A study on comparison between cereal (wheat) and non cereal (chickpea) flour characteristics

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ABSTRACT

Chickpea and wheat are the most important crops in the world because of their nutritional quality. The objective of the study was to compare cereal and non cereal flour characteristics. Chickpea flour had higher dry matter (90.63±0.09%), protein (21.7±1.75%), fat (5.81±0.35%), ash (3.46±0.33%), amylose (20.78±0.28%), crude fiber (1.85±0.05%) and pH (6.43±0.02) when compared to whole wheat flour. On the other hand, wheat flour contained higher moisture (12.92±1.82%), and total carbohydrate (69.47±3.01%) than chickpea flour. Chickpea flour exhibited lower water binding capacity (101.81±1.85%), oil absorption capacity (0.81±0.06 g g⁻¹) and bulk density (0.78±0.02 g ml⁻¹) than wheat flour. Swelling power (50-90°C) of chickpea flour ranged between 1.6-4.3 g g⁻¹. A higher foaming capacity and foaming stability was noticed in chickpea flour than wheat flour. Solubility of chickpea and wheat flours was significantly (P<0.05) varied up to 80°C, however no significant change was observed at 90°C. Chickpea flour had higher pasting temperature and lower peak, breakdown, trough, final and setback viscosities than wheat flour. In conclusion chickpea flour is suitable for food used in several dishes and as a supplement in weaning food mixes, bread and biscuits.

Keywords: Wheat flour, chickpea flour, chemical properties, functional properties, pasting properties.

Introduction

Wheat is one of the most commonly cultivated cereals in the world. In India, states such as Punjab, Uttar Pradesh and Gujrat grow wheat in large amounts. The distinctive pattern of Indian diets is that of high carbohydrate-fiber with cereals like wheat and rice forming the staple. Currently, average carbohydrate in Indian diets represents about 60-70% of calories of which 75% is starch derived mainly from cereals and pulses (Sharavathy et al., 2001). Production of wheat has not been sufficient to meet the increasing demand for bread to satisfy human needs. Recently, new efforts have been systematically undertaken to replace part of the wheat flour by other sources. Flours from corn, barley, cassava and chickpea are among the most predominant studied for the production of composite flour breads (Almazan, 1990; Deloor et al., 1993; Petrofsky and Hoseney, 1995; Ali et al., 2000). Chickpea is the primary pulse crop in South Asia where it is an important source of protein particularly in vegetarian diet. India has the highest area production and consumption of chickpea in the world. Chickpea is a good source of protein and carbohydrates, possessing vitamins like thiamine, niacin, minerals like Ca, P, Fe, Mg and K, and unsaturated fatty acids such as oleic acid and linoleic acid (Moreno et al., 2004; Costa et al., 2006; Wang et al., 2010). In view of the increasing utilization of grain legumes in composite flours for various food formulations, their functional properties ( water absorption, oil absorption, emulsion capacity, emulsion stability, foaming capacity and foaming stability etc.) are assuming greater significance because

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these properties constitute the major criteria for the adoption and acceptability of proteins in food systems (Kaur and Singh, 2005). Functionality has been defined as any property of a food ingredient, except their nutritional value, that has a great impact on its utilization (Mahajan and Dua, 2002) and in terms of diversified and novel food uses of crops, play an important role in the utilization of chickpea in the cereal based composite flours (Iyer and Singh, 1997). The objective of the study was to compare cereal and non cereal flour characteristics.

Materials and Methods

Materials

Wheat was purchased from local market of Salem in Tamil Nadu and Chickpea (Cicer arietinum L.) was obtained from Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India. The Wheat and Chickpea were placed separately in polyethylene bags to prevent loss of moisture during transportation to the laboratory of Department of Food Science and Nutrition, Periyar University, Salem, Tamil Nadu, India.

