KMITL Sci. Tech. J. Vol. 9 No. 1 Jan. - Jun. 2009

The Retrogradation of Canned Rice During Storage

Woatthichai Narkrugsa[1]* and Mayyawadee Saeleaw [2]

[1] Faculty of Agro Industry, King Mongkut Institue of Technology Ladkrabang, Chalongkrung Road, Bangkok 10520, Thailand
[2] Faculty of Home Economic Technology, Rajamongkala University of Technology Krungthep, Chareonkrung Road, Bangkok 10120, Thailand

Abstract

The retrogradation of canned rice products from three milled rice varieties, i.e., Thai Hom Mali (17.25% amylose, db.), Kaotahang (33.52% amylose, db.) and Koshihikari (15.55% amylose, db.) during storage at room temperature (27^0-29^0C) for 8 months was conducted. Canned rice was sterilized at 116 °C with F_0 1 and 5 min. Retrogradation of gelatinized canned rice was studied by measuring hardness of rice kernel with Modified Single Kernel method. It was found that during storage the hardness of the rice kernels increased with the duration of the storage time (r=0.48 at $p \leq 0.05$). Canned rice produced from high amylose rice variety (Kaotahang) had significantly higher retrogradation than the low amylose rice (Thai Hom Mali) (r=0.85 at $p \leq 0.01$). Comparing the effects of sterilization (F_0) and storage time on hardness of the low amylose rice varieties, Koshihikari (L/W= 1.67, short grain) and Thai Hom Mali rice (L/W =3.19, long grain), both varieties had similar chracteristics of retrogradation throughout the storage time even though the L/W ratio was different. The hardness of rice kernel sterilized at F_0 5min was lower than at F_0 1min. The longer the rice products were stored, the higher the retrogradation (r = 0.90 at $p \leq 0.01$).

Keywords: retrogradation, hardness, canned rice, storage

1. Introduction

Canned rice is a ready-to-eat product consumed as a whole grain cereal product. It is produced by packing cleaned milled rice into a can together with liquid, such as soup or water (wet pack) or without liquid (dry pack), and then sterilizing as described by Luh [1]. Starch gelatinization in the rice kernels during thermal processing by steam contribute to the change of texture as reported by Morrison and Tester [2], Narkrugsa [3, 4], Perdon *et al*. [5] and Sasaki *et al*. [6]. During storage or cooling, the starch in the cooked milled rice undergoes retrogradation .The amylase fraction retrogrades immediately while the amylopectin remain in an amorphous state. The amylopectin fraction either reassociates or recrystalizes during storage and contributes to starch retrogradation as shown by Juliano *et al*. [7], Fedriksson *et al*. [8], Singh *et al*.[9]. The texture of cooked milled

*Corresponding author: Tel: 662-737-3000 ext. 3579 Fax: 662-326-4091
E-mail: knwoaith@kmitl.ac.th

rice kernels is also changed. Most of the retrogradation studies is related to the texture or mechanical change, especially hardness and the changes of gelatinized starch in the rice kernels [5-7, 10-16]. The objective of this experiment was to determine the effects of the amylose content, sterilization (F_0) and the shape of the rice kernel (L/W ratio) on starch retrogradation in three varieties of canned rice during storage.

2. Materials and Methods

2.1 Materials

Three milled rice varieties used in the experiments were bought from various Thai companies. Thai Hom Mali, a low amylose indica rice variety was bought from Capital Rice Co., Ltd, Thailand; Kaotahang, a high amylose indica rice variety was bought from Chia Meng Rice Mill Co, Ltd, Thailand, and Koshihikari, a low amylose japonica rice variety was bought from Asia Inter Rice Company,Thailand.

2.2 Methods

2.2.1 Analysis of nutrients, physicochemical properties and cooking quality

Proximate analysis was determined by the method of AOAC [17] and carbohydrate computed by total difference. Amylose was analysed by the method of Juliano [18]. L/W ratio, weight per 1,000 grains were measured while cooking quality test was performed according to the method of Batcher *et .al*. [19].

