frac{0.00195 x volume\ of\ Fecl3\ consumed\ xDF}{x1000\ sample} \qquad \text{Where DF= dilution factor}$$

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2.5.2 Oxalates content determination

Oxalate was determined by the method describe by Adeniyi *et al.*[23]. Two (2 g) of the sample was digested with 10 ml 6 M HCl for one hour and made up to 250 ml in a volumetric flask. The pH of the filtrate was adjusted with conc. NH_4OH solution until the colour of solution changed from salmon pink colour to a faint yellow colour. Thereafter, the filtrate was treated with 10 ml of 5% $CaCl_2$ solution to precipitate the insoluble oxalate. The suspension is now centrifuged at 2500 rpm, after which the supernatant was decanted and precipitate completely dissolved in 10 ml of 20% (v/v) H_2SO_4. The total filtrate resulting from the dissolution in H_2SO4 is made up to 300 ml. An aliquot of 125 ml of the filtrate was heated until near boiling point and then titrated against 0.05 M of standardized $KMnO_4$ solution to a faint pink colour which persisted for about 30 seconds after which the burette reading was taken. The oxalate content was evaluated from the titre value.

2.5.3 Tannin content determination

Tannin was determined by the method described by Nwokenkwo et al.[24] using Unico UV-2102 Spectrophotometer. Five hundred milligrams of the sample was weighed into a 100 ml plastic bottle and 50 ml of distilled water was added mixed thoroughly for 1 hour using a mechanical shaker. The sample was subsequently filtered into a 50 ml volumetric flask and made up to mark with distilled water. Then 5 ml of the filtrate was transferred into a tube and mixed with 3 ml of 0.1m FeCl in 0.1N HCl and 0.008M Potassium ferocyanide (KCN) solution. The absorbance of the sample was measured spectrophotometrically at 120nm wavelengths for 10 minutes. A blank sample was prepared and the colour was developed and read at the same wavelength. A standard was prepared using tannin acid to get 100ppm and measured. The total tannin content was calculated using the formula:

$$tannin\ (\frac{mg}{cm3}) = \frac{absorbance\ of\ sample}{absorbance\ of\ standard} X \frac{conc. of\ standard}{1}$$

2.6 Sensory evaluation of bread produced from whole wheat, red kidney and defatted coconut flour blends

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Sensory evaluation was carried out using a preference test as described by **Hashim *et al*.[25]**. A 9-point hedonic scale where 1 represents "extremely dislike" and 9 represents "extremely like" was used for this study. The organoleptic evaluation of the bread samples was carried out for consumer acceptance and preference using 20 semi- trained panelists. The properties evaluated were appearance texture, aroma, taste, and overall acceptability.

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2.7 Statistical analysis

Data obtained were analysed using the one-way ANOVA and mean separated using Duncan Multiple Range Test (DMRT) at 5% limit of significant using Statistical package for social science (SPSS) version 26

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3. RESULTS AND DISCUSSION

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3.1 Functional Properties of whole wheat, red kidney bean and defatted coconut flour Blends

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The results for the functional properties of the flour blends are presented in table 1.

3.1.1 Water Absorption Capacity (WAC)

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The water absorption capacity (WAC) of the flour blends ranged from 0.62±0.06g/ml (S1) to 0.92±0.01 g/ml (S6). The results shows increased in WAC of flour blends with the addition of red kidney bean. The WAC of sample S1 (control 1) was significantly ($p<0.05$) lower than that of the other samples. Sample S2 (control 2) was significantly ($p<0.05$) lower than samples S4 to S6. The major chemical compositions that enhance the water absorption capacities of flours are proteins, fiber and carbohydrates since these constituents contain hydrophilic parts such as polar or charged side chains. Therefore the increased in the WAC of the flour is due to increased in the protein and fiber content of the flour as the quantity of red kidney bean flour increased. The lower WAC of refined wheat flour could be attributed to the presence of lower amount of hydrophilic constituents in wheat such as polysaccharides [26]. This report agrees with results presented by Chandra and Samsher[18]; Kaushal *et al*.[27], who noted that flour with high protein and fiber content had high WAC. The values presented here are higher due to addition of coconut flour which increased both protein and fiber content of the flour samples. Very low or excessive water absorption can negatively affect the quality of food products. Water absorption can influence the following parameters of bread and baking: Proofing, Fracture stress of bread crumb, Loaf volume, and Bread yield[28]. Under-absorption of water result to Firm and dense internal structure (crumb) and Low volume bread while over- absorption of water result to open crumb grain with large cells, Large volume and bread which is prone to mold[28].

