Pasting and Thermal Properties of Starch Extracted from Chenopodium Album Grain

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Abstract

The grain Chenopodium album is a rich source of carbohydrate, protein, lipids, dietary fiber and functional components. The grain has been considered as competent candidate for the extraction of starch in comparison to other conventional sources of starch viz. tuber, cereal and pulses. Therefore, Starch was extracted for maximum recovery by two methods viz. alkali and decantation. Alkali method and decantation method were compared for higher recovery. Alkali methods have been finalized on the basis of yield obtained. In this method steeping of seeds of Chenopodium album was done for 24 hrs under refrigeration. In process of alkali extraction, the steeped grains were grinded to obtain slurry and fibrous material was removed through the process of screening. The screened liquid suspension was centrifuged to obtain starch on wet basis. The sediment collected as wet starch was dried overnight at 40°C and weighted for final recovery. Starch isolated was examined for recovery and characterized for thermal and rheological properties. The starch obtained by alkali method of extraction from Chenopodium album grain was 28%. Thermal properties were studied by DSC viz. gelatinization temperatures To(34.43°C), Tp(60.55°C), Tc(97.88°C) and enthalpies of gelatinization (ΔHgel) (78.4286J/g). It was found that Chenopodium album gelatinization properties differ significantly from other conventional sources of starch. The pasting properties were studied by RVA (Rapid Visco Analyzer) viz. peak viscosity (5355.00cp), hold on (4173.00cp), breakdown viscosity (1182.00cp), set back viscosity (526.00cp) and final viscosity (4699.00cp) of the Chenopodium starch.

Keywords: Chenopodium album, yield, thermal, pasting, gelatinization, etc.
1. Introduction

Pseudo cereals are broadleaf plants (non-grasses) that are used in much the same way as cereals (true cereals or grasses). They are dicotyledons plants as opposed to cereals which are monocotyledons. Examples of pseudo cereals are amaranth, chenopodium and buckwheat. After processing, these plants can be used as flours or flakes or in biscuits and breakfast food (Kuhn et al, 1996; Brummer et al, 1992). These Pseudo-cereals are essentially a starchy crop. However, they may contain significant quantities of protein and oil, and it is frequently these constituents that determine suitability for specific end use. Pseudo-cereals frequently have a unique amino acid profile and can be used to supplement cereals for a more balanced amino acid diet. Chenopod (chenopodium sp.) is one of the largest genera of the family Chenopodiaceae and comprises over 250 species (Giusti, 1970). Four species, namely Chenopodium album, Chenopodium quinoa, Chenopodium nataliae and Chenopodium pallidicaule, are known to be cultivated. Out of the four domesticated species, C. album is the most widely distributed and is grown in the Himalayan region. Chenopodium album is mainly an annual weed diffused in cultivated fields, due to high-protein and a balanced amino acid spectrum with high lysine (5.1–6.4%) and methionine (0.4–1.0%) contents (Prakash and Pal, 1998). It has also been cultivated largely for centuries as a leafy vegetable as well as an important subsidiary grain crop for human and animal food-stuff (Bhargava et al, 2003). The plant has been used in the Himalayan region as an important subsidiary grain crop, as a potherb, for secondary fodder and salad dressings (Partap, 1990; Partap et al, 1998). The plant is a rich source of high quality proteins (30–47 g/kg), vitamin A (78–129 mg/kg), vitamin C (1.9–2.3 g/kg), vitamin E and a variety of minerals (Partap et al, 1998; Prakash et al, 1993). C. album has antioxidant capacity, total phenol flavonoid glycosides (quercetin, rutin, kaempferol), thus, should be considered as a nutraceutical food and an alternative source for nutrients and free radical scavenging compounds (Chludil et al, 2008). The seeds of these pseudocereals like amaranth and chenopodium are generally higher in protein, fat, ash, and fiber in comparison to common cereals. Moreover, the amino acid balance of these seeds are better than that of wheat and maize because the first limiting amino acid, lysine, is present in a relatively higher amount in these seeds. Nevertheless, the main components of the seeds are starches. In the United States (producer of more than 60% of the total world starch), it is almost the sole industrial material for starch extraction. Starch plays a crucial role in the food industry as a food ingredient. For example, more than 250 million bushels of corn were used in starch production in 2010, and an estimated 20 billion pounds of bread are produced yearly, a product in which wheat starch is a principal constituent (Zobel and Kulp, 1996). In the whole world the share of starch from corn is about 83%, followed by wheat (7%), potato (6%) and tapioca (4%). Nearly 53% of starch total production is used in the food sector (sweets – 18%, soft drinks – 11%, other food – 24%). Of the non-food sector (total share of 46%), 28% is used for production of paper, cardboard and corrugated board, and 13% is used for fermentation (Bergthale, 2004). The first Millennium Development Goal is to
reduce hunger and poverty by promoting non-conventional crop by 2015 (Dixon et al, 2006).

