

Effect of Coating Substance on Texture and Retrograded Properties of Frozen Cooked Brown Rice

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ABSTRACT

Three rice varieties : Niaw San-Pah-Tong (Br1), Khao Dawk Mali105 (Br2) and Khao Tah-Haeng17 (Br3) (6.32, 15.65 and 22.02 % amylose content) were milled to be brown rice and cooked in electric rice cooker and coated with 10 percent coating substance, freeze-dried at -30°C and stored at -18°C . The frozen cooked brown rice with coating substance was determined for texture and retrograded properties after 5 cycles of freeze-thaw compared to uncoated cooked brown rice. The results showed that the coated cooked brown rice was significantly ($P>0.05$) less in hardness (89.29, 125.10 and 127.83 N) than uncoated cooked brown rice (97.05, 132.92 and 190.10 N) for the three rice varieties; Br1, Br2 and Br3 after 5 cycles of freeze-thaw. Similar results were found for the retrograded properties which showed that the coated cooked brown rice was significantly ($P>0.05$) less in retrogradation (1.88, 2.38 and 3.02 J/g) than uncoated cooked brown rice (2.57, 2.97 and 3.64 J/g) for the three rice varieties; Br1, Br2 and Br3 after 5 cycles of freeze-thaw.

Key words: brown rice, freeze-thaw cycles, retrogradation, coating substance

INTRODUCTION

Brown rice (rice after the hull is removed) consists of a pericarp (about 2%), seed coat and aleurone (about 5%), germ (2-3%) and endosperm (89-94%) while milled rice consist of mainly endosperm after the abrasive milling removed the outer material tissues. So brown rice contains higher nutrients such as protein, fat, fiber, ash, vitamins, minerals and aroma than milled rice, excepts starch content. As brown rice still contains pericarp and other outer tissues, so it takes more time to cook and rougher texture than milled rice. Now a day, the consumers concern more about health but also prefer convenients, especially main dishes as cooked rice. The frozen food products are retained nutrients and freshness better than

other processed food products (such as canning or drying products). The frozen cooked brown rice will be one of nutritious and convenient food products for the modern consumers.

Lima and Singh (1993) measured the retrogradation in cooked rice during storage. They found that during storage of cooked rice, retrogradation of starch led to an increase in hardness as well as a decrease in the adhesion of cooked rice, resulted in a firmer texture with greater separation of individual kernels, and a dry appearance. Minimum retrogradation in cooked rice was observed at a storage temperature of -4°C for short grain rice (0% amylose). Medium (17.4% amylose) and long (25.4% amylose) grain rice varieties require temperature below -4°C for reducing retrograded levels.

Perdon *et al.* (1999) investigated the effect during storing cooked milled medium amylose content (16%) rice variety (Bengal) and high amylose content (25%) rice variety (Cypress) at -13, 3, 20, and 36°C on texture and degree of starch retrogradation. The results showed that during storage at -13 and 3°C, the cooked rice firmness increased, while stickiness decreased, but not at 36°C. At 20°C, retrogradation occurred in Cypress, but not in Bengal.

The objective of this research was to determine the effect of coating substance which was developed to decrease the hardness and retrogradation in three frozen cooked brown rice samples on texture and retrograded properties after 5 cycles of freeze-thaw.

MATERIALS AND METHODS

Materials

Three rice varieties : Niaw San-Pah-Tong (Br1), Khao Dawk Mali 105 (Br2) and Khao Tah-Haeng 17 (Br3) were used in this experiment. Br1 and Br3 were purchased from Rice Research Institute (Bangkhen) which were dehulled to be brown rice and kept at -18°C before cooking. Br2 was a commercial rice purchased from Karasinrungreong 3 Mill and was kept at -18°C before cooking. These three rice varieties were analyzed for moisture, protein and fat contents using AOAC (1990) method while their amylose were determined by the method of Juliano (1971).