Preparation of Chickpea flour

The chickpea was manually cleaned and devoid of contaminants such as stones, soil, bad seeds. Soil particles adhering to plant material were also removed. The chickpea was not dehulled before flour milling, because separating the tightly adhered hull results in the removal of considerable amount of seed material directly beneath it. Flours had been placed in airtight containers that were double sealed with para film and stored.

Preparation of Wheat flour

Wheat grains had been thoroughly cleaned to remove dirt, dust, insect excreta/ feathers and admixture of other food grains before the grains were ground into fine flour at local mill and stored.

Chemical Properties

Moisture content and Dry Matter

Moisture content and Dry Matter were estimated by the method of Adebayo et al., (2010). Two grams of each sample was measured into a previously weight crucible, dry over water for some time. The crucible plus sample taken was then transferred into the oven, set at 100°C for drying to constant weight for 24hours over night. At the end of 24hours, the crucible plus sample was removed from the oven and transfer to dessicator cooled for ten minutes and weighed. If the weight of empty crucible was W₀, then, the weight of crucible plus sample was W₁. Weight of crucible plus oven dried sample was W₃.

\[
\text{% Moisture} = \frac{W_{1} - W_{3}}{W_{1} - W_{0}} \times 100
\]

\[
\text{% Dry matter} = \frac{W_{3} - W_{0}}{W_{1} - W_{0}} \times 100
\]

Determination of Protein and Fat

Protein and fat were estimated by AOAC Methods [1990].

Determination of Ash

Ash content was estimated by the method given by AOAC Method (1990). The sample (2 g) was weighed into a porcelain crucible. This was transferred into the muffle furnace set at 550°C and left for about 4 hours. About this time it had turned to white ash. The crucible and its content were cooled to about 100°C in air, then room temperature in a dessicator and weighed.

\[
\text{The percentage ash was calculated from the formula below;}
\]

\[
\text{% Ash content} = \frac{\text{Weight of ash}}{\text{Original weight of sample}} \times 100
\]

Amylose content determination

Amylose was determined using the method of Williams et al., (1958) involving the preparation of stock iodine solution and iodine reagent. First 0.1g of the cassava flour was weighed into a 100ml volumetric flask, then 1ml of 99.7 – 100% (v/v) ethanol and 9ml 1N sodium hydroxide (NaOH) were added. The mouth of the flask was covered with parafilm or foil and the contents were mixed well. The samples were boiled for 10 min in a boiling water bath to gelatinize the starch (the timing was started when boiling began). The samples were removed from the water bath and allowed to cool very well, then made up to the mark with distilled water and shaken thoroughly. A portion (5ml) of the mixture was pipetted into another 100ml volumetric flask and 1 ml of 1N acetic acid and 2 ml of iodine solution were added. The flask was topped up to mark with distilled water. Absorbance (A) was read using a
spectrophotometer at 620nm. The blank contained 1ml of ethanol, 9ml of sodium hydroxide, boiled and topped up to the mark with distilled water. Finally 5ml was then pipetted into a 100ml volumetric flask, 1ml of 1N acetic acid and 2ml of iodine solution were added and then topped up to the mark. This was used to standardize the spectrophotometer at 620nm. The amylose content was calculated as:

\[
\text{Amylose content (\%) = 3.06} \times A \times 20
\]

Where: \( A \) = Absorbance value

**pH**

pH was estimated according to the method of Benesi, (2005). Flour samples (5 g) was weighed in duplicate in a beaker, mixed with 20 ml of distilled water, the resulting suspension stirred for 5 min and left to settle for 10 min. The pH of the water phase was measured using a calibrated pH meter.