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3.1.2 Oil Absorption Capacity (OAC)

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Oil absorption capacity (OAC) of the flour blends ranged from 0.96±0.02g/ml (S1) to 1.42±0.03 g/ml (S6). The oil absorption capacity increased from sample S1 to S6 with the addition of red kidney flour. The OAC of S2 to S6 were significantly ($p<0.05$) higher than S1 (control 1). The presence of high fat content in flours might have affected adversely the OAC of the composite flours. Therefore, the possible reason for increase in the OAC of composite flours after incorporation of red kidney bean and coconut flour is the variations in the presence of non-polar side chain, which might bind the hydrocarbon side chain of the oil among the flours[29]. The primary chemical component affecting OAC is protein that is composed of both hydrophilic and hydrophobic parts. Non-polar amino acid side chains can form hydrophobic interaction with hydrocarbon chains of lipids[28]. Increasing red kidney beans quantity was found to increase the protein content of the flour sample, resulting to increase in OAC. Similar findings were observed by chandra and Samsher[18]; Kaushal *et al*.[27], who noted flour of high protein retain more oil than flour with low protein content. The OAC makes the flour suitable in facilitating, enhancement in flavor and mouth feel when used in food preparation. Due to these properties, the protein probably could be used as functional ingredient in foods such as bread and cakes[28].

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3.1.3 Bulk Density (BD)

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The bulk density (BD) of the flour blends ranged from 0.84±0.01g/ml (S1) to 0.60±0.02g/ml (S6). There was a decreased in BD of the flour blends from sample S1 to sample S6 with the addition of red kidney bean. The BD of sample S1 (control 1) was significantly ($p<0.05$) higher than samples S2 to S6. BD depends on the particle size and moisture content of flours. Bulk density can be improved when the particles are smaller. The use of whole wheat, with the addition of red kidney bean and coconut flour increased the particles size, resulting to decrease in BD from sample S2 to S6. The variation in bulk density of foods could also be attributed to the variation in starch content of the foods. The higher the starch content the more likely the increase in bulk density[28][30]. This observation fails to agrees with works presented by[10] due to the addition of coconut flour which increased the particles size of the flour but agrees with report by Awuchi *et al.*[28], who observed that flour with fine particle had high BD than those with larger particles sizes. Bulk density reflects the relative volume or capacity of the required packaging material[28].

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3.1.4 Swelling Capacity (SC)

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The swelling capacity (SC) of the flour blends ranged from 1.05±0.01 (S1) to 1.73±0.01 (S6).From the results, there was an increased in swelling index of flour blends from sample S1 to S6 with the addition of red kidney bean. Sample S1 (control 1) was significantly ($P<0.05$) lower than other samples. Samples S4 to S6 also show significant difference ($p<0.05$) from sample S2 (control 2). Swelling capacity of composite flours increased with increase in the level of incorporation ratio of red kidney bean flour. The swelling capacity (index) of flours are influenced by the particle size, species variety and method of processing or unit operations[18]. The increased in SC may also be attributed to the increased in the fiber and pre-gelatinized starch content of the composite flour (since red kidney bean was parboiled)[29]. High starch content increases swelling capacity (index) of foods and flours, especially in starch with higher amount of the branched amylopectin. Starch is made up of amylose (linear chain) and amylopectin (branched chains), both are chains of glucose units. The amount and proportion of amylose and amylopectin found in starch vary according to the plant source. This explains why different flours from different (plant) sources and species have different swelling capacities[18]. Similar observation were made by Suresh *et al.* [29]; Moses and Olanrewaju [31]; Adejuyitan *et al.*[32], who stated that composite flour rich in fiber have high swelling capacity.