Preparation of coating substance

The coating substance was prepared by mixing boiled Pandan leaf water (about 60%) with the mixture of emulsifiers, rice bran oil, modified starch, calcium propionate and gums to be 100% until the mixture was homogeneous and kept at 8°C before used.

Cooking method

Br1, Br2 and Br3 brown rice were cooked

in electric rice cooker using the ratio between rice : water of 1:1.4, 1:1.5 and 1:1.7, respectively. The cooked brown rice was divided into 2 parts. One part was coated with 10 percent coating substance and another part was uncoated, both were placed in each cup. They were frozen at -30°C by using contact plate freezer and stored at -18°C (in normal freezer) before analyzing.

Freeze-thawing stability

Three cooked brown rice (Br1, Br2 and Br3) which was uncoated and coated with the coating substance, were stored in the freezer (-18°C) for 5 days. Then thawing was done at 30°C for 1.5 hours, to determine freeze-thaw stability by measuring the hardness and the retrogradation. The remaining samples were kept in the freezer for further freeze-thaw cycle. Five cycles of freeze-thaw were done in this study.

Texture measurement

The Ottawa cell of Texture Analyser (TA-Xt2) was used to measure the hardness of cooked brown rice. Thirty grams of cooked brown rice gently placed in the Ottawa cell. This cell consists of an extrusion plate 3 mm. in diameter and a square shape plunger that travels through the cell while extruding the rice sample. The test speed for measuring was set at 0.5 mm/sec until reaching 70% of sample height, after that the plunger automatically returned to the initial position. Hardness was defined as the maximum force (in Newton) required to compress 30 g of cooked brown rice through the extrusion plate (Stable Micro System, 1995).

Starch retrogradation measurement

After thawing, three cooked brown rice (Br1, Br2 and Br3) were dehydrated by adding 95% ethanol (1:4 w/w) for 10 min and dried at room temperature. The dried samples were ground and passed through 100 mesh sieve.

The starch retrogradation was analyzed by

using a Perkin-Elmer Pyris 1 Differential Scanning Calorimeter (DSC). Before analyzing, 30% (w/w) of sample was prepared and kept at room temperature for overnight. At least 12 to 13 mg of sample was weighed and placed on an aluminum pan and hermetically sealed. The scanning temperature range was 20 to 90°C at the speed of 10°C/min. The thermogram for retrograded starch enthalpy energy (ΔH , J/g) required to melt the crystalline material was used as an index of recrystallinity in the samples (modified method from Hibi *et al.*, 1990 and Kim *et al.*, 1997).

RESULTS AND DISCUSSIONS

Chemical properties

Three brown rice samples; Br1, Br2 and Br3 were analyzed for their moisture, protein, lipid and amylose content (Table 1). Moisture content of three brown rices ranged between 12.27-12.87% which were appropriated for quality stability (Ministry of Commerce, 1997). Protein content ranged between 7.28-9.81%, lipid content ranged between 2.36-3.0% which were similar to the results of Marshall and Wadsworth (1994) which reported that protein content in brown rice ranged between 8.3-9.6%, lipid content ranged between 2.1-3.3%. The amylose content of Br1, Br2 and Br3 were 6.52, 15.65 and 22.02% and were classified to glutinous rice, low amylose rice and high amylose rice, respectively.

Texture properties

The hardness value of three cooked brown rice varieties were average from 0 to 5 cycles of freeze-thaw showed significant ($P>0.05$) interaction among three varieties, which were 159.96, 129.02 and 93.18 N for Br3, Br2 and Br1, respectively (Figure 1). Br3 had the highest hardness value which showed the fast increasing from 0 to 2 cycles of freeze-thaw and slightly decreasing from 2 to 5 cycles of freeze-thaw. Br2 had lower hardness value than Br3 which showed increasing from 0 to 4 cycles of freeze-thaw and decreasing from 4 to 5 cycles of freeze-thaw. Br1 had the lowest hardness value which showed similarly changing to Br2 (Figure 1). After 5 cycles of freeze-thaw, appearance of Br3 was greater separation of individual kernels and dryer appearance (Figure 2) than the other two samples (Br1 and Br2).

