COMPARATIVE STUDY ON THE PROXIMATE COMPOSITION, FUNCTIONAL AND SENSORY PROPERTIES OF THREE VARIETIES OF BEANS *Phaseolus lunatus*, *Phaseolus vulgaris* AND *Vigna um - bellata*

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**ABSTRACT**

A comparative study on the proximate composition, functional properties and sensory properties of Christmas lima beans (*Phaseolus lunatus*), red kidney beans (*Phaseolus vulgaris*) and small red beans also known as rice bean (*Vigna umbellata*) were studied. Wholesome Christmas lima beans, red kidney beans and small red beans were sorted to remove dirt and contaminants. Each bean sample was then milled to fine flour to get undehulled flour. The flour samples were divided into two portions. One portion of each sample was allowed to stay as it was and the second portions of each flour sample were sieved with a mesh size 60mm sifter to separate the hulls from the flours. The resultant flours were evaluated for proximate, functional and sensory properties using standard analytical methods. The observed values were compared statistically. The result showed that the dehulled flours performed better in protein content than the undehulled form with the small red beans (SRB) scoring the highest, 25.17%, which is significantly different (p> 0.05) from the dehulled red kidney beans (DRKB), 22.92% while the least value was recorded for dehulled Christmas lima beans (DCLB), 19.83%. The undehulled form of each of the beans flour samples scored higher than the dehulled bean flour in swelling index, water absorption and oil absorption while the dehulled flour were better in gelation and not significantly different in bulk density, viscosity and pH. On the overall assessment of the cooked paste, the steamed bean cake from Christmas lima beans (CLB) and the vegetable salad prepared with the seed of Christmas lima beans were preferred by the panelists.

Keywords: Proximate, Functional properties, Christmas lima beans, red kidney beans and Rice bean
1.0 Introduction

In Nigeria, a lot of underexploited plant food crops with promising nutritional potentials exist. Lima bean is one of the underexploited food crops with nutritional and food industry processing potentials. Lima bean is among the lesser known legumes in the eastern part of Nigeria. The food crop is one of the traditional staples although in the most recent decades has been neglected. However, the neglect is attributed to difficulties in production, processing, preparation, utilization and negative image attached to it as “poor man’s food”. Lima bean has longer cooking time, especially as compared with other legumes. This longer cooking time phenomenon is a particular drawback for its cultivation and food use. It is imperative to investigate the positive attributes of this important food legume especially its nutrient potentials and overall acceptability.

Christmas lima bean (*Phaseolus lunatus*) is a leguminous plant named after the city Lima, the capital and largest city of Peru, where it was discovered by Europe explorers. It belongs to the family fabaceae and it is believed to have originated in South America around 2000BC (Akroyd and doughty, 1981). It is commonly known as lima bean, sieve bean, or butter bean. It is a long duration crop which is retained in the field for at least 9 months. Lima bean seeds are generally brown in colour although certain varieties have colour such as white, red, purple and black. Christmas lima beans have not received much popularity and acceptance, although most of them are widely distributed and with high yields. These neglected pulses of tropical origin have attracted research interest in recent times due to their nutrient contents as compared to the major legumes (Eke, 2002).

Red kidney beans (*Phaseolus vulgaris*) have greatest popularity in the U.S.A, as well as play long been a part of traditional plant based diet in many cultures of most of the world’s developing countries (Shimelis and Rakshit, 2007). It is the most important economic variety of the genus *Phaseolus*. It is an excellent source of vegetable protein, starch, soluble and insoluble fiber, vitamins (especially B group) and minerals (particularly potassium, iron, zinc, magnesium and manganese). They are low in fat (Ekanyakae *et al.*, 1999). The cooked beans are widely used in savory cuisine throughout the world in meals like casseroles, salads, curine soups, pasta and meat dishes. The straws are used as fodders for animals (Katharine, 2002). Red kidney beans have been associated with numerous health benefits including reduction of heart and renal
diseases risks (Bazzano, 2003), cataracts, relieve constipation, improve gastrointestinal integrity, stabilize blood sugar, brain and immune dysfunction.

Rice beans (*Vigna umbellata*) are small, oval-shaped beans with red skin. They are similar to red kidney beans except that they are smaller in size and also have a more delicate flavor than the red kidney beans. Small red beans are also called Mexican red beans. They hold their shape and firmness when cooked. They are particularly popular in the Caribbean region, where they are normally eaten with rice. Rice beans can be used in soups, salads, chilli and Creole dishes.