2. Material and Methods
The raw material for the present study was procured from local growers of Punjab. Chenopodium grains were milled with a mortal-pestle and passed through Sieve No. 70 by the British Sieve Standards (BSS) to obtain flour.

2.1 Proximate composition
The flour samples of Chenopodium album grains were analyzed for their moisture, protein, fat, and ash contents by employing standard methods of analysis (AOAC, 1990). The crude fiber content was determined using the AACC (2000) methods. The analysis was conducted in triplicate and average value was taken.

2.2 Starch isolation
Starch was extracted for maximum recovery by two methods viz. alkali and decantation methods. In Alkali method, steeping of seeds of Chenopodium album was done for 24 hrs under refrigeration, the steeped grains were grinded to obtain slurry and fibrous material was removed through the process of screening. The screened liquid suspension was centrifuged and the mucilaginous layer scraped from the surface. The operations of centrifugation and scraping were repeated four times to obtain starch on wet basis. The sediment collected as wet starch was dried overnight at 40°C and weighted for final recovery. In case of decantation method, the ground seeds of chenopodium album were steeped in distilled water and the pH of the slurry was adjusted to 11 by addition of alkali (NaOH). The slurry obtained was filtered through muslin cloth. The screened slurry was allowed to settle and after every 12 hr time period the upper layer was decanted away and lower sediment starch collected was dried at 40°C.

2.3. Thermal properties
Gelatinization characteristics were determined using a Differential Scanning Calorimeter (DSC) (Universal V3.0G T A instruments), New Castle (DE), USA. In order to achieve the uniform sampling, starch powder was thoroughly mixed with distilled water to 1:3.5 (w/w) starch to water ratio to make homogeneous slurry. Each sample (9-11mg) was immediately transferred to a reweighed aluminum dish and sealed hermetically using encapsulation press and weighed again. An empty aluminum crucible was used as a reference. The samples were subjected to DSC analysis within half an hour after the preparation. The gelatinization temperature parameters (in°C) to onset (To), to peak (Tp), to conclusion (Tc), and enthalpy (AH, j/g) were determined using software provided with the equipment. All measurements were replicated twice
2.4 Pasting properties
Rapid Visco Analyzer (RVA) (model 3D, RVA; Newport Scientific Pvt. Ltd., Warriewood, Australia) was used to determine the pasting properties of the starch samples. A suspension of 3 g starch (14% moisture basis) in 25 g of distilled water underwent a controlled heating and cooling cycle under constant shear where it was held at 50°C for 1 min, heated from 50 to 95°C at 6°C/min, held at 95°C for 5 min, cooled to 50°C at 6°C/min, and held at 50°C for 5 min. The following data were recorded: pasting parameters of time from onset of pasting to peak viscosity ($P_{\text{time}}$); temperature at which peak viscosity was reached ($P_{\text{temp}}$); peak viscosity ($P_V$); viscosity at the end of hold time at 95°C or hot paste viscosity ($HP_V$); breakdown, $P_V$ less than $HP_V$; viscosity at the end of the hold time at 50°C or cold paste viscosity ($CP_V$); and setback ratio ($CP_V/HP_V$). All tests were replicated twice.

3. Result and Discussion
3.1 Proximate composition
The nutritional content of Chenopodium album grain was investigated and the results of the proximate analysis are shown in Table 1.

<table>
<thead>
<tr>
<th>S No.</th>
<th>Chenopodium spp</th>
<th>CHO (%)</th>
<th>Protein (%)</th>
<th>Fat (%)</th>
<th>Fiber (%)</th>
<th>Ash (%)</th>
<th>Moisture (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Chenopodium album</td>
<td>55-60</td>
<td>15</td>
<td>6</td>
<td>3-4</td>
<td>4.98</td>
<td>11-13</td>
</tr>
</tbody>
</table>

3.2 Starch isolation
Chenopodium album grain was tested for maximum starch extraction. Alkali method and decantation method were compared for higher recovery (Table 2). The starch obtained by alkali method of extraction from Chenopodium album grain was 28% and the starch obtained by decantation was 18%. Alkali method was finalized on the basis of yield obtained.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Methods</th>
<th>Yield (%)</th>
<th>Protein (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Alkali method by Wu et al (1995)</td>
<td>28</td>
<td>0.38</td>
</tr>
<tr>
<td>2</td>
<td>Simple Decantation method</td>
<td>18</td>
<td>1.20</td>
</tr>
</tbody>
</table>

3.2 Pasting profile
The pasting properties of the starch extracted from Chenopodium album grain by alkali method were studied by Rapid Visco Analyzer (RVA). The pasting characteristics of
starch are used to obtain information of its functional behavior during heating and cooling periods, which is common during the processing of starchy products or in those foods where starch is added as ingredient. Pasting temperature (temperature at the onset of rise in viscosity) of starch from chenopodium album grain was found to be 77.45°C. Pasting temperature provides an indication of the minimum temperature required to cook the flour. The increase in viscosity with temperature may be attributed to the removal of water from the exuded amylose by the granules as they swell (Ghiasiey et al, 1982).