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3.1.5 Foaming Capacity (FC)

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The foaming capacity (FC) of the flour blends ranged from 11.47±0.02% (S1) to 13.20±0.05% (S6). There was increased in foaming capacity of the flour blends from sample S1 to sample S6 with the addition of red kidney bean. The FC of S1 (control 1) was significantly ($p<0.05$) lower than other samples. S2 (control 2) was significantly ($p<0.05$) lower than S4 to S6. Protein is mainly responsible for foaming. Foaming capacity and stability generally depend on the interfacial film formed by the proteins, which maintains the suspension of air bubbles and slows down the coalescence rate[28]. Increase in level of substitution of red kidney bean flour result to increase in the foaming capacity of the flour samples. This observation agrees with reports by Ukeyima *et al.* [10]; Abdelghafor *et al.*[33], who reported that legumes have high foaming capacity due to the high protein content of the flour.

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3.1.6 Foam Stability (FS)

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The Foam stability (FS) of the flour blends ranged from 50.93±0.01% (sample S1) to 53.47±0.01% (S6). There was increased in foaming stability (FS) of the flour from sample S1 to S6 with the addition of red kidney bean flour. There was significant difference ($p<0.05$) between samples S3 to S6 and the controls (S1 and S2). Increased in foam stability is due to increase in the protein content of the flour as the quantity of red kidney bean and flour increased. Flours are capable of producing foams due to surface active proteins. Foaming capacity and stability generally depend on the interfacial film formed by the proteins, which maintains the suspension of air bubbles and slows down the coalescence rate[28]. Protein in the dispersion may cause a lowering of the surface tension at the water air interface, thus always been due to protein which forms a continuous cohesive film around the air bubbles in the foam[27]. Stable foams are known to occur when low surface tension and high viscosity occur at the interface forming vacuoles in the foam[28]. This observation agrees with reports by Ukeyima *et al.* [10]; Abdelghafor *et al.*[33], who noted that Stable foams are known to occur when low surface tension and high viscosity occur at the interface forming a continuous cohesive film around the air vacuoles in the foam. But according to Kapil *et al.*[26], there is always an inverse relationship between the foaming capacity and the foam stability. Flours with high foaming capacity may form large air bubbles encircled by thinner less flexible protein film. Consequently, this air bubbles may collapse easily and consequently lower the foam stability. This is true for flour with low protein content but not true in this study because of high protein content of red kidney bean which increased the protein value of flour creating a stable cohesive film around the air bubbles as also reported by Hyacinthe *et al* [34].

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3.1.7 Emulsification Capacity (EC)

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Emulsification capacity (EC) of the flour blends ranged from 41.43±0.03% (sample S1) to 43.36±0.01% (sample S6). Emulsification capacity (EC) of the flour blends increased from sample S1 to S6 with the addition of red kidney bean. The EC of sample S1 was significantly ($p<0.05$) lower than samples S2 to S6. Sample S2 (control 2) was significant difference ($p<0.05$) from samples S3 to S6. The Increased in emulsion capacity of the flour as the quantity of red kidney bean and coconut flour increased is due to increased in the protein content of the flour. Emulsifiers like protein are compounds that typically have a non-polar (that is, lipophilic or hydrophobic) part and a polar or hydrophilic (water-soluble) part. Due to this, emulsifiers tend to be more or less soluble either in oil or in water. Emulsifiers which are more soluble in oil (and conversely, less soluble in water) will generally form water-in-oil emulsions, while emulsifiers that are more soluble in water, and less soluble in oil, will form oil-in-water emulsions. Emulsifying particles and emulsifiers (protein) tend to promote the dispersion of the food phases in which they are not well dissolved. For example, protein dissolves better in water than it does in oil, and as a result tend to form oil-in-water emulsions (i.e., protein promotes the dispersion of droplets of oil throughout the continuous phase of water)[28]. This report agrees with work presented by Kausha *et al*.[27], who noted that increased in protein content of composite flour resulted to increased in emulsification capacity.