2.2.2 Canned rice production

Canned rice was prepared according to the method described by Narkrugsa [3, 4] as shown in Figure1. Milled rice was cleaned by washing with water before cooking in a steam jacket kettle at 85^0C for 5 min with excess water. After cooking the liquid part was drained from the partial cooked rice kernels. Cooked rice (180g) was then packed into cans (307x113). Then passed through the exhauster with steam temperature at 80^0-85^0C for 10min and the cans were steamed. The partial cooked rice was sterilized in a retort at 116^0C for Fo =1 and 5min. The canned rice was cooled with tap water until the temperature of the cans dropped to 60^0-65^0C.

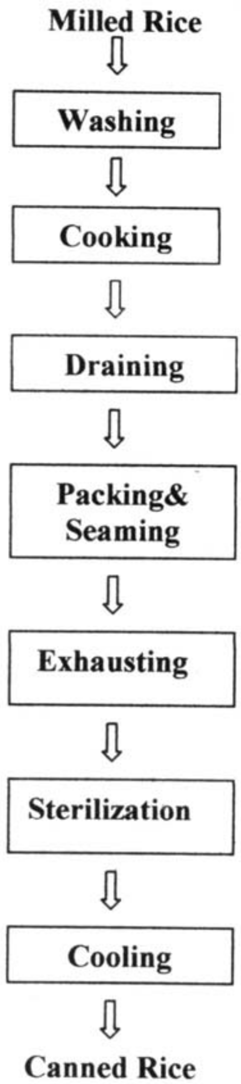

Figure 1 Flow chart of canned rice production.

2.2.3 Determination of retrogradaton of rice kernels

Hardness was used to express the retrogradation of cooked milled rice in the can during storage at room temperature (27^0-29^0C). Texture Analyzer TA-XT2i (Stable Micro Systems, SMS Surrey, England) was used to measure the hardness by the Modified Single Kernel Method of Okabe [20]. Three grains of rice kernels from the center of can were placed on the measurement stage 1 cm equidistant from each other. The kernels were compressed with a 75mm diameter probe at a speed of 1.5mm/sec. Hardness of rice kernels was measured every 0, 1, 2, 4, 6 and 8 months

2.2.4 Effects of sterilization level (Fo) and amylose content on retrogradation

This experiment used the 2^2 factorial design in CRD and contained 2 factors, amylose content (Thai Hom Mali, a low amylose rice; and Kaotahang, a high amylose rice) and the sterilizing values (Fo) 1 and 5 minutes. Canned rice stored at room temperature for 8 months was measured for retrogradation. Analysis of the experimental data was performed using ANOVA at 1 and 5% levels. The correlation coefficient (r) between hardness and the storage time were statistically analysed. The multiple regression model of the retrogradation was also simulated by computer software program, Trial Statgraphics Plus version 5 (Statistical Graphics Corps).

2.2.5 Effects of sterilization level (Fo) and shape of rice kernel (L/W ratio) on retrogradation

Rice with low amylose i.e.Thai Hom Mali (L/W ratio =3.19) and Koshihikari (L/W ratio =1.67) were studied. The 2^2 factorial design in CRD with Fo (1, 5 min) and L/W ratio (1.67, 3.19) as factors was used. Measurement of hardness during storage at room temperature for 8 months was performed. The correlation coefficient (r) between the hardness of the rice kernels and storage time was also computed.

3. Results and Discussion

Milled rice of three varieties used in this experiment had very low fat, ash and crude fibers while carbohydrate was very high (about 80%) as shown in Table1. Protein values were 6.63% (Thai Hom Mali), 5.75% (Kaotahang) and 6.36% (Koshihikari). Kaotahang variety had the highest amylose (33.52%) while Thai Hom Mali (17.25%) and Koshihikari (15.5%) had low amylase values.

Table 1 Nutrients and amylose content of the three milled rice varieties.

Rice variety	Moisture content (%)	Fat (%)	Protein (%)	Ash (%)	Crude Fiber (%)	Carbohydrate (%)	Amylose (%)
Thai Hom Mali	11.92±0.01	0.27±0.01	6.63+0.02	0.24±0.01	0.28±0.02	80.66±0.02	17.25±0.03
Kaotahang	12.82±0.02	0.38±0.01	5.75±0.02	0.31±0.01	0.32±0.01	80.42±0.02	33.52±0.03
Koshihikari	12.68±0.02	0.21±0.02	6.36±0.02	0.22±0.01	0.19±0.01	80.34±0.02	15.55±0.02

[1/]The data in the table are means and standard deviations from 3 replicates.

