

Effect of Storage Time and Storage Protein on Pasting Properties of Khao Dawk Mali 105 Rice Flour

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ABSTRACT

Aging significantly affected the solubility of storage proteins and pasting properties of Khao Dawk Mali 105 rice flour. The protein solubility of rice from freshly harvested and seven-month stored rice differed significantly. The freshly harvested rice showed higher protein content (5.35 g%), whereas the storage rice showed lower protein content (4.29 g%). The protein component of rice flour from non-stored and stored rice mainly consisted of glutelin, with values of 3.86 g% and 3.09 g%, respectively. The rice flour from non-stored rice consisted of 1.00 g% globulin, 0.25% albumin and 0.23% prolamin and the rice flour from stored rice consisted of 0.74 g% globulin, 0.12% albumin and 0.34% prolamin. Aging significantly increased the pasting viscosity of rice flour, but decreased the protein solubility. Peak viscosity of non-stored rice flour decreased by 24% in dealbumin rice, by 44% in deglobulin rice and by 3% in deprolamin rice, but increased 15% in deglutelin rice. Storage might lead to a protein matrix more closely associated with the starch granules and this could explain the changes observed in the solubility and pasting properties.

Key words: storage 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 (Reed, 1992). Whole rice grains contain many types of protein that have been isolated and characterised, mainly according to their solubility properties, using the Osborne extraction method (Agboola *et al.* 2005). Proteins are found in different parts of the rice grain including the endosperm, the polish and the bran, with most being within the endosperm (protein storage) cells, situated in

protein bodies between the starch granules (Lasztity and Salunkhe, 1979). Main cereal proteins can be classified into albumins, globulins, prolamins and glutelins. While glutelins and prolamins are the major proteins in wheat and corn, prolamins are very scarce (2%) in rice. Glutelins are the most abundant proteins in this cereal followed by albumins (11%) (Utsumi, 1992) and because of its abundance, rice glutelin has been extensively studied in biochemical and molecular-genetics investigations (Okita *et al.*, 1989). During storage of rice, the molecular weight of glutelin increased significantly, which correlated with an increase in disulphide bonding (Chrastil, 1990). The decrease in solubility is thought to explain

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the decrease in stickiness observed in stored rice (Chrastil, 1994). Since proteins have a dramatic impact 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 with those of the starch component. Therefore, it is important to be able to measure the contribution of proteins to rice quality. The aims of this paper were to present the effects of storage on the solubility of storage proteins of grain rice and to investigate the effect of the removal of storage proteins on the pasting properties of rice flour before and after storage.

MATERIALS AND METHODS

Rice samples

Khao Dawk Mali 105 paddy rice (100 kg) was provided by the Rice Research Center, Phatumthani province. The bags were stored at 25°C. Samples were analyzed for their physicochemical properties. Non-stored and seven-month stored paddy rice were used for the analysis of the albumin, globulin, glutelin and prolamin contents and the 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 3,000g 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. The extractable protein content was determined at 750 nm using the method of Lowry *et al.* (1951).

Analysis of pasting properties

The pasting properties of the various samples were determined with a Rapid Visco Analyser. Rice flour was slurried with distilled water. Viscosity profiles of flours from different stored rice samples were recorded using flour suspensions (6%, w/w; 25 g total weight). 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, using a heating rate of 25.3°C/min, held for 2.5 min, cooled to 50°C in 3.75 min, and held for 5 min. Values were 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 the total protein content in non-stored rice, followed by globulin, while the content of albumin and prolamin was nearly the same. Table 1 shows the effect of storage on the yield and protein content of the rice protein fractions of non-stored rice and seven-month stored rice. For non-stored rice, 72% of total protein was glutelin. The globulin fraction ranked second at around 19% yield, followed by albumin (5%) and prolamin (4%).

Table 1 also shows the effect of storage on the yield and protein content of the rice protein fractions of seven-month stored rice. Glutelin was about 69% of total protein. The globulin fraction was at around 17% yield, followed by prolamin (8%) and albumin (3%).