Lima and Singh(1993) reported that long grain (25.4% amylose) cooked milled rice showed the highest in hardness (299.99 N) followed by medium grain (17.4% amylose) cooked milled rice (82.84 N) and short grain (0% amylose) cooked milled rice was the lowest in hardness (57.34 N), during storage at 10 days. Similarity, Perdon *et al.* (1999) reported that Cypress cooked milled rice (25% amylose) was higher in hardness than Bengal cooked milled rice (16% amylose). The results of cooked milled rice were similar to these cooked brown rice that amylose content might affected

Table 1 Chemical properties of three brown rice varieties.

Sample ¹	Br1	Br2	Br3
Moisture (%) ²	12.87 a	12.27 b	12.78 a
Protein (%) ²	8.80 b	7.28 c	9.81 a
Lipid (%) ²	2.59 b	3.0 a	2.36 c
Amylose content (%) ²	6.32 c	15.65 b	22.02 a

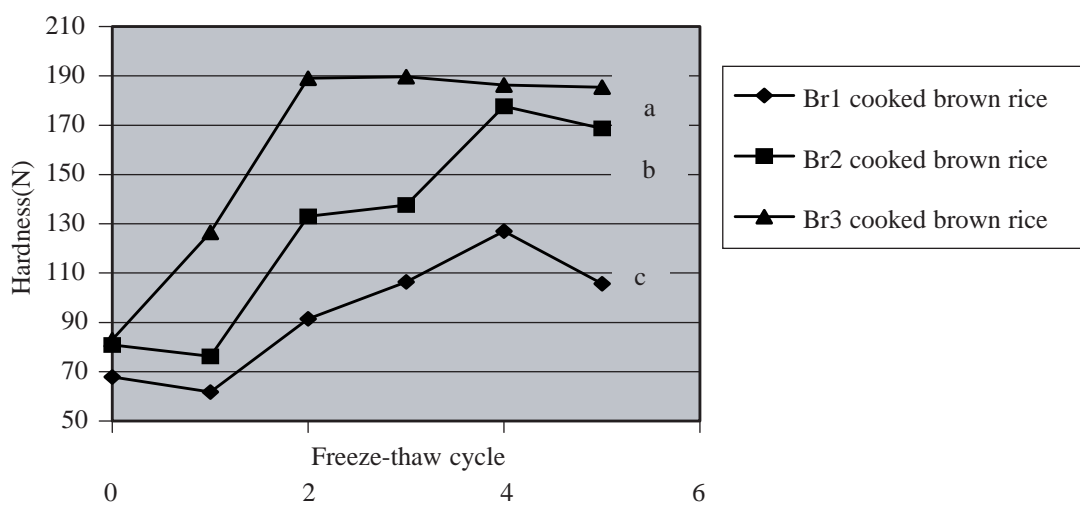
¹ Average of duplicated determination.

² Means within the same row followed by different letter are significantly different ($P>0.05$)

the changing of texture properties. Br3 (high amylose rice) had the highest hardness value followed by Br2 (low amylose rice) and Br1 (glutinous rice) had the lowest hardness value.

The hardness of cooked brown rice which was uncoated and coated with coating substance after 5 cycles of freeze-thaw showed that Br3 (22.0 % amylose) had the highest hardness value, followed by Br2 (15.7% amylose) and Br1 (6.3% amylose) had the lowest hardness value for

uncoated samples. The Br1 sample was not significantly different between uncoated and coated samples during 0 – 4 cycles of freeze-thaw, but significantly different at 5 cycle of freeze-thaw. The Br2 sample gave the similar results as Br1, except at the 2 cycle of freeze-thaw which was significantly different between uncoated (116.87 N) and coated (149.17 N) samples. The Br3 sample showed the significant different between uncoated samples of each cycle of freeze-thaw



a,b,c shows significantly different (P>0.05).