From Table 2, the results indicate that Thai Hom Mali (L/W=3.20) and Koatahang (L/W= 3.31) were long grain rice (Indica type) while Koshihikari (L/W=1.67) was short grain (Japonica type). Kaotahang had the highest volume expansion (2.92 times), water absorption (3.30 times) and total soluble solid (TSS, 6.49%). Koshihikari had the highest weight per 1,000 grains (20.30%) but the lowest water absorption (2.64 times) and volume expansion (2.50 times).

Table 2 Some physicochemical properties and cooking qualities of the three milled rice varieties.

Rice variety	Length,L (mm)	Width,W (mm)	L/W ratio	Weight/ 1000grains, g.	Water adsorption	Volume expansion	Total soluble solids (%)
Thai Hom Mali	7.42±0.03	2.32±0.03	3.20±0.05	17.98±0.02	2.80±0.02	2.67±0.03	5.18±0.03
Kaotahang	6.95±0.03	2.10±0.02	3.31±0.04	19.52±0.03	3.30±0.01	2.92±0.05	6.49±0.03
Koshihikari	4.60±0.02	2.76±0.03	1.67±0.02	20.30±0.02	2.64±0.02	2.50±0.05	6.20±0.02

Note: The data in the table are means and standard deviations from 3 replicates.

After storage of canned rice at room temperature for 8 months, the hardness of the rice kernels with high amylose rice (Kaotahang) was higher than low amylose rice (Thai Hom Mali) from the beginning till the end of storage. As reported by Perdon *et al*. [14], the high amylose rice was able to retrogradate quicker and higher than the low amylase rice. The effects of the amylose and the storage time on hardness of the cooked rice kernels were highly significant (r=0.85 at $p \le 0.01$) and significant (r=0.48 at $p \le 0.05$) respectively, while the sterilizing values (Fo) had no significant effect (Table3). But for low amylose rice (Thai Hom Mali and Koshihikari), the hardness of the rice kernels of canned rice sterilized at Fo=1 was higher than for Fo=5 (Figure2). Retrogradation of canned rice (Y) with the regression equation of the signified factors (amylose, X_1) and storage time (X_2) with a model of fitted (r^2) equal to 0.94 is shown below and in Figure 3.

$$Y = 1.206 + 0.187\ X_1 + 0.295\ X_2 + 0.0015\ X_1X_2 \ldots\ldots\ldots\ldots\ (r^2 = 0.94)$$

Table 3 Correlation coefficients between processing factors and storage time on the retrogradation of rice kernels.

Processing factors/ Storage time	Retrogradation (Hardness)
Amylose content , X_1	0.85**
Sterilizing value(Fo), X_2	-0.08ns
$X_1 * X_2$	0.32ns
Storage time	0.48*

Note: ns = non significant correlation
* = significant correlation at $p \le 0.05$
** = highly significant correlation at $p \le 0.01$

The correlation coefficients were calculated from 72 observations.

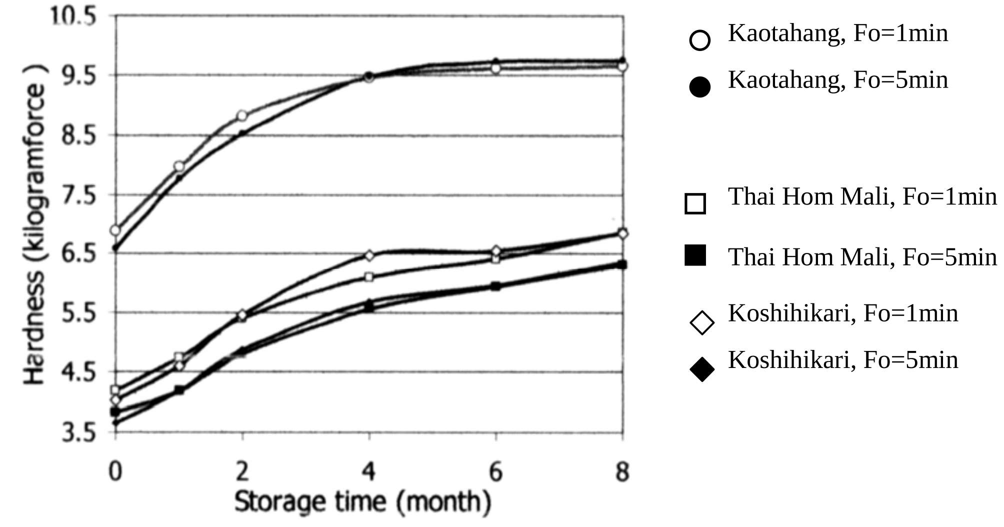

Figure 2 Hardness of the cooked milled rice during storage at room temperature.