**Total Carbohydrate**

Total carbohydrate content was calculated by difference method (Southgate 1991) as follows:

\[
\% \text{ Total carbohydrate} = 100\% - (\% \text{ moisture} + \% \text{ ash} + \% \text{ crude protein} + \% \text{ crude fat}).
\]

**Functional Properties**

**Water Binding Capacity**

The procedure described by Yamazaki, (1954) for the determination of alkaline water retention capacity of soft wheat flours was used with slight modification. Flour (5.0 g., dry basis) was added to 75ml distilled water in a tared 100ml centrifuge bottle. The bottle was stoppered and agitated on a wrist-action shaker for one hour. It was then centrifuged for 10 minutes at 2,200 x g, and the bottle was tipped up and allowed to drain for 10 min. more. The water binding capacity was calculated from the formula, gram bound water ×100/5.0.

**Oil Absorption Capacity**

Oil absorption capacity of the flour samples was determined by the modified method of Lin et al., (1974). The samples (0.5 g) were mixed with 5 ml of corn oil (commercial) in preweighed centrifuge tubes. The contents were stirred for 1 min with a glass rod to disperse the sample in oil. After a holding period of 30 min, the tubes were centrifuged for 25 min at 3000 x g. The separated oil layer was then removed with a pipette and the tubes were inverted for 25 min to drain any remaining oil prior to reweighing. The oil absorption capacity was expressed as gram of oil bound per gram of the sample on a dry weight basis.

**Foaming Capacity and Foaming Stability**

Foaming capacity (FC) and foaming stability were determined by the method of Narayana and Narasinga Rao (1982) with slight modifications. Sample (1.0 g) was added to 50 ml distilled water at 30±20°C in a graduated cylinder. The suspension was mixed and shaken for 5 min to foam. The volume of foam after whipping for 30 sec was expressed as foaming capacity. Where, AW: After whipping, BW: Before whipping. The volume of foam was recorded 1h after whipping to determine foaming stability as percent of the initial foam volume.

\[
\text{FC} = \frac{\text{Volume of foam (AW)} - \text{Volume of foam (BW)}}{\text{Volume of foam (BW)}} \times 100
\]

**Bulk Density**

Bulk density was estimated by the method of Adeleke and Odedeji (2010). 50 g flour sample was put into a 100 ml measuring cylinder. The cylinder was tapped several times on a laboratory bench to a constant volume. The volume of sample was recorded.

\[
\text{Bulk density (g/cm)} = \frac{\text{Weight of Sample}}{\text{Volume of Sample after tapping}}
\]

**Swelling Power and Solubility**

Swelling power and starch solubility of the starches were determined by the method of Gani et al. (2010). Starches of five suspensions (1%,w/v) was prepared in a flask, heated to 50, 60, 70, 80, and 90°C for 30 min. with shaking every 5 min and left for cooling to room temperature and centrifuged for 15 min at 3000xg. The supernatant was decanted and the residual volume was determined. The solid part was dried in an oven for 2 h at 130°C.

**Pasting Properties**

Pasting properties of chickpea and wheat flours were evaluated with Rapid Visco Analyzer (RVA) (RVA Tech Master, Perten Instruments,
Japan) according to the method described by Noda et al., (2004).

Statistical Analysis

Quantitative data analysis was carried out using MS-Excel 2007. Mean and standard deviation were calculated. Studies on chemical, functional and pasting properties of chickpea and wheat flours were analysed using two sample t-test assuming unequal variance.

Results and Discussion

Chemical properties of flours are presented in the Table 1. Moisture content of chickpea flour (9.35±0.09 %) was lower than wheat flour (12.92±1.82 %). Similar result was described by Mohammed et al., (2011) who stated that moisture content of chickpea flour was 9.5%. Dry matter of chickpea flour (90.63±0.09%) was higher than wheat flour (87.06±1.82%). Chickpea flour had significantly (P<0.05) more protein (1.45 times) than wheat flour. Similar results were described by Demir et al., (2010) for chickpea flour (21.88) where as higher values were found by Ma et al., (2011) for dehulled desi chickpea flour (24.47 %). Legumes contain more protein than cereals and protein-starch interaction in legumes may equally contribute to their decrease in glycemic responses (Madhusudhan and Tharanathan, 1995). Higher fat content of chickpea flour was observed than wheat flour.