Generally, developing countries do not produce enough foods which have the right nutritional quality to meet daily needs. Therefore there is a great need to search for more nutritionally good food in order to ensure that all the potentials sources of foods are exploited effectively and utilized industrially as food supplement which will meet up consumer acceptability. Hence the objective of this research work is to compare the proximate composition and functional properties of underutilized Leguminous seed flours (Christmas Lima and Rice bean) with that of Red kidney with the intention of using them as foods of plant source to overcome the acute food shortage of animal protein as encountered in under developing countries.

2.0 Materials And Method

2.1 Source and preparation of samples

The Christmas Lima beans (*Phaseolus lunatus*) used in this research was gotten from Nempi in Oru – West Local Government Area in Imo state, Nigeria. The red kidney beans (*Phaseolus vulgaris*) and rice beans (*Vigna umbellata*) also used for this research were bought from Relief Market Owerri in Imo state, Nigeria. The method described by Onwuka (2005) was employed. First the bean seeds were sorted manually to remove extraneous materials like dirt, residue, shriveled and diseased seeds. The healthy bean seeds were then used. The flour used for this study was gotten from the whole seeds, grinded without dehulling. It was then divided into two equal portions, with one portion sieved to a particle size of 1mm to separate the hulls from the flour. This method was done for the three legumes – Christmas lima beans, red kidney beans and rice beans.

2.2 Determination of Proximate Composition

This was carried out by a method adopted by association of official analytical chemists (AOAC, 2010). The procedure is for moisture, crude protein, crude fiber, ash, fat content and carbohydrate. The protein content was determined using micro kjeldhal method (N x 6.25) and
the carbohydrate was calculated by difference. The analysis was carried out on both flour sieved and not sieved gotten from Christmas lima beans, red kidney beans and rice beans respectively and results obtained was triplicated and the average taken.

Fig 2.1: Flow diagram for the production of dehulled and undehulled flour from beans sample

2.3 Determination of Functional Properties

The bulk density was determined using the method of AOAC (1984) modified by Onwuka (2005). The pH of the sample was measured by inserting the electrodes into the suspension. The result was recorded from a digital display and this was done with a martini (mi-151) pH meter.
For Oil and Water absorption capacities One gram of sample was mixed with 10ml refined soybean oil (Executive Cheff, Nigeria; density 0.916g/mL) or distilled water in a weighed 20mL centrifuge tube. The slurry was agitated on a Vortex mixer for 2 minutes, allowed to stand at 28°C for 30 minutes and then centrifuged at 500xg for 30 minutes. The clear supernatant was decanted and discarded. The adhering drops of oil or water were removed and the tube was weighed. The weight of oil or water absorbed by 1g of flour of protein was calculated and expressed as oil or water absorption capacity. The measurement of viscosity of extracted sample was carried out using method done by Ajani et al., (2012). 10 grams of the sample was dissolved 100ml of distilled water. The mixture was agitated vigorously for 15 minutes using a stirrer to homogenise the mixture. The viscosity of the sample was measured using a viscometer. The gelation and boiling point temperature was determined according to the method of Narayan and Rao, (1982). And determination of swelling index by Ukpabi and Ndimele (1990) was applied.

2.4 Preparation of Products
The products developed from the Christmas lima beans, red kidney beans and small red beans were Moin-Moin (gotten from the flours) and vegetable salad (produced using the beans grains). The products were used for the organoleptic properties of the food.

2.4.1 Moin-Moin Ingredients
Moin-Moin Ingredients are 250g flour, 40g onions, 10g crayfish (ground), 2g pepper, tartarshi, 3 dessert spoon vegetable oil, 200ml water (warm water), 2 cubes of magi, salt to taste and 200ml meat broth.

