Evaluation of the Phytochemical Composition and Pasting Characteristics of African Locust Bean Pulp Flour, Wheat Flour and Blends

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Authors’ contributions
This work was carried out in collaboration between all authors. Author PIA designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors JOO and COO managed the analyses of the study. Author COO managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aim: The study determined the phytochemical composition and pasting properties of locust bean pulp, wheat flour and the blends.
Study Design: The experiments in carried out in three replications in completely randomized design. The data were analyzed were analyzed by analysis of variance. Significance was accepted at p<0.05.
Place and Duration of the Study: The study was carried in 2016 at The Federal Polytechnic, Idah, Nigeria.
Methodology: Flour was prepared from locust bean pulp and used to substitute 10, 20, 30, 40, 50, 60, 70, 80 and 90% wheat flour. The phytochemical composition and pasting properties of the locust bean pulp flour and wheat flour were determined. The pasting properties of the blends were also assessed.

*Corresponding author: E-mail: akuborpeter@gmail.com;
et al. Wheat flour had significantly higher –
-ter. This drink is widely consumed as
This association
1 0g oxalates and 0.05 mg/100g hydrogen cyanide.
ncer, 2.0 mg/100g phytates, 1.0
-
-nd 0.09 mg/100g hydrogen cyanide.
trough viscosity, breakdown viscosity and setback viscosity of locust
Raw Materials
The locust bean pulp flour had higher amounts of flavonoids, carotenoids, tannins,
kaloids, 0.8 mg/100g glycosides
pasting;
is usually washed away
The pasting temperatur
Source of
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and vitamin C in the
es of locust bean pulp flour and wheat flour were
1 Dawadawa
Parkia biglobosa
It took
phytochemicals;
iru.
wheat
bean pulp
Blends
-
-or
locust
and alkaloids but lower pasting properties than wheat flour. Based on the pasting
,6
relation between maximum
Parkia
flour.
The study showed that locust bean pulp flour has potent
baked food products.
properties, the locust bean pulp flour and wheat flour blends would find applications in various
baked food products.

Keywords: Blends; locust bean pulp; pasting; phytochemicals; wheat flour.

1. INTRODUCTION

In Nigeria, African locust bean (Parkia biglobosa) tree grows widely throughout the savanna. The
tree produces about 25-52 kg of pods [1]. A mature pod contains yellow, dry and powdery
pulp in which dark brown seeds are embedded. The pulp is licked for its sweet taste but only to a
small extent. The pulp is usually washed away when the seeds are processed into condiment
called dawadawa or iru. Dawadawa is a source of protein intake among the low income groups
and rural populations of West Africa [2]. While the seed has been extensively studied [2], little
has been done on the utilization of the pulp. In West Africa, the pulp is prepared as flour and
used in soups and stews or eaten with cereals as porridge [1]. A traditional drink is prepared from
the fruit by infusing the dried ground fruit pulp in hot water. This drink is widely consumed as
health tonic and is valued for its many medicinal properties [1,3]. Products processed from locust
bean pulp on experimental basis include jam and syrup [3,4].

Locust bean pulp is rich in dietary fiber, essential
phytochemical compounds. Fruits and
vegetables are major sources of dietary
antioxidants [9]. Thus, more foods rich in
phytochemicals are required from conventional
and new sources. This necessitates the need to
identify local sources of phytochemicals and
enhance their levels through food processing and
product development. The presence of
flavonoids, carotenoids, and vitamin C in the
locust bean pulp would exert health promoting
effect in addition to those of the dietary fiber
[7,10]. However, successful performance of
locust bean pulp flour in food systems would
depend on the functional characteristics imparted
to the final products. The chemical composition
and functional properties of locust bean pulp flour
were assessed recently by Akubor[6]. Pasting
characteristics of flours are related to their
functionalities in various food systems [11].
Strong positive correlation between maximum
viscosity and baking quality of flours was
reported [12]. The paste viscosity of noodle flour
was related to the noodle cooking quality [12].
The objective of the present study was to
determine the phytochemical composition and
pasting properties of locust bean pulp, wheat
flour and the blends.

2. MATERIALS AND METHODS

2.1 Source of Raw Materials

Mature and ripe African locust bean (Parkia
biglobosa) fruit pods were plucked from locust
bean trees in a local farm in Ugwaka –Ollah
Township, Kogi State, Nigeria. Commercial wheat flour was purchased from a local shop in Idah Township, sieved through 60 mesh sieve (0.05 mm) (British standard) and stored in high density polyethylene bag in a refrigerator prior (10°C) to use.