Table 1 Chemical properties of chick pea and wheat flours

<table>
<thead>
<tr>
<th>Chemical properties</th>
<th>Chickpea flour</th>
<th>Wheat flour</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture (%)</td>
<td>9.35±0.09</td>
<td>12.92±1.82</td>
<td>3.38*</td>
</tr>
<tr>
<td>Dry matter (%)</td>
<td>90.63±0.09</td>
<td>87.06±1.82</td>
<td>3.38*</td>
</tr>
<tr>
<td>Protein (%)</td>
<td>21.7±1.75</td>
<td>14.88±0.75</td>
<td>6.19*</td>
</tr>
<tr>
<td>Fat (%)</td>
<td>5.81±0.35</td>
<td>1.73±0.17</td>
<td>18.01*</td>
</tr>
<tr>
<td>Ash (%)</td>
<td>3.46±0.33</td>
<td>0.98±0.55</td>
<td>6.68*</td>
</tr>
<tr>
<td>Amylose (%)</td>
<td>20.78±0.28</td>
<td>15.54±0.18</td>
<td>26.66*</td>
</tr>
<tr>
<td>Total carbohydrate (%)</td>
<td>59.66±1.63</td>
<td>69.47±3.01</td>
<td>4.94*</td>
</tr>
<tr>
<td>pH</td>
<td>6.43±0.02</td>
<td>5.38±0.37</td>
<td>4.77*</td>
</tr>
</tbody>
</table>

*-Significant at P<0.05 level, NS-Not significant

Similar results were described by Kohajdova et al., (2011) in instant chickpea flour (5.95 %). Ash content of chickpea flour was 3.5 times significantly (P<0.05) higher than wheat flour. This is on par with Hefnawy et al., (2012) who reported that the ash content of chickpea flour was 3.4% whereas lower values was found by Osorio-Diaz et al., (2008) for chickpea flour (2.7 %). Amylose content of chickpea flour (20.78±0.28%) was significantly (P<0.05) higher than wheat flour (15.54±0.18%). Higher values were found by Meares et al., (2004) in desi chickpea flour (26.1%). A higher amount of total carbohydrate content was observed in wheat flour than chickpea flour. Since the carbohydrate content of flour samples was calculated by difference, the variation in carbohydrate content may be attributed by the differences in other constituents (Yadav et al., 2012). The pH of chickpea flour (6.43±0.02%) was higher than wheat flour (5.38±0.37%). Similar results were described by Kohajdova et al., (2011) in instant chickpea flour (6.23 ± 0.01) and fine wheat flour (5.41 ± 0.07). Ocloo et al., (2010) stated that the pH values give a measure of the acidity or alkalinity of the flour and the level of pH are used to estimate the quality of flour.

Functional properties of flours are displayed in Table 2. Water binding capacity of chickpea flour (101.81±1.83%) was significantly (P<0.05) lower than wheat flour (113.43±1.00%). This result is on par with Yadav et al., (2012) who reported that water binding capacity of chickpea flour was 90.0±1.73% and refined wheat flour 149.3±0.88%. WAC represents the ability of a product to associate with water under conditions where water is limiting (Singh, 2001). The highest WAC of wheat flour could be due to the presence of greater amount of hydrophilic constituents like soluble fiber and lower amount of fat content.