2.4.1.1 Method of Preparing Moin-Moin
The method used for this production was done as described by Obiakor (2007). The flours gotten from the Christmas lima beans, red kidney beans and small red beans (rice beans) were used to prepare moin-moin. Two hundred and fifty grams (250g) of flour was mixed with warm meat broth in a bowl. Food ingredients (onions, crayfish, tartarshi, maggi, vegetable oil and salt) were blended into the mixture and stirred thoroughly. The mixtures were dispensed into wrapping foil and steamed for 60 minutes. This was done for each variety of flour. The moin-moin was kept in a food flask for evaluation.
2.4.2 Vegetable salad ingredients

Vegetable salad ingredients are 100g of Cabbage, 20g of Green beans, 30g of Carrots, One can of Sweet corn, 3 pieces of Green pepper, 2 pieces of cucumber, one bottle of Mayonnaise, cooked Christmas lima beans, red kidney beans and small red beans and rice beans.

![Diagram of Moi moi production process](image-url)

Fig 2.4: Flow diagram for the production of Moin- moin using the different bean flours.

2.4.2.1 Method of preparing Vegetable salad

The vegetables were washed thoroughly and allowed to drain water. Each of them was sliced to a proportionate size. After that, the cabbage and green beans were blanched for 5 minutes at 60°C.
Each of the beans was cooked until soft. Then, they were mixed together in a clean flask and a little mayonnaise added to it during the sensory evaluation.

2.5 Sensory Evaluation

Sensory evaluation was carried out using a 10- man untrained panelist to access the organoleptic attributes of the prepared samples. The organoleptic attributes assessed were; taste, texture, aroma, appearance and general acceptability. The panelists were selected randomly from the students of Federal University of Technology Owerri. The sensory evaluation was conducted using a 9 – point hedonic scale as described by (Ihekoronye and Ngoddy, 1985), where the scoring scale range from 9 = liked extremely and to 1 = disliked extremely.

2.6 Statistical Analysis

Data collected were subjected to analysis of variance (ANOVA). The mean scores obtained from the proximate composition, functional properties and sensory evaluation were tested for significant difference. The fisher’s least significant difference (LSD) test was used to separate means with significant differences at p> 0.05.

3.0 Result and Discussion

3.1 Proximate Composition

3.1.1 Moisture Content

The dehulled small red beans (DSRB) had the highest mean moisture content of 4.02% while the red kidney beans (RKB) had the least mean moisture content of 1.06% (Table 3.1). The mean moisture content (3.06%) of dehulled Christmas lima beans (DCLB) is significantly higher than the mean moisture content (2.00%) of Christmas lima beans (CLB). The result is in agreement with the research investigation of Rahma (2000) who reported values of 4% to 13% moisture for lima beans after dehulling. The low mean moisture content (2.00%) for undehulled Christmas lima beans and (3.06%) for dehulled Christmas lima beans (DCLB) is desirable because it will have a longer shelf life and would be less susceptible to deterioration and spoilage due to the action of mold and other microorganism which thrives well at higher moisture contents.(Singh, et al.,2005). The mean moisture content (2.00%) for undehulled christams lima beans (CLB) and (3.06%) for dehulled Christmas lima beans (DCLB) is higher when compared to the mean moisture content (1.06%) for undehulled red kidney beans (RKB).The dehulled form of all the
beans had higher mean value than their undehulled counterparts. This can be attributed to the fact that the dehulled form of flour could have absorbed water with time due to the increasing number of cells within the seed becoming hydrated (Nonogaki et al., 2010).

### 3.1.2 Protein Content

The mean protein content of the different bean flours studied in this work ranged from 25.17% for dehulled small red beans (DSRB) to 19.83% for dehulled Christmas lima beans (DCLB) and is significantly different at (p < 0.05). (Table 3.1) The mean protein content (19.83%) of dehulled Christmas lima beans is lower than the protein mean content (21.20%) of undehulled Christmas lima bean (CLB) which is in agreement with Youssef et al (2001) who showed that dehulling Faba beans decreased the protein content by 3.2%. This could be due to the various distribution of protein within various legumes as some legume proteins can be distributed in the hulls, endosperm or bran. However in the case of small red beans (SRB) and red kidney beans (RKB), dehulling increases the protein content from 22.46% (SRB) to 25.17% (DSRB), and 22.92% (RKB) to 20.31% (DRKB) which agree with the result of Ene-obong and obizoba (1996) that dehulling increased the protein content of jack beans by 2.3%, and this might be because the bean seeds (RKB and SRB) from which the flours were made are possibly from same or related geographical locations since soils with high nitrogen levels greatly influence protein levels (Brown,1999). The mean protein content (21.20%) of Christmas lima beans (CLB) compared favourably with those of other legumes reported by Arawande and Borokini (2010) who reported 24.13% (cowpea), 24.46% (pigeon pea) and 26.20% (jack bean).