### 2.2 Preparation of Locust Bean Pulp Flour

Locust bean fruit pods were cleaned and split open manually. The yellow pulp along with the attached seeds were removed from the hulls, sun dried (48h) and pounded lightly in a mortar with pestle. The pulps were separated from the seeds, milled in a hammer mill and sieved through 60 mesh sieve (British standard).

### 2.3 Flour Blending

Wheat flour was used to substitute 10, 20, 30, 40, 50, 60, 70, 80 and 90% wheat flour in a food blender that was operated at full speed (1200 rpm) for 10 min. The flour blends were packed in high density polyethylene bags and stored in a refrigerator (10°C) prior to use.

### 2.4 Evaluation of Phytochemical Composition

The African locust bean pulp and wheat flour, respectively were evaluated for the phytochemical composition. The tannins, saponins and flavonoids contents were determined as described by Okwu [13]. The alkaloids and glycosides contents were determined as described by Onimawo & Akubor [14]. The carotenoids content was measured following the procedure given by Olayiwola et al. [15]. The oxalates, phytates and hydrogen cyanide contents were determined as described by Onwuka [16]. The determinations were carried out in three replications.

### 2.5 Evaluation of Pasting Characteristics

Rapid Visco Analyser (RVA) (Model RVA-3D +, Newport Scientific Pty Ltd, Sydney, Australia) was used to determine the pasting properties of the flours as described by Adebowale et al. [17]. Flour sample (2.5 g) was weighed into a dry empty canister containing 25 ml distilled water. The mixture was mixed thoroughly and the canister was then fitted into the RVA. The slurry was heated from 50 to 90°C with holding time of 2 min. This was followed by cooling to 50°C within 2 min holding time. Heating and cooling were carried out at constant rate of 11.25°C/min. Peak viscosity, trough viscosity, breakdown viscosity, final viscosity, set back viscosity, peak time and pasting temperature were read from the pasting profile with the aid of thermocline for windows software connected to a computer.

### 2.6 Statistical Analysis

Data were subjected to analysis of variance in completely randomized design using Statistical Package for Social Sciences (SPSS) software (version 15, 2007). Means where significantly different were separated by the least significant difference (LSD) test [18]. Significance was accepted at P < 0.05.

### 3. RESULTS AND DISCUSSION

#### 3.1 Phytochemical Composition

The phytochemical composition of African locust bean pulp flour and wheat flour are presented in Table 1. The locust bean pulp flour contained significantly higher (p<0.05) amount of flavonoids (3.39 mg/100g) than wheat flour (0.5 mg/100g). Phytochemical composition is reported to be influenced by type or variety of the plant, specie, environmental conditions as well as the type of soil, climate, post harvest conditions, fertilizer applied etc [8,10]. These factors probably explain the difference in the flavonoids contents of the flours studied. Flavonoids have antioxidant properties that play protective role in the development of cardiovascular diseases, atherosclerosis, hypertension, ischemia/reperfusion injury, diabetes mellitus, neurodegenerative diseases (Alzheimer’s disease and Parkinson’s disease), rheumatoid, arthritis and aging [14]. Two antioxidant structural features of flavonoids are the presence of beta ring catechol group and C2-C3 double bonds in conjugation with oxo group at C4. The first serves to donate hydrogen/electron to stabilize radical specie and the second serves to bind transition metal ions such as iron and copper [14]. The carotenoids contents of locust bean pulp flour and wheat flour were 8.72 mg/100g and 0.8 mg/100g, respectively. The high content of carotenoids in locust bean pulp flour suggests that consumption of locust bean pulp flour could provide some health benefits [14]. Carotenoids are powerful antioxidants which protect the cell by reacting with oxidizing factors and neutralizing their effects [14]. Carotenoids are effective in preventing cancer and other degenerative diseases [19]. The locust bean pulp flour (9.81 mg/100g) had higher level of tannins than wheat...
flour (1.0 mg/100g). Phenols such as tannins form insoluble complexes with proteins and reduce their digestibility and palatability when present in foods in high amount [20]. However, moderate levels of polyphenols play significant role in human nutrition. Phenolic compounds possess significant antioxidant activity [20] due to their ability to adsorb, neutralize and quench free radicals [15]). Their ability as free radical scavenger is attributed to their redox properties, the presence of conjugated ring structures and carboxylic group which are reported to inhibit lipid peroxidation [14]. Tannins hasten the healing of wounds and inflamed mucus membrane [20]. The binding of iron by tannins and phytate prevents them from generating free radicals and thus, have protective effect against cancer [14].