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Table 1: Functional Properties of refined wheat, whole wheat, red kidney bean and defatted coconut Flour Blends

Flour blends	WAC (ml/g)	OAC (ml/g)	BD (g/ml)	SC (ml/ml)	FC (%)	FS (%)	EC (%)
S1	$0.62^{d}\pm0.06$	$0.96^{c}\pm0.02$	$0.84^{a}\pm0.01$	$1.05^{e}\pm0.01$	$11.47^{d}\pm0.02$	$50.93^{d}\pm0.01$	$41.43^{e}\pm0.03$
S2	$0.71^{c}\pm0.02$	$1.28^{b}\pm0.03$	$0.78^{b}\pm0.01$	$1.62^{d}\pm0.03$	$12.98^{c}\pm0.01$	$51.95^{c}\pm0.06$	$43.05^{d}\pm0.02$
S3	$0.75^{c}\pm0.05$	$1.29^{b}\pm0.01$	$0.75^{b}\pm0.01$	$1.63^{d}\pm0.01$	$12.99^{c}\pm0.00$	$52.88^{b}\pm0.02$	$43.09^{c}\pm0.01$
S4	$0.83^{b}\pm0.04$	$1.30^{b}\pm0.09$	$0.69^{c}\pm0.02$	$1.65^{c}\pm0.01$	$13.09^{b}\pm0.01$	$52.89^{b}\pm0.01$	$43.24^{b}\pm0.03$
S5	$0.88^{a}\pm0.03$	$1.36^{a}\pm0.03$	$0.63^{d}\pm0.03$	$1.70^{b}\pm0.00$	$13.11^{b}\pm0.02$	$53.43^{a}\pm0.02$	$43.33^{a}\pm0.03$
S6	$0.92^{a}\pm0.01$	$1.42^{a}\pm0.03$	$0.60^{d}\pm0.02$	$1.73^{a}\pm0.01$	$13.20^{a}\pm0.05$	$53.47^{a}\pm0.01$	$43.36^{a}\pm0.01$

Values are means of triplicate determinations ± S.D. Means followed by different superscript letters in the same column indicate significant difference at ($p<0.05$).

3.2 Effect of red kidney bead and defatted coconut flour on the Proximate Composition of whole wheat Flour

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3.2.1 Moisture content

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The moisture content of the flour blends ranged from 12.23±0.03% (S1) to 13.44±0.01% (S6).There was increased in moisture content of the flour blends with the addition of red kidney bean. The increased in moisture content could be attributed to increase in the of fiber content of the flour. Whole wheat flour and mostly whole grains absorb more liquid than other flours such as white flour. In whole wheat flour, the whole grain is used, the grain is rich in fiber that loves to trap water and therefore the flour will be able to retain more moisture. This result agrees with report presented by Okoye *et al*.[12], who reported that high fibre flour turn to hydrophilic. The results presented here is higher (but within the acceptable limits) due to addition of coconut flour which further increased the hydrophilic property of the flour [35]. The moisture content of flour is important for two reasons. First the higher the amount of moisture content the less the amount of dry solids in the flour. Secondly, flour with moisture content higher than 14- 15% is not stable at room temperature as this is prone to microbial spoilage. The moisture content of all the blends were within the acceptable range of flour specification according to Adelekan and Alamu[17].

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3.2.2 Ash content

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The ash content of the flour blends ranged from 0.66±0.01% (S1) to 1.66±0.02% (S6).There was increased in the ash content of the flour blends from sample S1 to sample S6 with the addition of red kidney bean. There was significant difference (*p<0.05*) between the control (S1) and the other samples. Comparing sample S2 (Control 2) with samples S4 to S6 there was significant difference (p<0.05) with ash content. The increased in ash content of the flours is due to the addition of red kidney bean and coconut flour which are rich sources of minerals. This report is similar to findings presented by Okoye *et al*.[12]; Stoin *et al*.[36], who reported on improving the ash content of composite flour using legume. The values reported here are slightly higher due to the addition of coconut flour who have been reported as good source of mineral[37][17]