### 3.1.3 Fat Content

The mean fat content ranged from 1.00% to 2.013% with the legumes flour significantly different from each other at (p < 0.05). The mean fat content (1.51%) of undehulled Christmas lima beans (CLB) is higher than the mean fat content (1.00) of dehulled Christmas lima beans (DCLB). This shows that dehulling reduces the fat content of Christmas lima beans. This can be attributed to the leaching out of the fat or oil molecules from the cotyledons during dehulling (Ihediohamma et al., 2014). The dehulled Christmas lima beans (DCLB) had the lowest mean value of 1.00% which agrees with the values of 1.05% reported by Onyeike et al, (1995). Christmas lima bean is not an oil bearing seed, as a result, it contains quite little fat. However dehulling increases the fat content of Small red beans (SRB) from 1.41% to 2.013% (DSRB).
which agrees with the work of Deshpande et al., (2002) that dehulling increases the fat content from 1.43% to 2.00% for small red beans. Fat plays a significant role in the shelf-life of food products and as such relatively high fat content could be undesirable in processed food products (Weiss, 2000; Potter and Hotchkiss, 2006; and Ajani et. al., 2012). This is because fat can promote rancidity in foods, leading to development of unpleasant and odorous compounds (Ajani et. al., 2012).

3.1.4 Ash Content
The mean ash content gotten from this study ranged from 6.00% for dehulled small red beans (DSRB) to 3.00% for both undehulled Christmas lima beans (CLB) and dehulled Christmas lima beans (DCLB) which shows that they are significantly different (p< 0.05) from each other while the mean ash content (5.01%) of undehulled small red beans and (5.00%) for undehulld red kidney beans (RKB) are not significantly different from each other at (p > 0.05). Ash is the inorganic residue remaining, after the water and organic matter have been removed by heating in the presence of oxidizing agent. The ash content is the measure of the total amount of minerals within a food (Manders, 2005). The mean ash content (5.49%) of dehulled red kidney beans (DRKB) and (6.00%) for dehulled small red beans shows that dehulling increased the ash content of the sample, which implies that undehulled red kidney beans (RKB) and undehulled small red beans (SRB) could be an important source of minerals than undehulled Christmas lima beans (CLB) used for this work, though unfortunately, researches have shown that high ash content could also be an Indication of adulteration (Bazzano et al., 2003). Adulteration is the contamination of food products due to inorganic substances present in the food being analysed.

3.1.5 Crude Fibre
The mean crude fibre content of the different bean samples analysed in this research were significantly different at (p< 0.05) from each other with dehulled red kidney beans (DRKB) having the highest mean crude fibre content of 6.99% and undehulled Christmas lima bean (CLB) having the least mean value of 4.20%. This is in contrast to what Obiakor, (2009) reported that Christmas lima beans is high in fibre (4.98%) and this could be as a result of the dehulling process which removed most of the hulls from the seeds, hence reducing its fibre content to 3.71% (DCLB) However, dehulling increased the fibre content of both small red beans and red kidney beans to 6.49 and 6.99 respectively and this agrees with the research done by
Arawande and Borokini (2010) that dehulling increases the crude fibre content of legumes (jack beans).

3.1.6 Carbohydrates
The mean carbohydrate content of the different legumes flours ranged from 56.28% to 68.88% and they were significantly different (p< 0.05) from each other. The mean carbohydrate content (68.57%) of undehulled Christmas lima beans (CLB) is not significantly different from the mean carbohydrate content (68.88%) of dehulled Christmas lima beans shows that dehulling had no significant difference to (CLB) undehulled Christmas lima beans when compared to the other bean flour samples analyzed. This was in line with the work of Oluwole and Olayinka (2011) who reported that different form of dehulling had no effect on the carbohydrate content of black beans. DCLB had the highest mean value for carbohydrates of 68.88% and the lowest was DSRB (56.28%). From here, we can see that dehulling significantly increased the carbohydrate content of the CLB and also significantly reduced the carbohydrate content of the other two legumes – SRB and RKB. Although they are all good sources of carbohydrates, Christmas lima beans will be more preferred for energy giving food.

