Effect of Storage Proteins on Pasting Properties of Rice Starch

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Abstract
The purpose of this research was to study the effect of storage rice protein and storage time on the pasting properties of rice starch. In the experiment, rice cv. Khao Dawk Mali was stored for 0-7 month at 25°C. The rice flours were extracted for storage proteins and evaluated for the pasting properties. The results were found that storage time significantly affected the solubility of storage proteins and physiochemical properties of the rice flour by decreasing extractable albumin, globulin, glutelin and prolamin. The total protein content of non-stored rice was 5.35 g/100 g while the total protein content of the stored rice for 7 month at 25°C was 4.29 g/100 g or decreased 19.81% of the total rice protein. Glutelin consisted in the highest content of 70% and globulin was 20% while albumin and prolamin were found in relatively equal amount in rice grain. Storage time significantly increased the physiochemical properties of peak viscosity, setback and final viscosity by 12.58%, 49.42% and 23.14%, respectively, compared to the non-extracted rice protein sample but decreased breakdown by 13.73%. In addition, it was found that each storage protein affected on different physiochemical properties. Glutelin was most significantly affected on pasting temperature, final viscosity, setback and breakdown while globulin affected on peak viscosity and also setback and breakdown but less than glutelin. Albumin and prolamin affected mostly on setback. The results were shown that the each type of storage proteins affected on viscosity of pasting properties of rice starch during storage.

Key words: protein, rice, pasting property

Introduction
Cereal grains can be stored for long periods without microbial spoilage, however, biochemical changes do occur during aging. The grain respires, dry matter is lost, and functional and nutritional aspects of the grain are altered. Whole rice grain contains many types of proteins which have been isolated and characterised, mainly according to their solubility properties, using the Osborne extraction method. Proteins are found in different parts of the rice grain including the endosperm, the polish and the bran, most being within the endosperm (storage proteins) cells, situated in protein bodies between the starch granules. Main cereal proteins can be classified into albumins, globulins, prolamins, and glutelins fractions. While glutelins and prolamins are the majority proteins in wheat and corn, prolamins are very scarce (2%) in rice, being glutelins the most abundant proteins in this cereal followed by albumins (11%). Because of its abundance, rice glutelin has been extensively studied in biochemical and molecular genetic investigations. During storage of rice, the molecular weight of glutelin increases significantly, which correlates with an increase in disulphide bonding. The decrease in solubility is thought to explain the decrease in stickiness observed in stored rice. Since proteins impact so much on the end-use of other cereals, it is most likely that they contribute to the quality of cooked rice.
However, studies on rice proteins have been limited when compared to those of the starch component. Therefore, it is important to be able to measure the contribution of proteins to rice quality.

The purposes of this paper are to present the effects the storage on the solubility of storage proteins of the grain rice and to investigate the effect of storage proteins removal on the pasting properties of rice flour before and after storage.

Materials and Methods

*Rice samples*

One hundred kilos of the paddy rice Khao Dawk Mali 105 were provided by the Rice Research Center, Phathumthani province. The bags were placed at 25°C. Samples were analyzed for physicochemical properties of rice. Non-stored and 7 month stored paddy rice were isolated for albumin, globulin, glutelin and prolamin contents and physicochemical properties.

*Isolation of proteins*

Proteins were extracted from rice flour based on their solubility at room temperature (25°C) in water, 5% NaCl, 0.1 M NaOH and 70% ethanol using the procedure of Ju et al. (2001). Milled rice flour (100 g) was defatted with 400 ml hexane and dried. The defatted flour was then extracted with 400 ml distilled water and centrifuged at 3000g for 30 min to obtain the albumin fraction (supernatant). The residue was extracted with 400 ml of 5% NaCl to obtain the globulin fraction. The residue after extraction of globulin was extracted with 0.1 M NaOH (1 h) to obtain the glutelin fraction, while the residue after glutelin extraction was extracted with 70% ethanol to obtain the prolamin fraction.

