บทบาทของอุณหภูมิและอายุการเก็บรักษาต่อองค์ประกอบของไขมัน สมบัติทางกายภาพและเคมีกายภาพของข้าวกล้องพันธุ์ขาวดอกมะลิ 105

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บทคัดย่อ

การเปลี่ยนแปลงไขมันในข้าวเกิดในระหว่างการเก็บรักษา และส่วนประกอบของไขมันมีความสัมพันธ์กับคุณสมบัติของข้าว การวิจัยนี้ได้ศึกษาปริมาณของไขมัน กรดไขมัน และคุณสมบัติของแป้งข้าวกล้องของข้าวพันธุ์ขาวดอกมะลิในระหว่างการเก็บรักษาที่อุณหภูมิ 25 และ 37 องศาเซลเซียส เป็นเวลา 7 เดือน โดยข้าวที่เก็บเกี่ยวใหม่ได้ถูกนำมาลดความชื้นเป็นร้อยละ 15.23 และเก็บไว้ในถุงพลาสติก ผลการทดลองพบว่าสีของข้าวกล้องมีค่าเพิ่มขึ้น แป้งข้าวกล้องมีค่าคงตัวแป้งสุกลดลง กรดไขมันของข้าวที่เก็บไว้ที่อุณหภูมิ 37 องศาเซลเซียส มีปริมาณต่ำกว่าข้าวที่เก็บไว้ที่อุณหภูมิ 25 องศาเซลเซียส การเก็บรักษาทำให้เกิดการเปลี่ยนแปลงของคุณสมบัติความหนืดของแป้งข้าวกล้อง และขึ้นกับระยะเวลาและอุณหภูมิ ข้าวที่เก็บไว้ที่อุณหภูมิ 25 องศาเซลเซียส มีอุณหภูมิแป้งสุกลดลงในขณะที่ข้าวที่เก็บไว้ที่อุณหภูมิ 37 องศาเซลเซียส มีค่าอุณหภูมิแป้งสุกเพิ่มขึ้น การเก็บรักษาข้าวที่อุณหภูมิ 25 องศาเซลเซียสทำให้แป้งข้าวกล้องมีความหนืดเพิ่มขึ้น ในขณะที่การเก็บรักษาข้าวที่อุณหภูมิ 37 องศาเซลเซียส ทำให้แป้งมีความหนืดลดลง ผลการทดลองได้แสดงความสัมพันธ์ระหว่างปริมาณของกรดไขมันและค่าความหนืด การเก็บรักษาภายใต้สภาวะการศึกษานี้ทำให้เกิดการเปลี่ยนแปลงในคุณสมบัติของความหนืดของแป้งข้าวกล้อง ดังนั้นกรดไขมันและองค์ประกอบของไขมันจึงเป็นส่วนหนึ่งของกระบวนการเกิดเป็นข้าวเก่า

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Role of Aging Temperature on Lipid Components, Physical Properties and Physicochemical Behaviour of Brown Rice cv. Khaw Dok Mali 105

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Abstract

Changes in the extent of rice lipids are associated with the storage of rice. Knowledge of the lipid components is essential to an understanding of rice functionality. This study presents data on the lipid, fatty acid contents and pasting properties of brown rice flour following storage of the rice cv. Khaw Dok Mali for up to 7 months. Two storage temperatures, 25 °C and 37 °C were examined as aging process. In this study, the newly harvested paddy was dried to reduce the moisture content to 15.23% and packed in polypropylene bags. The results show that the significant increase between the color of the brown rice and decrease in gel consistency. The fatty acid content of storage rice at 37 °C was lower than that of storage rice at 25 °C in brown rice. Storage produced changes in the RVA pasting properties of the flour as time and temperature dependent phenomenon. The significant change in the pasting property was the decrease in pasting temperature over time of the samples stored at 25 °C while pasting temperature of the samples stored at 37 °C was increase over the storage time. The notable effect was produced by storage temperature treatment which increased PV (peak viscosity) of sample stored at 25 °C and decreased PV of flours from aged (higher temperature storage) rice samples. From the results it was shown the relationship between the total free fatty acid content and PV and this condition tended to cause the changes in viscosity properties of the flour during storage. Aged samples treated in this way suggested that fatty acid and lipid compositions appear as component involved in the aging process.

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1. Introduction

Most physicochemical properties of rice change during storage. As rice aged, cooked rice texture became fluffier and harder [1]. Perdon et al.[2] suggest that rice aging is a complex process that is seen in the native rice grain, brown rice, milled rice, rice starch and cooked rice. One of the most sensitive indices of the aging process in rice was the change in pasting properties which was usually measured by thermoviscometry [2]. The data have been inconsistent but suggest that viscosity of rice paste increases dramatically after short- to intermediate-term storage (months) of milled rice [3] but decreases during longer-term storage (years) [4]. Attempts to explain the changes in functionality associated with aging have focused on the properties of rice components, such as starch, protein, and lipids, and the interactions between them during storage [5]. As with functionality, changes in starch, lipid and protein components were most apparent at an elevated storage temperature although gross changes in starch, amylose, and protein contents of the rice grain [1] during storage were minimal. However, it is now apparent that the minor components at the granule surface (lipids and proteins) have a disproportionate influence on granule properties and that aging-induced changes in these components may account for the changes in physicochemical properties seen after storage. This study investigates changes in pasting properties following rice storage and the lipid composition as well as the factor that influence these changes.