3.2.0 Functional Properties
3.2.1 Bulk Density
The bulk density values (table 3.2) which ranged from 0.63g/cm$^3$ for DRKB to 0.67g/cm$^3$ for RKB were not significantly different (p<0.05). Bulk density values for bean flours were somewhat similar to that of all-purpose wheat flour with a value of 0.62g/cm$^3$ (Siddiq et al., 2009). Tasha and Ibrahim (2002) stated that bulk density, BD (stated as g/m or g/cm$^3$) is an important factor since it helps in choosing the appropriate packaging units. Higher bulk densities are desirable since it helps to reduce paste thickness. Bulk density of the bean flour samples could be used to determine their handling requirement, because it is the function of mass and volume (Oluwatoyin,.and Osundahunsi, 2002).Bulk is also important in infant feeding where less bulk is desirable. Since DRKB (0.63g/cm$^3$) showed the least bulk density, it can be clearly stated that it would occupy greater space and therefore would require more packaging material per unit weight and so could have high packaging cost (Shittu and Taniumu, 2012).The low bulk density DRKB of could be an advantage in its use for preparation of complementary foods.
Table 3.1: Proximate composition of different legume flours

<table>
<thead>
<tr>
<th>Sample</th>
<th>Moisture</th>
<th>Fibre</th>
<th>Fat</th>
<th>Protein</th>
<th>Carbohydrate</th>
<th>Ash</th>
</tr>
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<tr>
<td></td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>CLB</td>
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<td>4.20</td>
<td>±0.01</td>
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<td></td>
<td>±0.10</td>
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<td></td>
<td>21.20</td>
<td>±0.25</td>
<td>68.51</td>
<td>±0.11</td>
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<td>±0.09</td>
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<td>SRB</td>
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<td>±0.01</td>
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<td></td>
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<td>±0.13</td>
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<td></td>
<td>19.83</td>
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<td>58.57</td>
<td>±0.63</td>
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<td>0.000291</td>
<td>0.00138</td>
<td>0.0297</td>
<td>0.0002</td>
</tr>
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</table>

Values represent the means ± standard deviations of triplicate sample. Mean values carrying the same letters along the columns are not significantly (p>0.05) different.

Key:
CLB = Christmas lima beans  SRB = Small red beans  RKB = Red kidney beans
DCLB = Dehulled Christmas lima beans  DSRB = Dehulled small red beans.
DRKB = Dehulled red kidney beans  LSD = least significant difference.

3.2.2 Water Absorption
The different legume flours had a water absorption capacity ranging from 1.85% to 2.87%. RKB had the highest water absorption capacity of 2.87% while small red beans had the least water absorption capacity of 1.94%. This is significantly different (p < 0.05) from other flour samples. Dehulling increases the water absorption capacity of the samples as can be seen in the case of RKB form 2.60% to 2.87% in the DRKB. This may be due to increase proportions of proteins which was in line with the research established by Obiakor (2009) where different treatments
increases the water absorption capacity of the beans. DCLB had lower water absorption capacity of 2.01% when compared to CLB (2.01%), which can be attributed to the fact that there is less availability of polar amino acids (Kuntz and Irwin, 2007). Water absorption capacity represents the ability of the products to associate with water under conditions when water is limiting such as dough and pastas (Onweluzo et al., 1995). The result of this work suggested that dehulling reduced the ability of CLB in production of foods such as bakery products which require hydration to improve handling features (Anonymous, 2008).

3.2.3 Oil Absorption

Oil absorption capacity is attributed mainly to the physical entrapment of oils. It is an indication of the rate at which protein builds to fat in food formulation. From table 3.2, it could be seen that the oil absorption of the different beans ranged from 1.62% for DRKB to 2.85% for CLB. They were slightly different from each other at p < 0.05. CLB had the highest mean value of 2.85% but dehulling reduced it to 1.71% (DCLB). This may be due to presence of large proportion of hydrophilic group and polar amino acid on the surface of the protein molecules (Kuntz and Irwin 2007; Adeleke and Odedeji.2010). SRB had a lower oil absorption capacity of 1.73% when compared to RKB (1.84%) and CLB (2.85%) higher than RKB (1.84%). This ability of protein to bind fat is very important in food formulations. This is because fat acts as a flavour retainer and increase the mouthfeel of foods. (Roday, 2007).