$$\mathbf{Y = 1.206 + 0.187\,X_1 + 0.295\,X_2 + 0.0015\,X_1X_2 \quad \ldots\ldots\ldots\ (r^2=0.94)}$$?

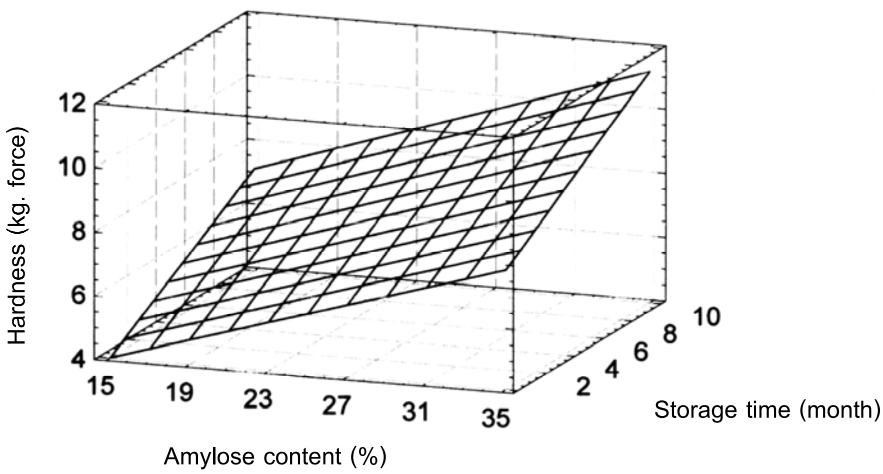

Figure 3 Response surface plot of the retrogradation (hardness) of canned rice during storage at room temperature.

With rice containing a similar amount of amylase (17.25% for Thai Hom Mali Rice and 15.5% for Koshohikari), the results indicate that the shape of the rice kernel (L/W ratio) and sterlization (Fo) did not affect the retrogradation of rice kernels while the storage time was correlated with r=0.90 ($p \leq 0.01$) (Table4). The hardness of the canned rice produced at the same Fo from the two varieties was nearly the same from the beginning of storage till the end (Figure 2).

The effects of sterilization time (Fo) and storage time on the retrogradation were more marked for the low amylose rice varieties than for high amylose rice. Fredriksson *et al*. [8] and Vandeputte *et al*. [17] have shown that the amylopectin fraction of the rice starch may play an important role in changing or recrystalisation in the rice kernels during storage. This would affect the texture of the rice kernels making them harder, especially the high amylose rice, like the results shown in the experiments of Champagne *et al*. [10], Lima and Singh [8], Okabe [13], Perdon *et al*. [14], Perez and Juliano [15] and Singh *et al*. [19].

Table 4 Correlation coefficients between factors and storage time on the retrogradation of canned low amylose rice

Factors/Storage time	Retrogradation(Hardness)
Sterilizing value(Fo) , X_1	-0.28ns
L/W ratio , X_2	0.02ns
X_1*X_2	-0.22ns
Storage time	0.90**

Note: ns = non significant correlation
* = significant correlation at $p \leq 0.05$
**= highly significant correlation at $p \leq 0.01$
*The correlation coefficients were calculated from 72 observations.

4. Conclusions

Retrogradation of cooked milled rice from low and high amylose rice occurred during storage at room temperature. Amylose content and storage time significantly affected the hardness of the rice kernels, especially for high amylose rice. Sterilizing value (Fo) and kernel shape (L/W ratio) did not significantly affect retrogradation. The longer the storage time the higher the retrogradation.