Figure 1 Hardness of cooked brown rice; Br1, Br2 and Br3 from 0 to 5 cycles of freeze-thaw.



Figure 2 Comparison of (a) fresh cooked brown rice (Br3) and (b) cooked brown rice after 5 cycles of freeze-thaw.

(Table 2).

The average value of hardness from 0 to 5 cycles of freeze-thaw within the same rice variety was compared between the uncoated and coated sample (Figure 3). Three cooked brown rice samples; Br1, Br2 and Br3 coated with the coating

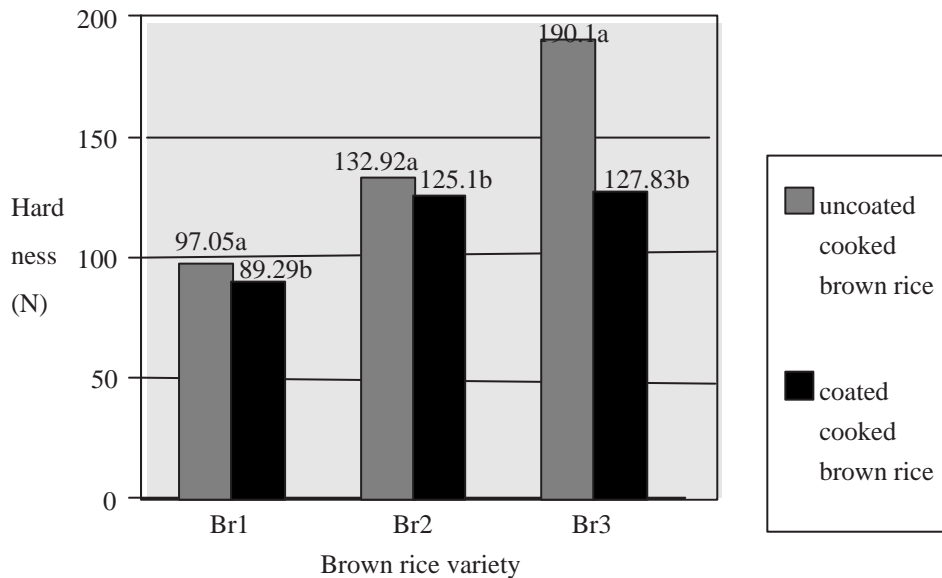
substance showed significantly ($P>0.05$) less hardness (89.29, 125.10 and 127.83 N) than the uncoated samples (97.05, 132.92 and 190.10 N). The result indicated that coating substance had the effect on decreasing the hardness of texture for all three cooked brown rice samples.

Table 2 Hardness of cooked uncoated and coated brown rice after each cycle of freeze-thaw.

Freeze-thaw cycle	Hardness (N) ¹					
	Niaw San-Pah-Tong ² (Br1)		Khao Dawk Mali105 ² (Br2)		Khao Tah-Haeng17 ² (Br3)	
	Uncoated	Coated	Uncoated	Coated	Uncoated	Coated
0	60.98f	74.68def	81.59e	80.06e	105.88g	60.0h
1	63.49ef	60.08f	80.98e	71.42e	143.61def	109.37fg
2	98.80bc	84.10cde	116.87d	149.17c	199.74bc	178.34cd
3	100.56bc	112.22b	142.31c	133.0cd	247.71a	131.66efg
4	135.04a	114.34ab	180.36ab	174.77b	239.71a	132.83efg
5	123.51ab	90.32cd	195.27a	142.21c	215.95ab	154.76de

¹ Average of duplicated determination.

² Means within the same variety, followed by different letters are significantly different ($P>0.05$).



a,b within the same variety is significantly different ($P>0.05$).

Figure 3 Comparison the average hardness of cooked brown rice samples; Br1, Br2 and Br3 uncoated and cooked with coating substance from 0 to 5 cycles of freeze-thaw.