Table 2 Functional properties of chick pea and wheat flours

<table>
<thead>
<tr>
<th>Functional properties</th>
<th>Chickpea flour</th>
<th>Wheat flour</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>WBC (%)</td>
<td>101.81±1.85</td>
<td>113.43±1.00</td>
<td>9.60*</td>
</tr>
<tr>
<td>OAC (g g⁻¹)</td>
<td>0.81±0.06</td>
<td>1.17±0.00</td>
<td>9.55*</td>
</tr>
<tr>
<td>BD (g ml⁻¹)</td>
<td>0.78±0.02</td>
<td>0.83±0.07</td>
<td>1.01*</td>
</tr>
<tr>
<td>FC (%)</td>
<td>29.27±6.35</td>
<td>14.83±1.25</td>
<td>3.86*</td>
</tr>
<tr>
<td>FS (%)</td>
<td>96.91±1.35</td>
<td>94.82±1.17</td>
<td>2.01*</td>
</tr>
</tbody>
</table>

*-Significant at P<0.05 level, NS-Not significant WBC.
Water binding capacity, OAC-Oil absorption capacity, BD-Bulk density, FC-Foaming capacity, FS-Foaming stability.

Oil absorption capacity of chickpea flour (0.81±0.06 g g⁻¹) was significantly (P<0.05) lower than wheat flour (1.17±0.00 g g⁻¹). Similar result was noticed by Sanjeewa et al., (2010) who stated that oil absorption capacity of different desi chickpea flours were 0.78 ± 0.01 g g⁻¹-0.81 ± 0.06 g g⁻¹. The oil absorption capacity of flour helps to improve mouth feel and flavor retention (Kinsella, 1976). High OAC is due to the presence of a large proportion of hydrophobic groups as compared with the hydrophilic groups on the surface of protein molecules (Subagio, 2006). Bulk density of chickpea flour (0.78±0.02 g ml⁻¹) was lower than that of wheat flour (0.83±0.07 g ml⁻¹). This result is in agreement with Yadav et al., (2012) who reported that bulk density of chickpea flour was 0.7±0.01 g ml⁻¹. Low bulk density is desirable in preparation of infant and weaning foods (Nicole et al., 2010). Foaming capacity of chickpea flour (29.27±6.35%) was higher than wheat flour (14.83±1.25%). This result is confirmed with Yadav et al., (2012) who stated that foaming capacity of chickpea flour was 35.9% and refined wheat flour was 12.8%. Foaming stability of chickpea flour (96.91±1.35%) was higher than wheat flour (94.82±1.17%). This result is confirmed with Yadav et al., (2012) who stated that foaming stability of chickpea flour was 97.5% and refined wheat flour was 95.7%. Food ingredients with good foaming capacity and stability can be used in bakery products (Akubor et al., 2000).

**Fig. 1 Swelling power of chickpea and wheat flours from 50 to 90°C**

Swelling power of wheat and chickpea flours at different temperatures ranging from 50 to 90°C is shown in the figure 1. The swelling power of chickpea and wheat flours was increased gradually when the temperature raised to 90°C. A significant difference was noticed in swelling power (60-90°C) between chickpea and wheat flours. However no difference was found at initial temperature. This result is confirmed with Sung and Stone, (2003) who reported that swelling power of different wheat flours from 60-90°C was in the range of 2.8-7.4 g g⁻¹ respectively.

**Fig. 2 Solubility of chickpea and wheat flours from 50 to 90°C**

Solubility data for chickpea and wheat flours are represented in figure 2. In general, flour solubility increased with increasing temperatures up to 70°C later it decreased with increasing temperature to 90°C. Solubility of chickpea and wheat flours was significantly (P<0.05) varied up to 80°C, however no significant difference was observed at 90°C. This result is confirmed with Sung and Stone, (2003) who reported that solubility of different wheat flours from 60-90°C was in the range of 9.7-8.3 percent. A possible reason for the decrease in solubility with increasing temperature in all flour and starch samples is that the coagulated protein matrix and gelatinized starch can prevent leaching of soluble material into water (Sung and Stone, 2003). Pasting properties of starch samples is given in Table 3. Peak, breakdown, final and setback viscosities of chickpea flour (872.66±7.42Cp, 822.33±69.60Cp, 50.33±14.01Cp, 1041.66±68.63Cp and 219.33±16.28Cp) were significantly (P<0.05) lower than those of wheat flour(1554.66±38.52Cp, 522.66±5.03Cp, 2332.33±70.2Cp and 1300.33±28.98Cp). Trough viscosity of chickpea flour (822.33±69.60Cp) was lower than those of wheat flour (1032±41.58Cp). This result is confirmed with Gomez et al., (2008) who reported that a peak, holding strength, breakdown, and final and setback viscosities of wheat flour was 2621Cp, 1728Cp, 893Cp, 3213Cp and 1485Cp respectively. Similar results were described by Gomez et al., (2008) who reported that a peak, holding strength, breakdown, final
and setback viscosities of different chickpea flours were in the range of 877-1032 cP, 817-964 cP, 38-68 cP, 1066-1264 cP and 247-300 cP respectively.