There was a marked difference (45%) between the prolamin content of 7.9% for stored

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

Protein	Non-stored rice		Stored rice	
	Protein content (g/100 g dry basis)	Percentage (%)	Protein content (g/100 g dry basis)	Percentage (%)
Albumin	0.2530 ± 0.004 ^{aA}	4.7	0.1244 ± 0.0006 ^{aB}	2.79
Globulin	1.0044 ± 0.003 ^{bC}	18.78	0.7404 ± 0.0006 ^{bD}	16.62
Glutelin	3.8560 ± 0.036 ^{cE}	72.13	3.0896 ± 0.0305 ^{cF}	69.35
Prolamin	0.2324 ± 0.001 ^{dG}	4.34	0.3390 ± 0.0020 ^{dH}	7.90
Total	5.3458 ± 0.024 ^{eI}	100	4.2934 ± 0.0102 ^{eJ}	100

Data are means of at least two analyses ± standard deviation. Results with a different lower case letter in the same column and a different upper case letter in the same row are significantly different ($P \leq 0.05$).

rice and 4.34% for non-stored rice. There was also a difference (40%) between albumin content of 4.7% for stored rice and 2.79% for non-stored rice.

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

Pasting properties

Storage caused changes in the pasting properties of rice flour (Figure 1A and Tables 2 and 3). Peak viscosity, setback and final viscosity of stored rice increased 6, 33 and 19%, respectively, compared with non-stored rice.

Protein isolation caused significant changes in the RVA curves of non-stored rice flour (Figure 1 and Table 2). Peak viscosity of non-stored rice decreased in dealbumin rice (24%), deglobulin rice (44%) and deprolamin rice (3%), but increased 15% in deglutelin rice. Decreases in pasting temperature were observed in dealbumin rice, deglobulin rice, deglutelin rice and deprolamin rice. The pasting temperature of rice before storage decreased in dealbumin rice (15°C), deglobulin rice (2°C), deglutelin rice (14°C) and deprolamin rice (16°C). Decreases in setback

were observed in dealbumin rice (14%), deglutelin rice (4%) and deprolamin rice (20%), with setback increasing by 6% in deglobulin rice. Final viscosity of non-stored rice decreased in dealbumin rice (14%), deglobulin rice (15%) and deglutelin rice (39%), but increased 2% in deprolamin rice.

Protein isolation caused significant changes in the RVA curves of stored rice (Figure 1 and Table 2). Decreases in peak viscosity were observed in dealbumin, deglobulin and deglutelin stored rice compared with deprotein non-stored rice. Peak viscosity decreased 50% in dealbumin rice, but increased in deglobulin rice (34%), deglutelin rice (13%) and deprolamin rice (23%). Decreases in pasting temperature after storage were observed in dealbumin rice (15°C), deglutelin rice (15°C) and deprolamin rice (7°C). Setback decreased in dealbumin rice (58%), deglobulin rice (5%), deglutelin rice (43%) and deprolamin rice (35%). Final viscosity decreased in dealbumin rice (61%), but increased in deglobulin rice (23%), deglutelin rice (3%) and deprolamin rice (9%).

DISCUSSION

Deprotein caused significant alterations in the RVA curves of non-stored Khao Dawk Mali 105 rice flour and stored rice. The physicochemical properties of each type of deprotein rice altered in all samples and storage affected the RVA behavior

of rice as shown in Figure 1B-E. Other researchers have reported an increase in peak viscosity during storage of rice at temperatures of 37, 20, and 3°C (Perdon *et al.*, 1997) and at 26°C (Sowbhagya and Bhattacharya, 2001). The current study used ambient temperature (27-30°C) over the seven

months of storage, which may have obscured the rise in peak viscosity.