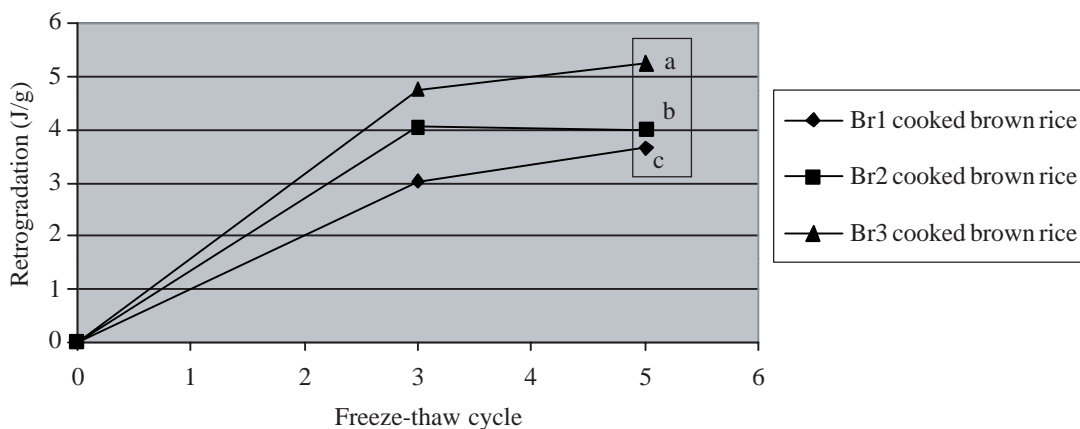
Retrogradation properties

Three cooked brown rice samples showed significantly difference in retrogradation. The retrogradation from 0 to 5 cycles of freeze-thaw were 2.22, 2.68 and 3.33 J/g (dry weight) for the Br1, Br2 and Br3, respectively (Figure.4). These varieties were fast increasing retrogradation from 0 to 3 cycles of freeze-thaw and slowly increasing from 3 to 5 cycles of freeze-thaw, except Br2. The Br3 was the highest retrogradation followed by Br2, while Br1 was the lowest retrogradation.

The retrograded properties of cooked brown rice which was uncoated and coated with coating

substance after 5 cycles of freeze-thaw showed the significant different within the same rice variety for each cycle of freeze-thaw (Table 3).

Three brown rice samples; Br1, Br2 and Br3 coated with coating substance showed significantly less in retrogradation (1.88, 2.38 and 3.02 J/g) than the uncoated samples (2.57, 2.97 and 3.64 J/g). The average value of retrogradation from 0 to 5 cycles of freeze-thaw within the same rice variety was compared between the uncoated and coated sample (Figure 5). The result showed that the coated substance could reduce retrogradation of cooked brown rice.



a,b,c shows significantly different ($P > 0.05$).

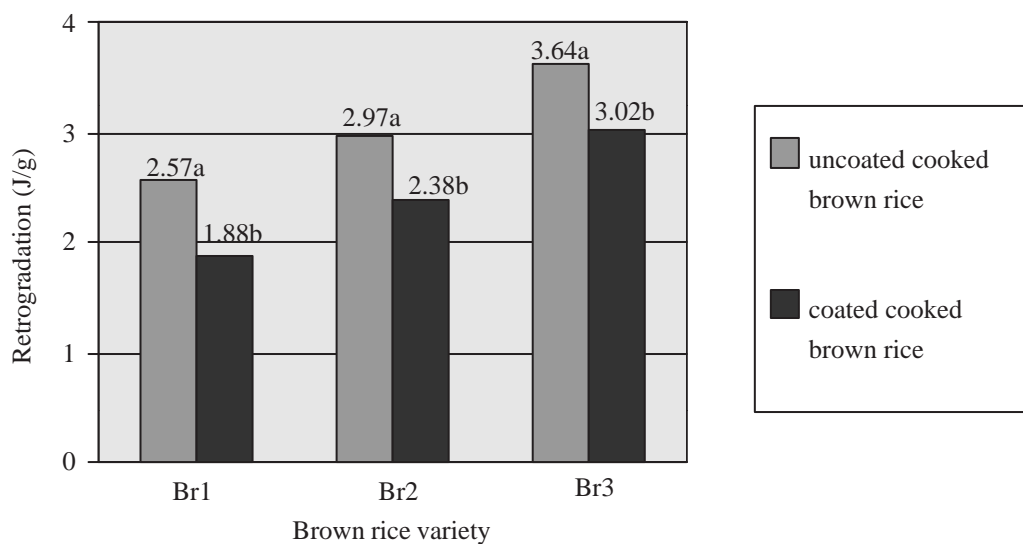
Figure 4 Retrogradation of cooked brown rice; Br1, Br2 and Br3 from 0 to 3 and 5 cycle of freeze-thaw.