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3.2.3 Fat content

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The fat content of the flour blends ranged from 0.22±0.3% (S1) to 2.57±0.01% (S6). There was increased in the fat content of the flour blends from sample S1 to Sample S6 with the addition of red kidney bean. The fat content of sample S1 was significantly ($p<0.05$) lower than samples S2 to S 6. Samples S2 (control 2) was significantly ($p<0.05$) lower than the other samples (S3 to S6). The increased in fat content is due to the use of whole wheat flour and addition of defatted coconut flour which may contain a certain percentage of oil. Red kidney bean though very low in fat could also contribute to increased in fat content. This report fails to agree with finding reported by Okoye *et al*.[12]; Sachithra *et al* [37], who reported that addition of kidney bean reduce the fat content of the composite flour. This could be attributed to the addition of defatted coconut flour which increased the fat content contrary to their finding.

3.2.4 Fiber content

The fiber content ranged from 0.67±0.26% (S1) to 4.34±0.02% (S6). There was an increased in the fiber content of the flour blends with the addition red kidney bean. There was significant difference ($p<0.05$) between samples S1 (control 1) and the other samples. The fiber content of Samples S1 was significantly ($p<0.05$) lower than other samples (control). The increased in the fiber content is due to high fiber content of whole wheat, red kidney bean and coconut flour. This report is similar with work presented by Manonmani *et al*. [38]; Okoye *et al*. [12]; Adelekan and Alamu[17], who reported on the use of legumes and nuts for the development of functional foods due to their fiber content. Nutritionally, consumption of these experimental dough meals would be of benefits to the consumers, since, evidences have shown that dietary fibres promote good health by preventing degenerative diseases like diabetes and hypertension. Fibre in food helps in burning of fat and busting of the immune system. It could also provide bulk in the diet, enhance gastrointestinal function, and prevent constipation[39]

3.2.5 Protein content

The protein content ranged from 10.70±0.12% (S1) to 13.06±0.03% (S6).There was an increased in the protein content of the flour blends with increased in re kidney bean addition. There was a significant difference ($p<0.05$) between sample S1 (control 1) and the other samples. The protein content of samples S2 to S6 were significantly ($p<0.05$) higher than sample S1. Sample S2 (control 2) and sample S3 did not show any significant difference ($p>0.05$). Samples S4 to S6 show significant difference ($p<0.05$) with sample S2 (control 2). The increased in protein content as the quantity of red kidney bean increased is because of the high protein content of the red kidney bean as report by Manonmani *et al*.[38]; Kambabazi *et al*.[40]. This report is in agreement with report presented by Okoye *et al*.[12]; Akinjayeju *et al*.[41]; Adelekan and Alamu [17]; ukeyima *et al*[10], who reported that combination of two or more varieties of cereals and legumes usually increased the protein content of the end products.

3.2.6 Carbohydrate Content

The carbohydrate content of flour decreased from 75.52±0.33% (S1) to 64.93±0.04% (S6) The carbohydrate content of flour decreased from sample S1to sample S6. The decreased is due to increased in the addition of red kidney which is a low carbohydrate food. Also increase in other proximate components' result to decrease in carbohydrate since it is obtain by difference. This report agrees with finding by Okoye *et al*.[12]; Ndife *et al.* [4]; Ukeyima *et al*.[10], who reported a decreased in the carbohydrate content of their products when fortified with legumes.