*Rapid viscoanalysis (RVA)*

The pasting properties of the various samples were determined with a Rapid Visco Analyser. Rice flour was slurried with distilled water. The temperature profile involved an initial 10 s high-speed stir that dispersed the sample prior to the beginning of the measuring phase at 160 rotations/min. Temperature was held at 50°C for 1 min and then raised to 95°C in 3.75 min, held for 2.5 min, cooled to 50°C in 3.75 min, and held for 5 min. Values are reported in min, °C or rapid viscoanalyser units (RVU).

Results

*Isolation of rice protein fractions*

Of the four protein components, glutelin represented approximately 80% of total protein content in non-stored rice, followed by globulin, while albumin and prolamin contents were nearly the same. Table 1 shows the effect of isolation methods on the yield and protein content of the rice protein fractions of non-stored rice and 7 month stored rice. For non-stored rice, the major fraction (about 72% of total) was glutelin which also had the highest protein concentration. The globulin fraction was next at around 19% yield followed by albumin (5%) and prolamin (4%).

Table 1 shows the effect of isolation methods on the yield and protein content of the rice protein fractions of 7 month stored rice. The major fraction (about 69% of total) was glutelin which also had the highest protein concentration. The globulin fraction was next at around 17% yield followed by prolamin (8%) and albumin (3%). In the extraction, the albumin fraction had the lowest in protein content compared with the globulin, prolamin or glutelin fractions.

There was a marked difference in prolamin content, containing 7.9% for stored rice and 4.34% for non-stored rice, with the relative difference being higher than 45% and there
was also difference in albumin content, containing 4.7% for stored rice and 2.79% for non-stored rice, with the relative difference being higher than 40%.

On the other hand, there was little difference in globulin and glutelin content among non-stored rice and stored rice with the relative difference being lower than 12%. Although albumin and prolamin contents were lower in the rice, their relative difference between non-stored rice and stored rice was approximately 40-45%.

**Pasting and gelatinization properties**

Stored rice caused alterations in the RVA properties from non-stored rice (Table 2). Peak viscosity, setback and final viscosity of stored rice increased 6%, 33% and 19%, respectively, comparing to non-stored rice.

Deprotein rice caused significant alterations in the RVA curves of non-stored rice (Table 2). Peak viscosity of non-stored rice decreased 24% in dealbumin rice, 44% in deglobulin rice, 3% in deprolamin rice, but increased 15% in deglutelin rice. Pasting temperature decreased in all materials before storage. Decreases in pasting temperature were observed in dealbumin rice, deglobulin rice, deprolamin rice and deglutelin rice. Pasting temperature of rice before storage decreased 15ºC in dealbumin rice, 2ºC in deglobulin rice, 14ºC in deglutelin rice and 16 ºC in deprolamin rice. Setback of deprotein rice decreased in all materials before storage except deglobulin rice. Decreases in setback were observed in dealbumin rice, deglutelin rice and deprolamin rice. Setback decreased 14% in dealbumin rice, 4% in deglutelin rice, 20% in deprolamin rice, but increased 6% in deglobulin rice. Final viscosity of non-stored rice decreased 14% in dealbumin rice, 15% in deglobulin rice, 39% in deglutelin rice, but increased 2% in deprolamin rice.

**Table 1** Contents of protein isolates from non-stored rice and 7 month stored rice prepared by the traditional extraction (Osborne) method.

<table>
<thead>
<tr>
<th>Protein</th>
<th>Non-stored rice</th>
<th>Stored rice</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Protein content (g / 100 g)</td>
<td>Percentage (%)</td>
</tr>
<tr>
<td>Albumin</td>
<td>0.2530 ± 0.004</td>
<td>4.7</td>
</tr>
<tr>
<td>Globulin</td>
<td>1.0044 ± 0.003</td>
<td>18.78</td>
</tr>
<tr>
<td>Glutelin</td>
<td>3.8560 ± 0.036</td>
<td>72.13</td>
</tr>
<tr>
<td>Prolamin</td>
<td>0.2324 ± 0.001</td>
<td>4.34</td>
</tr>
<tr>
<td>Total</td>
<td>5.3458</td>
<td>100</td>
</tr>
</tbody>
</table>

Data are means of at least two analyses with standard deviation.