Table 3 Retrogradation of cooked uncoated and coated brown rice after each cycle of freeze-thaw.

Freeze-thaw cycle	Retrogradation (J/g) ¹					
	Niaw San-Pah-Tong ² (Br1)		Khao Dawk Mali105 ² (Br2)		Khao Tah-Haeng17 ² (Br3)	
	Uncoated	Coated	Uncoated	Coated	Uncoated	Coated
0	0e	0e	0d	0d	0e	0e
3	3.60b	2.42d	4.56a	3.52c	5.19b	4.34d
5	4.10a	3.21c	4.35b	3.62c	5.74a	4.72c

¹ Average of duplicated determination.

² Means within the same variety, follow by different letters are significantly different ($P > 0.05$).



a,b, within same variety is significantly different ($P>0.05$).

Figure 5 Comparison the average retrogradation of cooked brown rice samples; Br1 ,Br2 and Br3 uncoated and coated with the coating substance from 0 to 5 cycles of freeze-thaw.

CONCLUSIONS

The coating substance and the cycle of freeze-thaw affected the texture and retrogradated properties of frozen cooked brown rice variety. Br3 (high amylose rice, 22.02%) gave the highest changing properties followed by Br2 (low amylose rice, 15.65%) and Br1 (glutinous rice, 6.32%) had the lowest changing properties. Three cooked brown rice samples coated with 10% coating substance were less in retrogradation and hardness than the uncoated samples after 5 cycles of freeze-thaw.

LITERATURE CITED

- AOAC. 1990. **Official Method of Analysis**. 15thed. The Association of Official Analytical Chemists Inc., Virginia. 1298p.
- Hibi, Y.,S. Kitamara and T. Kuge. 1990. Effect of lipid on the retrogradation of cooked rice. **Cereal Chem.** 67(1) : 7-10.
- Juliano, B.O. 1971. A simplified assay for milled rice amylose. **Cereal Sci Today** 16 : 334, 338, 340, 360.
- Kim, J.O., W.S. Kim and M.S. Shin. 1997. A comparative study on the retrogradation of rice starch gel by DSC, X-ray and α -amylase method. **Starch/Stärke** 49(2) : 71-75.
- Lima, I. and R.P. Singh. 1993. Objective measurement of retrogradation in cooked rice during storage. **J. of Food Quality** 16 : 321-337.
- Marshall, W.E. and J.I. Wadsworth. 1994. **Rice Science and Technology**. Marcel Dekker Inc., New York. 470p.
- Ministry of Commerce. 1997. **Thai Rice Standard**. Ministry of Commerce. Bangkok. 142p.
- Perdon, A.A., T.J. Sibenmorgen., R.W. Buescher. and E.E. Gbur. 1999. Starch retrogradation and texture of cooked milled rice during storage. **J. of Food Sci.** 64(5) : 828-832.
- Stable Micro System. 1995. **Texture Analyser**. Stable Micro System, Surrey, England. 77 p.