3.2.4 Viscosity

For all bean flours, an increasing apparent viscosity trend was observed with increasing solids content in the dispersion, the highest viscosity (11.3 Pa.s) was recorded for red kidney beans flour dispersion at 30g/100ml while dehulled Christmas lima beans (DCLB) had the least apparent viscosity at all levels tested. The particle size distributions can influence the viscosity of the dispersion, small particle six samples dispersion tend to be more uniform and offer higher resistance due to the inter particle friction resulting in high viscosity of the dispersion. Solubility is another critical factor, which also influences the viscosity of the dispersion (Ravi and Sushelamma, 2005). Another possible reason might be the starch granules absorb water and the amount absorbed depends upon the condition of the granules as damaged granules absorb higher amounts of water than do the native granules.
3.2.5 Swelling Index

The swelling index of the legume range from 4.90m/m to 6.20m/m. the result indicated that there was significant difference (p < 0.05) except for RKB (5.03m/m) and DCLB (5.16m/m), which was not significantly different from each other at(p > 0.05). The swelling index is the measure of the ability of starch to imbibe water (Ikegwu et al., 2009). Dehulling had no significant difference on their swelling index except for DCLB which had 5.16m/m lower than CLB (6.20m/m). This could be attributed to the extent of starch damage due to thermal and mechanical processes. According to Ezema, (1989), the extent of swelling in the presence of water depends on the temperature, water availability, starch species, extent of starch damage and other carbohydrates and proteins (Sui, et al., 2006).According to Sui, et al., (2006), increase in water absorption capacity increases the swelling power leading to an improved solubility. The high swelling index of CLB suggests that it could be useful in food systems where swelling is required.

3.2.6 Gelation Capacity

The gelation capacity of different legumes ranged from 81.33°C to 94.67°C. They were significantly different from each other except for SRB (92.0°C) and RKB (90.66°C) which are not significantly different from each other at (p> 0.05). Both SRB (92.0°C) and DSRB (94.67°C) had the highest mean value when compared to RKB (90.66°C). According to Schmidt (1981) gelation may be defined as a protein aggregation phenomenon in which polymer–polymer and polymer-solvent interactions and attractive and repulsive forces are so balanced that a tertiary network or matrix is formed. Such a matrix is capable of immobilizing or trapping large amounts of water. Factors that affect gelation properties include protein concentration, other protein components, pH, ionic and reducing agents, and heat treatment conditions. Dehulling increased the gelation capacity of SRB (92.00°C) to DSRB (94.67°C). Improved gelling abilities as a result of dehulling may be attributed to the higher protein content of the dehulled flours and removal of the seed coat fractions (Deshpande, et al 2002). The values of the different gelation capacity of legume flours agreed with the report of Arawande and Borokini (2010) on jack beans and cowpea flours. These legumes have good gelating ability of protein ingredient but the gelation capacity of CLB and SRB are better than that of RKB flours.
3.2.7 pH
The pH of the different legumes flours ranged from 6.70 to 6.78 which is not significantly different from each other. This shows that the legume flours are in the alkaline state. This is good for those suffering from cancer and other heart diseases, as the beans are not acidic and can help in the prevention of cancer and other cancerous diseases (Bazzano, 2001).
Table 3.2 Functional properties of the different legume flours