Table 2: Proximate Composition (%) of refined wheat, whole wheat, red kidney bean and defatted coconut Flour Blends

Flour blends	Moisture	Ash	Fat	Fiber	Protein	Carbohydrate
S1	12.23^{d}±0.03	0.66^{d}±0.01	0.22^{e}±0.03	0.67^{d}±0.26	10.70^{d}±0.12	75.52^{a}±0.33
S2	13.33^{c}±0.03	1.51^{c}±0.03	2.40^{d}±0.01	4.07^{c}±0.02	11.15^{c}±0.06	67.54^{b}±0.11
S3	13.34^{c}±0.03	1.53^{c}±0.03	2.44^{c}±.03	4.13^{c}±0.03	11.21^{c}±0.02	67.34^{b}±0.02
S4	13.38^{b}±0.01	1.58^{b}±0.02	2.50^{b}±0.01	4.20^{b}±0.01	12.07^{b}±0.01	66.27^{c}±0.02
S5	13.40^{ab}±0.02	1.60^{b}±0.02	2.52^{b}±0.02	4.30^{a}±0.02	12.56^{b}±0.01	65.62^{c}±0.00
S6	13.44^{a}±0.01	1.65^{a}±0.02	2.57^{a}±0.01	4.34^{a}±0.02	13.06^{a}±0.03	64.93^{d}±0.04

Values are means of triplicate determinations ± S.D. Means followed by different superscript letters in the same column indicate significant difference at ($p<0.05$).

3.3 effect of red kidney bean and defatted flour on the Anti nutrients composition whole wheat flour

The results for the anti nutrient composition of the flour blends is presented in table 3

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3.3.1 Phytate content

The phytate content of the flour blends increased from 0.03±0.00mg/100g (S1) to 1.09±0.01mg/100g (S6). There was an increased in the phytate content of the flour blends from sample S1 to S2 with the addition of red kidney bean. The phytate content of sample S1 (control 1) was significantly ($p<0.05$) lower than other samples. The increased in the phytate content of the flour samples is due to the addition of red kidney beans flour which are known to content phytate[42][22]. The phytate content of sample S1 was far lower due to refining (Refining of wheat grain remove part of the bran which contains highest percentage of phytate). The result of this study is similar to findings by[43]. The values reported here are lower due to use of combined (soaking, fermentation dehulling and boiling) methods of reducing anti nutrient in food. These treatments methods have been reported to greatly reduced or eliminate phytate content of kidney bean. But the values are higher than those presented by Ayele et al.[44], due to the use of whole wheat flour in the research as part of the composite flour with legume. Phytate are known to form complexes with iron, zinc, calcium and magnesium making them less available and thus inadequate in food samples especially for children. However, the phytate content in this study is far lower than the minimum amount of phytic acid reported to hinder the absorption of iron and zinc. It is known that 10-50 mg phytate per 100g will not cause a negative effect on the absorption of zinc and iron[43].

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3.3.2 Oxalate content

The oxalate content of the flour blends increased from 0.02±0.02mg/100g (S1) to 0.14±0.01mg/100g (S6) There was an increased in the oxalate content of the flour blends from sample S1 to sample S6 with the addition of red kidney bean. The oxalate content of sample S1 was significantly ($p<0.05$) lower than that of samples S2 to S6. Comparing control 2 (sample S2) with sample S3 there was no significant difference ($p>0.05$) but when compared with samples S4 to S6 there was a significant difference ($p<0.05$). The increased in oxalate content is due to the addition of red kidney bean flour which have been reported to contain oxalate[22][23]. The oxalate content of sample S1 was far lower equally due to refining (Refining of wheat grain remove part of the bran which contains the highest percentage of oxalate). This report agrees with findings by Adeniyi *et al*. [23]; Rasha *et al*.[42], but the values here are far lower due to soaking, fermenting and boiling of the raw material before milling to flour. These treatments have been reported to greatly reduced anti nutrients (oxalate) content of red kidney bean[45]. Oxalate is known to form complexes with calcium to form insoluble calcium -oxalate salt. According to ohini *et al*.[43] reported a safe range of 4- 9 mg/100g for oxalates. This implies that, the oxalates content of the flour samples was within the safe range.