Deprotein also decreased the rate of swelling of starch granules, as measured by the slope of the pasting curve (Figure 1B-E). Consequently, higher temperatures were needed

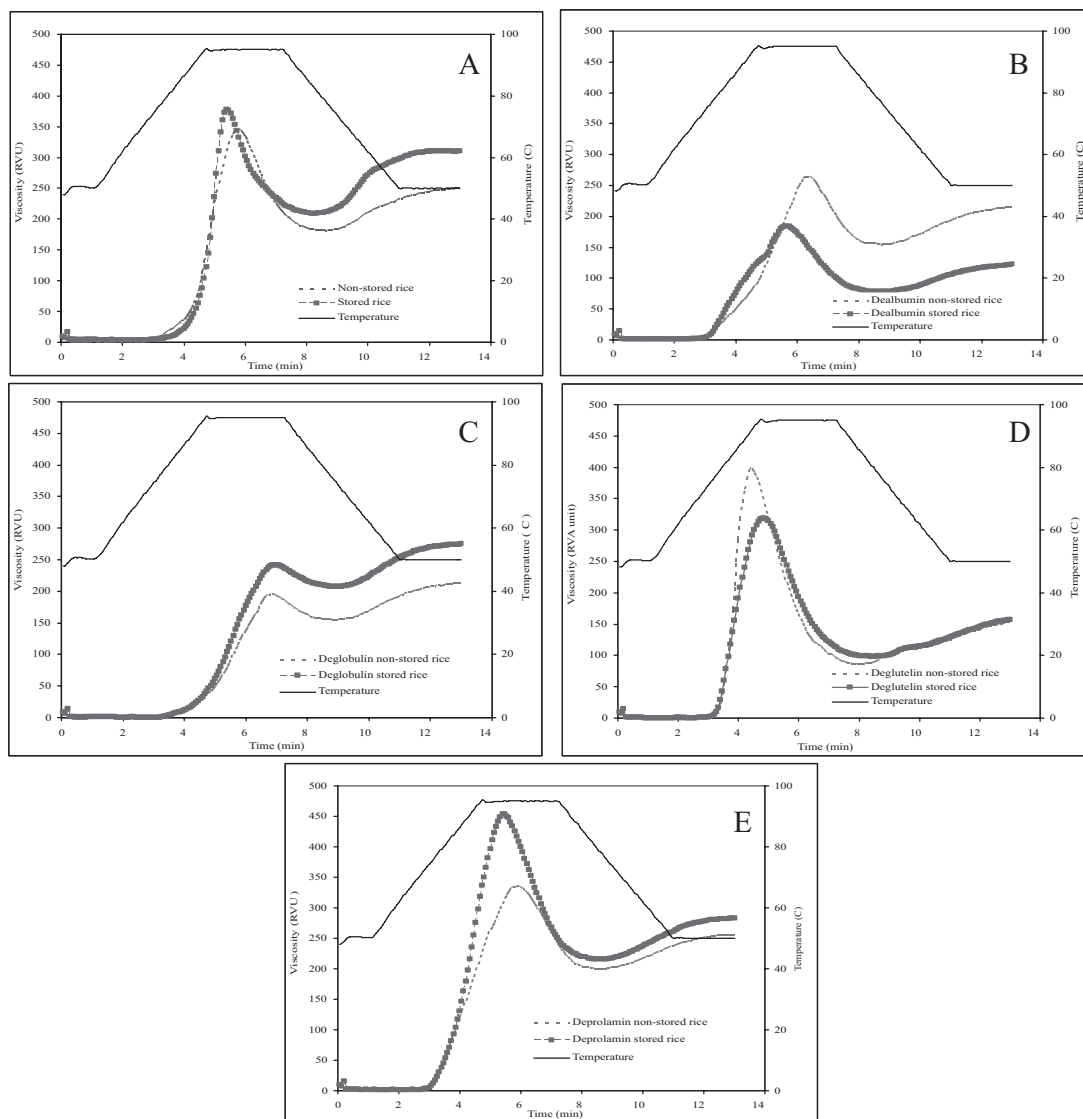


Figure 1 Representative comparative viscosity profiles of: (A) non-stored rice flour and seven-month stored rice flour; (B) dealbumin non-stored rice flour and dealbumin seven-month stored rice flour; (C) deglobulin non-stored rice flour and deglobulin seven-month stored rice flour; (D) degluteulin non-stored rice flour and degluteulin seven-month stored rice flours; and (E) deprolamin non-stored rice flour and deprolamin seven-month stored rice flour.