<table>
<thead>
<tr>
<th>SAMPLES</th>
<th>Bulk density (g/cm³)</th>
<th>Swelling index (m/m)</th>
<th>Gelation capacity (ºC)</th>
<th>Water absorption (%)</th>
<th>Oil absorption (%)</th>
<th>Viscosity (pa.s)</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLB</td>
<td>0.67±0.28</td>
<td>6.20±0.10</td>
<td>83.33c±1.52</td>
<td>2.16c±0.10</td>
<td>2.85d±0.005</td>
<td>8.96b±0.5</td>
<td>6.78a±0.13</td>
</tr>
<tr>
<td>SRB</td>
<td>0.66±0.40</td>
<td>4.90±0.10</td>
<td>92.00ab±2.64</td>
<td>1.94c±0.10</td>
<td>1.73a±0.005</td>
<td>11.00a±0.20</td>
<td>6.70a±0.02</td>
</tr>
<tr>
<td>RKB</td>
<td>0.67±0.40</td>
<td>5.03b±0.57</td>
<td>90.66b±1.15</td>
<td>2.60b±0.005</td>
<td>1.84b±0.005</td>
<td>11.13a±0.50</td>
<td>6.70a±0.07</td>
</tr>
<tr>
<td>DCLB</td>
<td>0.66±0.40</td>
<td>5.16b±0.57</td>
<td>86.00c±2.00</td>
<td>2.01d±0.11</td>
<td>1.71c±0.10</td>
<td>7.70f±0.81</td>
<td>6.73a±0.02</td>
</tr>
<tr>
<td>DSRB</td>
<td>0.67±0.28</td>
<td>4.90c±0.10</td>
<td>94.67d±1.52</td>
<td>1.85f±0.005</td>
<td>1.80c±0.005</td>
<td>10.43a±9.92</td>
<td>6.72a±0.02</td>
</tr>
<tr>
<td>DRKB</td>
<td>0.63±0.00</td>
<td>5.00c±0.00</td>
<td>81.33d±1.52</td>
<td>2.87a±0.005</td>
<td>1.62f±0.00</td>
<td>10.30a±0.57</td>
<td>6.70a±0.011</td>
</tr>
<tr>
<td>LSD</td>
<td>0.001816</td>
<td>0.021</td>
<td>5.083</td>
<td>7.26</td>
<td>7.262</td>
<td>1.881042</td>
<td>0.001162</td>
</tr>
</tbody>
</table>

Values represent the means ± standard deviations of triplicate sample. Mean values carrying the same letters along the columns are not significantly (p>0.05) different.

Key:
CLB = Christmas Lima beans  
SRB = Small red beans  
RKB = Red kidney beans  
DCLB = Dehulled Christmas Lima beans  
DSRB = Dehulled small red beans  
DRKB = Dehulled red kidney beans
3.3.0 Sensory Evaluation

3.3.1 Sensory Evaluation of Moin - Moin Produced From Different Legume Flours

Table 3.3, shows the mean sensory and physical quality of moin - moin samples prepared from the flours of Christmas lima bean. Red kidney beans and small red beans respectively. The sensory scores on the 9 – point hedonic scale ranged from 5.00 to 6.00 for aroma, 3.50 to 4.70 for taste, 3.40 to 4.00 for appearance, 3.40 to 5.50 for texture and 3.40 to 4.60 for general acceptability. (Table 3.3)

For aroma, moin-moin produced from CLB flour had the highest mean value of 6.00 and the least mean value of 5.00 (RKB). This can be attributed to the fact that RKB has less protein of 20.31% than that of Christmas lima beans 21.20%. The aroma values were not significantly different at (p < 0.05) for the different legume seeds.

The moin-moin produced with the flour of RKB had the least mean value of 3.50 and CLB had the highest value of 4.70 for taste. This means that the panelist preferred the taste of moin-moin produced from CLB to RKB although they are not significantly different at p < 0.05.

The appearance mean values ranged from 3.40 to 4.00 with RKB having the least mean value of 3.40 and CLB and SRB having the same highest mean value for appearance (4.00). This could be attributed to the dark colour of red kidney beans as a result of the red pigmentation of the beans that affected its colour.

The texture values of the moin - moin ranged from 3.40 to 5.50 with RKB having the lowest mean value and CLB having the highest mean value. The low texture of red kidney beans can be attributed to its low water absorption and gelation capacity making it unable to form paste and gel properly. The moin - moin produced from CLB had the overall acceptability among the three different legume bean flours. Although they are not significantly different (p < 0.05) hence they can be substituted for each other in the market and by the consumer if either of them is preferred by such consumer. Although generally RKB have the lowest mean value and can face outright rejection from the consumer.
Table 3.3 Sensory evaluation of Moin – Moin produced with the different legume flours