References

[1] Luh, B.S. **2001.** Rice production. In: Owen, G., Ed. *Cereal Processing Technology*. Woodhead Publishing Limited, Cambridge, England.
[2] Morrison, W.R. and Tester, R.F. **1991**. Chemical and Physical Factors that Affect the Gelatinisation and Swelling of Cereal Starches. *Cereal International*, Sep, 138-137.
[3] Narkrugsa, W. **1996**. Study on Thermal Processing of Canned Rice. *Journal of the National Research Council of Thailand*, *28*(2), 243-258**.**
[4] Narkragsa, W. **1998**. Industrialized Processing of Canned Rice. Thailand Patent No.9584.
[5] Perdon, A.A., Siebenmorgen, T.J., Buescher, R.W. and Gbur, E.E. **1999**. Starch Retrogradation and Texture of Cooked Milled Rice During Storage. *Journal of Food Science*, *64*(5), 828-832.
[6] Sasaki, T., Yasui, T. and Matsuki, J. **2000**. Effect of Amylose Content on Gelatinization, Retrogradation, and Pasting Properties of Starches from Waxy and Nonwaxy Wheat and Their F1 Seeds". *Cereal Chemistry*, *77*(1), 58-63.

[7] Juliano, B.O, Perez, C.M., Villareal, C.P., Tonogai, J. and Billiaderis, C.G. **1991**. Role of Amylopectin in Varietal Differences in Hardness of Cooked Rice and Starch Gels: A Status Report. *Cereals International*, Sep., 143-146.
[8] Fredriksson, H., Silverio, J., Anderson, R., Eliasson, A.C. and Aman, P. **1998**. The Influence of Amylose and Amylopectin Characteristics on Gelatinization and Retrogradation Properties of Different Starches. *Carbohydrate Polymer*, *35*,119-134.
[9] Singh, N., Singh, J., Kaur, L., Sodhi, N.S. and Gill, S.B. **2003**. Morphological, Thermal and Rheological Properties of Starches from Different Botanical Sources. *Food Chemistry*, *81*, 219-231.
[10] Champagne, E.T., Lyon, B.G., Min, B.K., Vinyard, B.T., Bett, K.L., Barton II, F.E., Webb, B.D., McClung, A.M., Moldenhauer, K.A., Linscombe, S., McKenzie, K.S. and Kohlway, D.E. **1998**. Effect of Postharvest Processing on Texture Profile Analysis of Cooked Rice. *Cereal Chemistry*, *75*(2), 181-186.
[11] Chang, M.S. and Liu, L.C. **1991**. Retrogradation of Rice Starches Studied by Differential Scanning Calorimetry and Influence of Sugars, NaCl and Lipids. *Journal of Food Science*, *56*(2), 564-570.
[12] Lima, I. and Singh, R.P. **1993**. Objective Measurement of Retrogradation in Cooked Rice During Storage. *Journal of Food Quality*, *16*, 321-337.
[13] Perez, M.C. and Juliano, B.O. **1981**. Texture Changes and Storage of Rice. *Journal of Texture Studies*, *12*, 321-333.
[14] Qi, X., Tester, R.F., Snape, C.E. and Ansell, R. **2002**. Molecular Basis of The Gelatinization and Swelling Characteristics of Waxy Rice Starches Grown in the Same Location During the Same Season. *Journal of Cereal Science*, *37*, 363-376.
[15] Riva, M., Fessas , D. and Schiraldi, A. **2000**. Starch Retrogradation in Cooked Pasta and Rice. *Cereal Chemistry*, *77*(4), 433-438.
[16] Vandeputte, G.E., Vermeylen, R., Geeroms, J. and Delcour, J.A. **2003**. Rice Starch III. Structural Aspects Provide Insight in Amylopectin Retrogradation Properties and Gel Texture. *Journal of Cereal Science*, *38*, 61-6
[17] AOAC. **1995**. *The Association of Official Analytical Chemists, Official Method of Analysis.* 16^{th} edition. Arlington,Virginia.
[18] Juliano, B.O. **1971**. A Simplified Assay for Milled-Rice Amylose. *Cereal Science Today*, *16*, 334-340.
[19] Batcher, O.M., Helmintoller, K.F. and Dawson, E.H. **1956**. Development and Application of Methods for Evaluation Cooking and Eating Quality of Rice. *Journal of Rice*, *59*, 4 -8.
[20] Okabe, M. **1979**. Texture Measurement of Cooked Rice and Its Relationship to the Eating Quality. *Journal of Texture Studies*, *10*, 131-152.