The levels of saponins in locust bean pulp flour and wheat flour were 8.92 and 0.8 mg/100g, respectively. Saponins possess health benefits which include antioxidative, anti inflammatory, anti-apoptosis, immune-stimulant properties [21]. Saponins inhibit growth of cancer cells and help to lower blood cholesterol [14]. They reduce uptake of glucose and cholesterol through intralumenal physicochemical interaction during food transition in the gut. This confers chemoprotection against heart diseases [14]. Hence, saponins are useful in the treatment of cardiovascular disease and other health problems [22]. The cholesterol lowering mechanism of saponins is that it binds cholesterol in the intestinal lumen, making it less readily reabsorbed. Saponins may also bind bile acid, causing reduction in its enterohepatic circulation and increasing its fecal extraction [23]. When there is increased bile acid excretion, synthesis of cholesterol in the liver is enhanced, thus, lowering plasma cholesterol [23]. Saponins boost energy and serve as natural antibiotics [22]. Humans generally, do not suffer severe poisoning from saponins [21]. The alkaloids content of locust bean pulp flour (2.92 mg/100g) was significantly higher (p<0.05) than that of wheat flour (0.5 mg/100g). The presence of alkaloids in locust bean pulp flour suggests its potential to promote health. Alkaloids possess analgesic, anti spasmodic and bactericidal properties [14]. The levels of alkaloids and flavonoids in locust bean pulp flour were within the safe margin of 52.02 mg/100g reported by WHO [8].

The glycoside and hydrogen cyanide(HCN) contents of locust bean pulp flour and wheat flour were low, values ranged from 0.7- 0.8 and 0.05-0.09 mg/100g, respectively. Hydrogen cyanide does not occur freely but combined with sugars to form non toxic compound known as cyanogenic glycoside. However, high level of HCN is known to inhibit the respiratory chain at the cytochrome oxidase level [14]. The levels of HCN in locust bean pulp flour and wheat flour were far below the toxic limit of 35 mg/100g [14]. Heat treatment is a reliable method of destroying many antinutritional factors in many foods [14].

The phytates contents of locust bean pulp flour (1.81 mg/100g) and wheat flour (2.00 mg/100g) were not significantly different (p<0.05). Phytates are considered antinutrients when available in large quantity (>3 g/100g [14] by virtue of their ability to chelate divalent metals and prevent their absorption. The structure of phytate has high density of negatively charged phosphate groups which can complex many mineral ions [24]. The complex ions are not availability for intestinal absorption [24]. Phytates have also been implicated in decreasing protein digestibility by forming complexes and also by interacting with enzymes such as trypsin and pepsin [24].

<table>
<thead>
<tr>
<th>Phytochemical (mg/100 g)</th>
<th>Locust bean pulp flour</th>
<th>Wheat flour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flavonoids (mg/100 g)</td>
<td>3.97± 0.2</td>
<td>0.5± 0.1</td>
</tr>
<tr>
<td>Carotenoids</td>
<td>8.72± 0.2</td>
<td>0.8± 0.5</td>
</tr>
<tr>
<td>Tannins</td>
<td>9.81± 0.6</td>
<td>1.0± 0.2</td>
</tr>
<tr>
<td>Saponins</td>
<td>8.92± 0.3</td>
<td>0.8± 0.2</td>
</tr>
<tr>
<td>Alkaloids</td>
<td>2.92± 0.5</td>
<td>0.5± 0.1</td>
</tr>
<tr>
<td>Glycosides</td>
<td>0.70± 0.4</td>
<td>0.8± 0.3</td>
</tr>
<tr>
<td>Phytates</td>
<td>1.81± 0.4</td>
<td>2.0± 0.9</td>
</tr>
<tr>
<td>Oxalates</td>
<td>0.88± 0.3</td>
<td>1.0± 0.1</td>
</tr>
<tr>
<td>Hydrocyanic acid(HCN)</td>
<td>0.7± 0.3</td>
<td>0.09± 0.2</td>
</tr>
</tbody>
</table>

Values are means ±SD of three replications. Means within a row with the same superscript are not significantly different (P>0.05)
However, at low levels as in locust bean pulp flour and wheat flour, phytates have anticancer and antioxidant activity [24]. It forms iron chelate that suppresses lipid oxidation by blocking iron driven hydroxyl radical generation [14].

The oxalates contents of locust bean pulp flour and wheat flour were 0.88 and 1.00 mg/100g, respectively. The oxalic acid content of food is used as an index of toxicity level of the food [15]. Dietary oxalate complexes Ca, Mg and Fe forming insoluble oxalate salts which cause oxalate stone [15]. However, oxalate at safe level (2-5 5g/100g) [7], confers antioxidant activity in both food and human. Oxalic acid chelates radical initiating divalent metals (Fe, Cu) thereby, reducing incidence of degenerative diseases in humans [24].