for starch swelling and viscosity development. Both non-stored rice and stored samples of dealbumin, deglutelin, deprolamin and deprotein rice showed a decrease in (or had decreased) pasting temperature compared with the non deprotein samples, while only the aged deglobulin rice showed no decrease in pasting temperature as a result of storage. A decrease in pasting temperature was probably related to protein components, and as a result, less time and energy were required to increase the viscosity of the gelatinized starch. However, the decrease in the pasting slope shows that for the deprotein samples, more time and energy were required to increase the viscosity of the gelatinized starch.

The cause of the altered starch granule swelling pattern in the deprotein and non-deprotein non-stored and stored rice samples probably indicated the changes in the protein composition and starch. Decreased amounts of albumin, globulin and prolamin before storage and decreased amounts of albumin, globulin and glutelin after storage, probably related to interactions within the starch granule, which may have been 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 have been related to the storage time affecting the interaction of starch and protein compositions.

The decreased swelling behavior of starch may have been related to the altered associations of amylose with amylopectin during annealing (Tester and Debon, 2000). A 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, a decrease in 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 (Hamaker and Griffin, 1993). Storage might increase the organization within the rice kernel, making it more

Table 2 Effect of albumin, globulin, glutelin and prolamin removal on RVA pasting properties of non-stored rice flour and stored rice flour cv. Khao Dawk Mali 105.

Protein	Pasting temp. (°C)	Peak viscosity	Setback	Final viscosity
Non-stored rice flour				
Native	93.05 ± 0.71 ^a	346.08 ± 0.59 ^a	69.58 ± 1.24 ^a	250.83 ± 0.29 ^a
Dealbumin	79.35 ± 0.60 ^b	264.83 ± 4.12 ^b	60.00 ± 0.65 ^b	215.00 ± 1.59 ^b
Deglobulin	91.25 ± 0.46 ^c	195.67 ± 1.83 ^c	73.75 ± 1.41 ^c	212.50 ± 1.77 ^c
Deglutelin	80.05 ± 0.07 ^b	398.42 ± 5.42 ^d	66.75 ± 1.41 ^d	152.75 ± 1.24 ^d
Deprolamin	77.75 ± 0.67 ^d	335.08 ± 3.00 ^e	56.00 ± 0.17 ^f	256.17 ± 1.06 ^e
Stored rice flour				
Native	93.90 ± 0.53 ^a	367.08 ± 0.59 ^f	103.58 ± 1.30 ^g	309.25 ± 0.88 ^f
Dealbumin	80.15 ± 0.53 ^b	183.58 ± 0.12 ^g	43.92 ± 0.82 ^h	122.00 ± 0.47 ^g
Deglobulin	93.90 ± 0.60 ^a	241.83 ± 4.06 ^h	98.08 ± 2.30 ⁱ	274.75 ± 1.41 ^h
Deglutelin	80.10 ± 0.03 ^b	318.75 ± 6.66 ⁱ	58.92 ± 1.24 ^j	156.83 ± 1.03 ⁱ
Deprolamin	87.25 ± 1.06 ^c	453.17 ± 1.77 ^j	67.33 ± 0.53 ^d	282.58 ± 1.53 ^j

Data are means of at least two analyses ± standard deviation. Results with the same letter in the same column are not significantly different ($P \leq 0.05$).

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 (Zhou *et al.*, 2003). These changes were dependent upon storage temperature and occurred more quickly at higher storage temperatures.

CONCLUSIONS

This study has demonstrated that the isolated rice protein fractions affected the 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 behavior of the paste/gel throughout breakdown and lift-off from the trough. Taken together, the results demonstrated that storage proteins influenced the viscosity curves probably through binding water, which caused the concentration of the dispersed and viscous phases of gelatinized starch. Removal of storage proteins affected the viscosity peak value. According to the pasting curve, proteins may affect the amount of water the rice absorbs during the pasting process, and the water available in the early in pasting process will determine the hydration of the protein and the concentration of the dispersed and viscous phases of the starch.

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