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3.3.3 Tannins content

The tannins content of the flour blends increased from 0.01±0.01mg/100g (S1) to 0.09±0.01mg/100g (S6).There was a significant ($p<0.05$) increased in tannins content of flour from sample S1 to S6. The increased in the tannins content of the flour samples was due to the addition of red kidney flour which have been reported to contain tannins[45]. The study agrees with finding by Mamiro *et al.* [46]; Pandit and Kaur [47]. But the values are lower due to soaking, fermenting and boiling of the raw material before milling to flour. These treatments methods have been reported to greatly reduced oxalate content of wheat red kidney bean[45]. On the other hand the values are higher compared to those presented by Ayele *et al.*[44], due to the used of whole wheat flour in this research. The permissible limit of tannins in food is 20mg/g, implying that the tannins content of the flour blends was within the acceptable limit.

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Table 3: Anti nutrient Composition (mg/100g) of refined wheat, whole wheat, red kidney bean and defatted coconut Flour Blends

Flour blends	Phytate	Oxalate	Tannins
S1	$0.03^{f}\pm0.00$	$0.02^{d}\pm0.02$	$0.01^{d}\pm0.01$
S2	$1.05^{e}\pm0.00$	$0.06^{c}\pm0.00$	$0.05^{c}\pm0.01$
S3	$1.06^{d}\pm0.00$	$0.09^{c}\pm0.01$	$0.06^{c}\pm0.01$
S4	$1.07^{c}\pm0.00$	$0.11^{b}\pm0.00$	$0.07^{b}\pm0.00$
S5	$1.08^{b}\pm0.00$	$0.12^{b}\pm0.01$	$0.08^{a}\pm0.01$
S6	$1.09^{a}\pm0.01$	$0.14^{a}\pm0.01$	$0.09^{a}\pm0.01$

Values are means of triplicate determinations ± S.D. Means followed by different superscript letters in the same column indicate significant difference at (p<0.05).

3.4 Effects of red kidney bean and defatted coconut flour on the Sensory attributes of whole wheat bread

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The results of the sensory attributes of the bread are presented in table 4.

3.4.1 Appearance

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The appearance scores ranged from 8.50±0.61 like very much (S1) to 6.60±0.60 like slightly (S6).Sample S1 has the best appearance while sample S6 has the least appearance with the addition of red kidney bean. There was significant different (*p<0.05*) between sample S1 (control 1) and the other samples. Appearance was evaluated in terms of the crust and crumb colour and honey comb structure of the bread loaves. The colour of the samples changes from white to dark as it move from sample S1 (control 1) to sample S2 (control 2) and become darker as the substitution of red kidney beans flour increases. The dark bran of wheat flour is responsible for the dark colour of sample S2 (control 2). Also coconut and red kidney beans flours are dark in colour and together with the dark bran of whole wheat flour are responsible for the darker appearances of samples S3 to S6, as compared to refined wheat flour. Again difference in colour could be as a result of Millard browning reaction caused by the reaction between the wheat protein, and sugars[48] . The darker colour of the crumbs of whole wheat bread and fortified breads have been reported by Adelekan and Alamu [17]; Ndife *et al*.[4]; Serrem *et al.* [49]. Sample S1 was found to develop the best honey corn (sponge) structure while sample S6 was found to develop the least. The reduction in the sponge structure of the bread samples was due to the dilution of the gluten content of the flour with non - wheat flour[50].

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3.4.2 Aroma

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The aroma scores ranged from 6.45±0.76 like slightly (S2) to 8.55±0.69 like very much (S3). The sensory scores for samples S3 to S6 were significantly (*p<0.05*) higher than those of S1and S2 (controls). This is because incorporation of coconut flour resulted in very good flavour/aroma. This result did not agree with work done by Ndife *et al*.[4], who reported that increase in the level of substitution of wheat with bean (legumes) flour result to beany- flavour and aroma from the beans in the composite breads. The result was different due to soaking, fermentation and blanching which help to get rid of the beany - flavour as earlier reported by ukeyima *et al*.[10], using white kidney bean in bread production. Also coconut flour was reported by Adelekan and Alamu [17] to add good aroma to baked products.