### 3.2 Pasting Properties

The pasting characteristics of African locust bean pulp flour, wheat flour and the blends are presented in Table 2. Wheat flour had significantly higher (P<0.05) peak viscosity (157.83 RVU) and final viscosity (179.33 RVU) than the locust bean pulp flour. The peak viscosity and final viscosity of locust bean pulp flour were -3017 and -2.75 RVU, respectively. The absence of gluten in locust bean pulp flour and its low starch content [25] may have contributed to its low peak viscosity and final viscosity. The peak viscosity and final viscosity decreased with increased level of locust bean pulp flour in the blends, probably due to the decrease in the levels of wheat starch and glutens [26]. Peak viscosity is reported to be closely associated with degree of starch damage with high starch damage giving high viscosity [27]. Wheat flour contained highly damaged starch while locust bean contained undamaged starch [14]. This explains why the peak viscosity was lowered by the addition of the locust bean pulp flour. The interaction of oil and protein in locust bean pulp flour with wheat flour starch probably lowered the peak viscosity of the blends [3]). Sanni et al. [12] reported restriction in swelling, solubilization and viscosity due to the presence of lipid and other non-carbohydrates in starch suspension. Peak viscosity is an important characteristic of starch granule and reflects the ability of starch to swell freely before physical breakdown [28]. Peak viscosity is the maximum viscosity developed during or after the heating stage. High peak viscosity correlates well with high swelling power which provides indication of the viscous load to be encountered during mixing of dough [29]. Final viscosity is useful in determining the ability of flour to form gel during processing [30]. The 100% locust bean pulp flour would not form good gel and thus, would not be useful in products requiring gelling and thickening. However, the high peak viscosity (107.23-230.48 RVU) and final viscosity (128.38-263.84 RVU) of the blends containing up to 40% locust bean pulp flour suggest that such blends would find applications in products requiring high gel strength and elasticity [17].

The trough viscosity of wheat flour was 92.42 RVU and increased from -3.67 RVU in the 100% locust bean pulp flour to 110.24 RVU for the blend containing 90% level of locust bean pulp. The trough viscosity of the blends decreased with the level of LBPF. Trough viscosity is the minimum viscosity value in the constant temperature phase of the RVA profile [31]. It measures the ability of gel to withstand break down during cooling [17]. The locust bean pulp flour had significantly (P<0.05) lower break down viscosity (0.50 RVU) than the wheat flour (65.42 RVU). The breakdown viscosity increased with the level of wheat flour in the blends. The low break down viscosity of locust bean pulp flour indicates that the starch possessed cross linking properties [14]. The decrease in dough stability may be due to the reduction in the level of wheat flour gluten protein in the blend [14]. This may also be due to interaction between fibrous materials and gluten, which was reported to adversely affect dough mixing properties [12, 27]. Less stability of starch paste after cooling is accompanied by high viscosity breakdown [27]. Adebowale et al. [17] showed that flour with high break down viscosity did not withstand heating and shear stress during cooking. Thus, the blends containing high amount of locust bean pulp flour have less potential to withstand heating and mechanical stirring.

The setback viscosity of wheat flour was 21.5 RVU and increased from 0.42 RVU in 100% locust bean pulp flour to 33.36 RVU for the blend containing 90% wheat flour. The set back viscosity increased with the level of wheat flour in the blends. Set back viscosity is the range of viscosity where retrogradation (re-ordering of starch molecules) occurs [14]. Low setback viscosity indicates greater resistance to retrogradation and products with low setback viscosity may have low staling rate [26,27]. Thus, products containing locust bean pulp flour/wheat flour blends would have higher resistance to staling than the 100% wheat flour.
Table 2. Pasting characteristics of African locust bean pulp flour (ALBPF), wheat flour (WF) and the blends