Deprotein rice also caused significant alterations in the RVA curves of stored rice (Table 3). Peak viscosity of deprotein rice decreased in all materials after storage except deprolamin rice. Decreases in peak viscosity were observed dealbumin stored rice, deglobulin stored rice and deglutelin stored rice. Peak viscosity decreased 50% in dealbumin rice, 34% in deglobulin rice, 13% in deglutelin rice, but increased 23% in deprolamin rice. Pasting temperature decreased in all materials after storage except in deglobulin rice. Decreases in pasting temperature were observed in storage of dealbumin rice, deprolamin rice and deglutelin rice. Pasting temperature after storage decreased 15ºC in dealbumin rice, 15ºC in deprolamin rice and 7ºC in deprolamin rice. Setback decreased in all materials after storage. Setback decreased 58% in dealbumin rice, 5% in deglobulin rice, 43% in deglutelin rice and 35% in deprolamin rice. Final viscosity of deprotein rice decreased in all materials after storage. Final viscosity decreased 61% in dealbumin rice, 11% in deglobulin rice, 49% in deglutelin rice and 9% in deprolamin rice.
Table 2 Effect of albumin, globulin, glutelin and prolamin removal on RVA pasting properties of non-stored rice cv. Khaw Dok Mali.

<table>
<thead>
<tr>
<th>Protein</th>
<th>Pasting Temp. (°C)</th>
<th>Peak Viscosity</th>
<th>Setback</th>
<th>Final viscosity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Native</td>
<td>93.05 ± 0.71</td>
<td>346.08 ± 0.59</td>
<td>69.58 ± 1.24</td>
<td>250.83 ± 0.29</td>
</tr>
<tr>
<td>Dealbumin</td>
<td>79.35 ± 0.60</td>
<td>264.83 ± 4.12</td>
<td>60.00 ± 0.65</td>
<td>215.00 ± 1.59</td>
</tr>
<tr>
<td>Deglobulin</td>
<td>91.25 ± 0.46</td>
<td>195.67 ± 1.83</td>
<td>73.75 ± 1.41</td>
<td>212.50 ± 1.77</td>
</tr>
<tr>
<td>Deglutelin</td>
<td>80.05 ± 0.07</td>
<td>398.42 ± 5.42</td>
<td>66.75 ± 1.41</td>
<td>152.75 ± 1.24</td>
</tr>
<tr>
<td>Deprolamin</td>
<td>77.75 ± 0.67</td>
<td>335.08 ± 3.00</td>
<td>56.00 ± 0.17</td>
<td>256.17 ± 1.06</td>
</tr>
</tbody>
</table>

Data are means of at least two analyses with standard deviation.

Table 3 Effect of albumin, globulin, glutelin and prolamin removal on RVA pasting properties of 7 month stored rice cv. Khaw Dok Mali.

<table>
<thead>
<tr>
<th>Protein</th>
<th>Pasting Temp. (°C)</th>
<th>Peak Viscosity</th>
<th>Setback</th>
<th>Final viscosity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Native</td>
<td>93.90 ± 0.53</td>
<td>367.08 ± 0.59</td>
<td>103.58 ± 1.30</td>
<td>309.25 ± 0.88</td>
</tr>
<tr>
<td>Dealbumin</td>
<td>80.15 ± 0.53</td>
<td>183.58 ± 0.12</td>
<td>43.92 ± 0.82</td>
<td>122.00 ± 0.47</td>
</tr>
<tr>
<td>Deglobulin</td>
<td>93.90 ± 0.60</td>
<td>241.83 ± 4.06</td>
<td>98.08 ± 2.30</td>
<td>274.75 ± 1.41</td>
</tr>
<tr>
<td>Deglutelin</td>
<td>80.10 ± 0.03</td>
<td>318.75 ± 6.66</td>
<td>58.92 ± 1.24</td>
<td>156.83 ± 1.03</td>
</tr>
<tr>
<td>Deprolamin</td>
<td>87.25 ± 1.06</td>
<td>453.17 ± 1.77</td>
<td>67.33 ± 0.53</td>
<td>282.58 ± 1.53</td>
</tr>
</tbody>
</table>