Table 3 Pasting properties chick pea and wheat flours

<table>
<thead>
<tr>
<th>Pasting properties</th>
<th>Chick pea flour</th>
<th>Wheat flour</th>
<th>t - value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak viscosity (cP)</td>
<td>872.66±77.42</td>
<td>1554.66±38.52</td>
<td>13.65*</td>
</tr>
<tr>
<td>Trough (cP)</td>
<td>822.33±69.60</td>
<td>1032±41.58</td>
<td>4.47 NS</td>
</tr>
<tr>
<td>Breakdown (cP)</td>
<td>50.33±14.01</td>
<td>522.66±5.03</td>
<td>54.94*</td>
</tr>
<tr>
<td>Final viscosity (cP)</td>
<td>1041.66±68.63</td>
<td>2332.33±70.23</td>
<td>22.76*</td>
</tr>
<tr>
<td>Setback (cP)</td>
<td>219.33±16.28</td>
<td>1300.33±28.98</td>
<td>56.30*</td>
</tr>
<tr>
<td>Peak time (min)</td>
<td>5.88±0.21</td>
<td>5.55±0.07</td>
<td>2.52 NS</td>
</tr>
<tr>
<td>Pasting temperature(°C)</td>
<td>73.4±7.14</td>
<td>70.18±0.05</td>
<td>0.77 NS</td>
</tr>
</tbody>
</table>

*-Significant at P<0.05 level, NS-Not significant, cP-centri poise, Min-minutes, °C-Centigrade

Chickpea flours resulted in pastes with lower peak viscosity, holding strength, breakdown, final viscosity and total setback than the wheat flour; this is likely due to their lower carbohydrate content, and also their different protein content could affect the viscometric parameters (Gomez et al., 2008). Chickpea flours presented lower peak viscosity than wheat flours, thus lower gas retention and lower expansion of the product could be expected. Chickpea flour (5.88±0.21 min) showed higher peak time than wheat flour (5.55±0.07 min). This result is confirmed with Gomez et al., (2008) who stated that peak time of different chickpea flours were 5.9-6.9 min and wheat flour was 6.3 min. Chickpea flour (73.4±7.14°C) showed higher pasting temperature than wheat flour (70.18±0.05°C). This result is confirmed with previous literature given by Gomez et al., (2008); Sanjeeawa et al., (2010); Kaur and Singh, (2005). Pasting temperature is an indication of the minimum temperature needed to cook the flour sample (Sanjeewa et al., 2010).

Conclusion

Chickpea flour had higher dry matter, protein, fat, ash, amyllose content, crude fiber and pH than whole wheat flour. On the other hand, wheat flour contained higher moisture, total starch and total carbohydrate level than chickpea flour. Moreover lower water absorption capacity, oil absorption capacity, bulk density and swelling power was observed in chickpea flour but it shows higher solubility, foaming capacity and foaming stability than wheat flour. Chickpea flour had higher pasting temperature and lower peak, breakdown, through, final and setback viscosities than wheat flour. Hence, chickpea flour is suitable for food uses where a thermo-stable paste without breakdown and with restricted swelling is required. Chickpea flour could be used for the preparation of bakery products due its high foaming capacity and stability.

References


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