<table>
<thead>
<tr>
<th>Samples</th>
<th>Aroma</th>
<th>Taste</th>
<th>Appearance</th>
<th>Texture</th>
<th>Overall Acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLB</td>
<td>6.00^a±1.49</td>
<td>4.70^a±1.25</td>
<td>4.00^a±0.81</td>
<td>5.50^a±1.95</td>
<td>4.60^a±0.96</td>
</tr>
<tr>
<td>RKB</td>
<td>5.00^a±1.24</td>
<td>3.50^a±1.50</td>
<td>3.40^a±1.34</td>
<td>3.40^ab±1.71</td>
<td>3.40^a±1.50</td>
</tr>
<tr>
<td>SRB</td>
<td>5.60^a±1.42</td>
<td>4.40^a±1.50</td>
<td>4.00^a±1.33</td>
<td>4.40^a±2.06</td>
<td>4.20^a±1.31</td>
</tr>
<tr>
<td>LSD</td>
<td>4.8596</td>
<td>3.214</td>
<td>1.367</td>
<td>7.863</td>
<td>1.915</td>
</tr>
</tbody>
</table>

Values represent the means ± standard deviations of triplicate sample. Mean values carrying the same letters along the columns are not significantly (p>0.05) different.

**Key:**
- CLB = Christmas lima beans
- SRB = Small red beans
- RKB = Red kidney beans
- DCLB = Dehulled Christmas lima beans
- DSRB = Dehulled small red beans.
- DRKB = Dehulled red kidney beans
- LSD = least significant difference.

### 3.3.2 Sensory Evaluation of Vegetable Salad Produced From Different Bean Seeds

Table 3.4, shows the mean sensory and physical quality of vegetable salad samples prepared from Christmas lima bean (CLB), Red kidney beans (RKB) and small red beans (SRB) respectively. The mean sensory scores on the 9 – point hedonic scale ranged from 6.60 to 7.40 for aroma, 5.10 to 6.10 for taste, 6.20 to 6.90 for appearance, 5.60 to 6.40 for texture and 5.30 to 6.40 for overall acceptability (Table 3.4).

The vegetable salad produced with SRB was the most generally accepted among the three different legume bean flours, followed by that produced with CLB. Although they are not significantly different (p < 0.05) hence they can be substituted for each other in the market and by the consumer if either of them is preferred by such consumer.

Table 3.4 Sensory evaluation of vegetable salad produced with different bean seeds
### Samples

<table>
<thead>
<tr>
<th>Samples</th>
<th>Aroma</th>
<th>Appearance</th>
<th>Taste</th>
<th>overall acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLB</td>
<td>7.40±0.69</td>
<td>6.90±1.28</td>
<td>6.00±2.10</td>
<td>6.20±1.87</td>
</tr>
<tr>
<td>RKB</td>
<td>6.70±1.05</td>
<td>6.20±1.47</td>
<td>5.10±1.52</td>
<td>5.30±1.76</td>
</tr>
<tr>
<td>SRB</td>
<td>6.60±1.26</td>
<td>6.80±1.75</td>
<td>6.10±2.28</td>
<td>6.30±1.70</td>
</tr>
<tr>
<td>LSD</td>
<td>1.003</td>
<td>3.39</td>
<td>6.4062</td>
<td>7.204</td>
</tr>
</tbody>
</table>

Values represent the means ± standard deviations of triplicate sample. Mean values carrying the same letters along the columns are not significantly (p>0.05) different.

**Key:**

CLB = Christmas lima beans  
SRB = Small red beans  
RKB = Red kidney beans  
DCLB = Dehulled Christmas lima beans  
DSRB = Dehulled small red beans.  
DRKB = Dehulled red kidney beans  
LSD = least significant difference.

### 4.0 Conclusion

This work has provided a base line information on lima bean availability, consumption, as well as the chemical, functional, and sensory properties of its flour and products. Christmas Lima bean is one of the under-exploited food crops that has high nutrient potentials. It is one of the legumes that have been neglected in the recent decades due to difficulties in its production, processing, preparation and utilization. It is clear now that Christmas lima bean could substantially improve the nutritional needs of a population. Both urban and rural populations, especially the low income groups would benefit from nutrient potentials of Christmas lima bean, particularly at times of seasonal scarcity of staple crops. Christmas Lima bean is rich in both macro and micro-nutrients. Despite its high nutritional quality, lima bean contains various anti-nutrients and food toxicants that militate against its full nutrient bioavailability, and increases its cooking time.
Moin-moin, and vegetable salad produced from Christmas lima bean flours and the bean seeds had high nutrient profile and desirable organoleptic attributes. It offers opportunity for increased use of neglected and under-exploited legumes in Nigeria ecosystem.

REFERENCES