Final viscosity (indicates the ability of the material to form a viscous paste) and setback (measure of retrogradation tendency or syneresis of starch upon cooling of cooked starch pastes) of chenopodium album grain starch was 4699.00 and 526.00Cp, respectively. The lowest setback value of starch indicates its lower tendency to retrograde. The smaller tendencies to retrograde are an advantage in food products such as soups and sauces, which undergo loss of viscosity and precipitation as a result of retrogradation (Adebowale and Lawal, 2003a). Breakdown viscosity (measure of the ease with which the swollen granules can be disintegrated) observed for chenopodium album grain starch was 1182.00 Cp (Table 3).

**Table 3:** Pasting properties of starch measured by rapid visco analyzer (RVA).

<table>
<thead>
<tr>
<th>Starch</th>
<th>Pasting temp (°C)</th>
<th>Peak Viscosity (Cp)</th>
<th>Trough Viscosity (Cp)</th>
<th>Breakdown viscosity (Cp)</th>
<th>Setback viscosity (Cp)</th>
<th>Final Viscosity (Cp)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chenopodium album</td>
<td>77.45</td>
<td>5355.00</td>
<td>4173.00</td>
<td>1182.00</td>
<td>526.00</td>
<td>4699.00</td>
</tr>
</tbody>
</table>

3.3 Thermal analysis
Gelatinization temperatures studied were found to be T0(34.43°C), Tp(60.55°C), Tc(97.88°C) and enthalpies of gelatinization (ΔHgel) (78.4286J/g). The thermal characterization is important for determining the cooking variables of chenopodium album grain starch.
album grain starch \( T_p \) gives a measure of crystallite quality (double helix length). Enthalpy of gelatinization (\( \Delta H_{gel} \)) gives an overall measure of crystallinity (quality and quantity) and is an indicator of the loss of molecular order within the granule (Cooke and Gidley, 1992; Hoover and Vasanthan, 1994; Tester and Morrison, 1990). Chenopodium album grain starch had lower temperatures for gelatinization and smaller heats of gelatinization (\( \Delta H \)) as compared to normal maize starches (Konishi et al, 1999). The order–disorder transitions that occur on heating an aqueous suspension of starch granules have been extensively investigated using DSC (Donovan, 1979; Jenkins, 1994; Lelievre and Mitchell, 1975). Starch transition temperatures and gelatinization enthalpies by DSC may be related to characteristics of the starch granule, such as degree of crystallinity (Krueger et al, 1987). Tester (1997) has postulated that the extent of crystalline perfection is reflected in the gelatinization temperatures.

**Table 4:** DSC characteristics of starch obtained from chenopodium album grain.

<table>
<thead>
<tr>
<th>Starch</th>
<th>To(°c)</th>
<th>( T_p(°c) )</th>
<th>( T_c(°c) )</th>
<th>( \Delta H ) (J/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chenopodium album</td>
<td>34.43</td>
<td>60.55</td>
<td>97.88</td>
<td>78.4286</td>
</tr>
</tbody>
</table>

To-onset; \( T_p \)-peak; and \( T_c \) - conclusion temperatures and \( \Delta H \) is heat of gelatinization.

4. Conclusion

The highest recovery of starch was obtained from *chenopodium album grain* by alkali method. The starch obtained by alkali method of extraction from *Chenopodium album* grain was 28%. Thermal properties were studied by DSC viz. gelatinization temperatures \( T_o(34.43°c) \), \( T_p(60.55°c) \), \( T_c(97.88°c) \) and enthalpies of gelatinization \( \Delta H_{gel}(78.4286J/g) \). It was found that *Chenopodium album* gelatinization properties differ significantly from other conventional sources of starch. The pasting properties were also studied by RVA (Rapid Visco Analyzer) viz. peak viscosity (535.00cp), hold on (4173.00cp), breakdown viscosity (1182.00cp), set back viscosity (526.00cp) and final viscosity (4699.00cp) of the *Chenopodium* starch.

References