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3.4.3 Texture

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The texture scores (softness and chewiness) of bread sample ranged from 8.40±0.68 like very much (S1) to 5.55±0.76 neither like nor dislike (S6). There was decreased in acceptability in terms of texture with increase in non- wheat flour substitution. The sensory scores for sample S3 to S6 was significantly (*p<0.05*) lower than that of samples S1 and S2 (controls). Between the controls there was a significant different (*P<0.05*) in texture. Hard crumb texture of samples was due to fibre from wheat bran and dilution in the gluten content of the flour[4]. This result agrees with works done by Eimam *et al*.[51]; Ukeyima *et al*.[10], who reported that the addition of non- wheat flour (legumes) into wheat flour increased the hardness of the bread due to dilution of gluten protein.

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3.4.4 Taste

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The taste scores ranged from 8.25±0.87 like very much (S3) to 6.55±0.69 like slightly (S6). Sample S3 was the most preferred and sample S6 was the least preferred in terms of taste. This is due to the fact that coconut flour is kwon to introduce a characteristic taste to baked products as reported by Adelekan and Alamu[17]. But as the quantity of non- wheat flour (red kidney bean) increased, the coconut taste is subdued resulting to a significant (*p>0.05*) drop in sensory scores samples S4 to S6. This was because of the high fiber content of the samples which give the bread a blend taste. Samples S3, S1 shows no significant difference (*P>0.05*).

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3.4.5 Overall acceptability

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The overall acceptability scores range from 8.45±0.39 like very much (S1) to 6.05±1.39 like slightly (S6). Samples S1, S3 shows no significantly difference (*P>0.05*) and were the most preferred. Sample S6 was the least preferred. Therefore it was concluded that good bread of acceptable sensory attributes can be produced from whole 90%, red kidney bean 5% and coconut flour 5% (sample S3).

Table 4: Sensory attributes of bread produced from refined wheat, whole wheat, red kidney bean and coconut flour blends

Bread Samples	Appearance	Aroma	Taste	Texture	Overall acceptability
S1	8.50^{a}±0.61	6.55^{b}±0.69	8.20^{a}±0.59	8.40^{a}±0.68	8.45^{a}±0.39
S2	7.50^{b}±0.51	6.45^{b}±0.76	7.25^{b}±0.91	7.25^{b}±0.55	6.75^{c}±0.91
S3	7.75^{b}±0.72	8.55^{a}±0.69	8.25^{a}±0.87	6.60^{c}±1.23	8.12^{a}±0.96
S4	6.80^{c}±0.77	8.45^{a}±0.60	7.30^{c}±0.86	6.40^{c}±0.94	7.15^{bc}±1.08
S5	6.70^{c}±0.73	8.40^{a}±0.68	6.90^{cd}±0.91	5.75^{d}±1.01	6.25^{d}±1.29
S6	6.60^{c}±0.60	8.30^{a}±0.73	6.55^{d}±0.69	5.55^{d}±0.76	6.05^{d}±1.39

Values are means of triplicate determinations ± S.D. Means followed by different superscript letters in the same column indicate significant difference at (p<0.05).

4. Conclusion

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The study has shown that acceptable flour of improved functional properties and nutritional quality could be produced from blends of whole wheat, red kidney bean and defatted coconut flours. Production of flour from whole wheat flour supplemented with red kidney bean and defatted coconut flours will help to reduce dependence on wheat flour thereby reducing wheat importation into the country for bread production. It will lead to increased utilization of red kidney bean and coconut and farmers will be encouraged to produce more and generate more income. The high protein content in kidney bean incorporated flour could be used to alleviate the problem of protein-energy malnutrition that is still common in most developing countries. Also, the high dietary fibre of the flour would provide some health benefits to the consumers especially those with carbohydrate related disorder (type 2 diabetes). Also the result showed the ant nutrients contents were within the permissible level making the composite flour safe to human consumption. More so, the sensory scores indicate that bread of acceptable sensory quality can be produced from blends (sample S3), since it shows no significant difference with sample S1 (control).
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References

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[1] Shewry, P. R. (2009) “Darwin wheat review,” *Journal of Experimental Botany,* vol. 60, no. 6. pp. 1537–1553, doi: 10.1093/jxb/erp058.

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