Data are means of at least two analyses with standard deviation.

Discussion and Conclusion

Deprotein caused significant alterations in the RVA curves of non stored and stored rices. Physicochemical properties of each type of deprotein rice altered in all materials and storage also effected to the RVA behavior of rice. Other researchers have reported an increase in peak viscosity during storage of rice at lower temperatures (37, 20, and 3°C) and 26°C. The current study used ambient temperatures for 7 month durations the storage process, which may have obscured the rise in peak viscosity.

Deprotein also decreased the rate of swelling of starch granules. As a consequence, higher temperatures were needed for starch swelling and viscosity development. Both non-stored rice and stored samples of dealbumin, deglutein, deprolamin and deprotein rice had decrease pasting temperature compared to non deprotein material while only the aged deglobulin rice had not decrease pasting temperature caused by storage. Decrease pasting temperature is probably related that as deprotein materials, less time and energy were required to increase the viscosity of the gelatinized starch. However, decreased pasting slope shows that as deprotein materials, more time and energy were required to increase the viscosity of the gelatinized starch.

The cause of the altered starch granule swelling pattern in deprotein and non-deprotein of non-stored and stored rices is probably indicated the changes in the protein composition and starch. Peak viscosity was positively correlated to albumin, globulin and prolamin content and extractable proteins while only glutelin was negatively correlated in non-stored rice. Decreasing amounts proteins, albumin, globulin and prolamin, before storage and decreasing amounts, albumin, globulin and glutelin after storage, probably indicating that increased non-covalent associations within the starch granule may be partially responsible for the delayed and lower pasting properties of starch granules in grain. The difference in RVA properties between deprotein of non-stored and stored rice may be related to the storage time affected to the interaction of starch and protein compositions.

The decreased swelling behavior of starch may be related to the altered associations of amylose with amyllopectin during annealing. Certain protein matrix probably becoming
more closely associated with the starch granules during storage could explain the changes seen in the RVA behavior. During gelatinization, the protein matrix developed more crosslinks and acted as a barrier to water penetration, hydration, and swelling of the starch granules. However, decrease amount of certain proteins might also decrease the water penetration, hydration, and swelling of the starch granules. The tight association of the protein matrix increased swelling of the granule thus increasing viscosity development. Altering the protein structure by using reducing agents has been shown to change the gelatinization character of starch. Storage might increase the organization within the rice kernel, making it more susceptible to disintegration during mixing and increasing the ability of the starch to swell. In other rice storage studies, peak viscosity increased as storage increased. These changes were dependent upon storage temperature and occurred more quickly at higher storage temperatures.

This study has demonstrated that the isolating rice protein fractions affects viscosity profile of non-stored rice and stored rice. The rheological processes resulting in a paste during the formation of the peak will determine the behaviour of the paste/gel throughout breakdown and lift-off from the trough. Taken together, the results demonstrate that storage proteins influence viscosity curves probably through binding water, which cause the concentration of the dispersed and viscous phases of gelatinised starch. Removal of storage proteins effect to peak height. Interpreting the viscosity curve, proteins may affect the amount of water the rice absorbs in pasting, and the availability of water early in pasting will determine the hydration of the protein and the concentration of the dispersed and viscous phases of the starch.

References