<table>
<thead>
<tr>
<th>ALBPF: WF</th>
<th>Pasting temp (°C)</th>
<th>Peak time (Min)</th>
<th>Peak viscosity (RVU)</th>
<th>Trough viscosity (RVU)</th>
<th>Break down viscosity (RVU)</th>
<th>Final viscosity (RVU)</th>
<th>Set back from peak viscosity (RVU)</th>
<th>Set back from trough viscosity (RVU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0:100</td>
<td>79.5a</td>
<td>6.2a</td>
<td>157.8a</td>
<td>92.4b</td>
<td>65.4a</td>
<td>179.3a</td>
<td>21.5b</td>
<td>86.9a</td>
</tr>
<tr>
<td>10:90</td>
<td>92.3b</td>
<td>6.1a</td>
<td>230.5b</td>
<td>110.24a</td>
<td>120.2a</td>
<td>263.8a</td>
<td>33.4a</td>
<td>153.6a</td>
</tr>
<tr>
<td>20:80</td>
<td>89.7c</td>
<td>6.1a</td>
<td>288.2c</td>
<td>108.75d</td>
<td>119.4d</td>
<td>260.8c</td>
<td>32.6c</td>
<td>158.0c</td>
</tr>
<tr>
<td>30:70</td>
<td>88.2d</td>
<td>6.0a</td>
<td>191.3e</td>
<td>80.6f</td>
<td>110.7g</td>
<td>214.2f</td>
<td>22.8g</td>
<td>133.3h</td>
</tr>
<tr>
<td>40:60</td>
<td>88.9e</td>
<td>5.8g</td>
<td>107.2h</td>
<td>53.7i</td>
<td>53.5k</td>
<td>128.4l</td>
<td>21.2m</td>
<td>74.7n</td>
</tr>
<tr>
<td>50:50</td>
<td>90.1f</td>
<td>5.5k</td>
<td>53.3l</td>
<td>30.0m</td>
<td>23.3n</td>
<td>70.7o</td>
<td>17.3p</td>
<td>40.7q</td>
</tr>
<tr>
<td>60:40</td>
<td>89.2g</td>
<td>5.4b</td>
<td>38.0p</td>
<td>21.9q</td>
<td>16.2r</td>
<td>51.2s</td>
<td>13.2t</td>
<td>29.4u</td>
</tr>
<tr>
<td>70:30</td>
<td>88.2i</td>
<td>5.2r</td>
<td>26.5t</td>
<td>15.3u</td>
<td>11.2v</td>
<td>30.9w</td>
<td>9.4x</td>
<td>15.6y</td>
</tr>
<tr>
<td>80:20</td>
<td>88.6w</td>
<td>5.1x</td>
<td>13.4z</td>
<td>10.2ss</td>
<td>3.3yy</td>
<td>19.8zz</td>
<td>6.3aa</td>
<td>9.6bb</td>
</tr>
<tr>
<td>90:10</td>
<td>80.1aa</td>
<td>5.0aa</td>
<td>4.2aaa</td>
<td>2.9ab</td>
<td>1.3bc</td>
<td>5.3cd</td>
<td>1.1d</td>
<td>2.4ee</td>
</tr>
<tr>
<td>100:0</td>
<td>95.0b</td>
<td>6.1a</td>
<td>-30.2c</td>
<td>-3.7e</td>
<td>0.5f</td>
<td>-2.8g</td>
<td>0.4h</td>
<td>0.9i</td>
</tr>
</tbody>
</table>

Values are means of three replications. Means within the column with the same superscript are not significantly different (P>0.05)

The pasting (gelatinization) temperatures of locust bean pulp flour and wheat flour were 95.05°C and 79.45°C, respectively. The pasting temperature increased steadily with the level of wheat flour in the blends. Pasting temperature is the range of temperatures whereby at least 90% of starch granules swell irreversibly in hot water without loss of crystallinity and birefringence [30]. The lower gelatinization temperature of wheat flour suggests it contains some starch portions resistant to swelling [31]. It took locust bean pulp flour 6.13 min to reach peak viscosity and wheat flour 6.20 min. The pasting time decreased as the level of locust bean pulp flour increased in the blends. Gelatinization temperature provides indication of the minimum temperature for sample cooking, energy cost involved and other components stability [26,27,31]. These results indicate that wheat flour and locust bean pulp flour blends with lower gelatinization temperature and peak time than the locust bean pulp flour will likely cook easier than locust bean pulp flour when applied in food systems. The increase in the gelatinization temperature with increase in the level of locust bean pulp flour might be due to the interaction of amylose and amylopectin following the addition of locust bean pulp flour. However, this needs to be investigated. Meanwhile, Adebowale et al. [17] reported increase in gelatinization temperature of wheat flour on incorporation of millet flour.

4. CONCLUSION

The locust bean pulp flour contained higher amounts of flavonoids, carotenoids, tannins, saponins and alkaloids than the wheat flour. However, wheat flour possessed better pasting properties than the African locust bean pulp flour. The pasting properties of locust bean pulp flour were improved by blending it with wheat flour. Based on the pasting properties evaluated in the present study, the locust bean pulp flour and wheat flour blends would find applications in various baked food products.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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