2. Materials and methods

2.1 Rice samples

One hundred kilos of the paddy rice Khao Dok Mali 105 were derived from the Rice Research Center, Phathumthani province and used as experiment materials. The contaminant free paddy rice was cleaned then air dried on the floor to 14-15% moisture content and then packed into polypropylene bags of 70 micrometer thickness. Each bag contained 400 g of rice. The bags were place at 25 °C and 37 °C in thermostatically controlled incubators. Triplicate samples were withdrawn for analysis after an initial period and at one month intervals thereafter until 7 months. Storage trials were designed as completely randomized with 2×8 factorial in completely randomized design. The factor A are two storage conditions temperature at 25 °C in 40-50% relative humidity and 37 °C in 30% relative humidity and factor B are 8 storage times (0-7 month). Samples were analyzed for moisture content, physical, chemical and physicochemical properties of rice. Every month the paddy rice was analyzed for moisture content the unpolished rice was ground into flour and sieved to 50 mesh powder and analyzed for lipid content and its physicochemical properties.

2.2 Physical analysis

The color of brown rice was determined by colorimeter Minolta Model DP-301. Color values (L, a and b) were measured using a white standard tile was used to calibrate the colorimeter (L = 100.01, a = - 0.01, b = - 0.02) before measurements. The opponent-color scales give measurements of color in units of approximate visual, uniformity throughout the color solid. Therefore L measures lightness (luminosity) and varies from white to black. The chromatically (a and b value) gives designations of colour as follows; a-value measures redness when positive, gray when zero, and greenness when negative, b-value measures yellowness when positive, gray when zero, and blueness when negative. Gel consistency determined according to Cagampang and coworkers [6].

2.3 Chemical analysis

Total lipid and total free fatty acid contents of the brown rice were determined according to the method of Juliano [7] and Dhaliwal et al. [8], respectively.

2.4 Rapid viscoanalysis (RVA)

The pasting properties of the various samples were determined with a rapid viscoanalyser. 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^{-1}. 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).

2.5 Statistical analysis

Statistical analysis primarily consisted of summarizing statistics, including means and standard deviation. Pearson correlation coefficients between the biochemical compositions were determined on storage time and temperature separately.

3. Results

The relationship between b value represented yellow color of the brown rice during storage and storage temperature at 25 °C and 37 °C is shown in Fig. 1. The results shows b vaule increased according storage and the b value at 37 °C was higher than the storage at 25 °C.

The total lipid contents (2.50%) were found in brown rice and aging at 25 °C and 37 °C had no apparent effect on total lipid contents during storage.

As shown in Fig. 2 the storage temperature and time affect on total free fatty acid content of rice flour. When stored at the relatively low temperature of 25 °C, there was a slow but gradual decrease in total fatty acid content. Rice storage at 37°C, an decrease in total free fatty acid content also occurred after storage and reached a minimum value till 7 months. The decrease in total free fatty acid after storage at 37 °C was lower than that of at 25 °C.

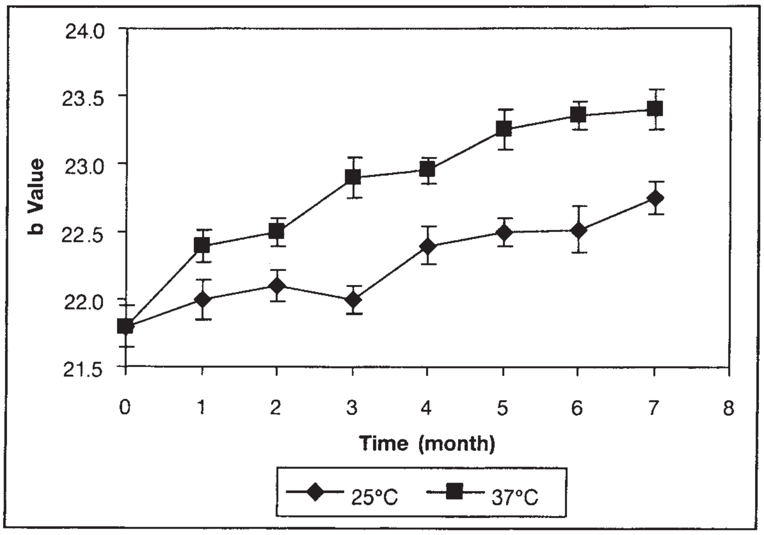

Fig. 1 Effects of storage temperature and time on b value of brown rice. (Error bar denotes ± 1 S.D. from the mean.)

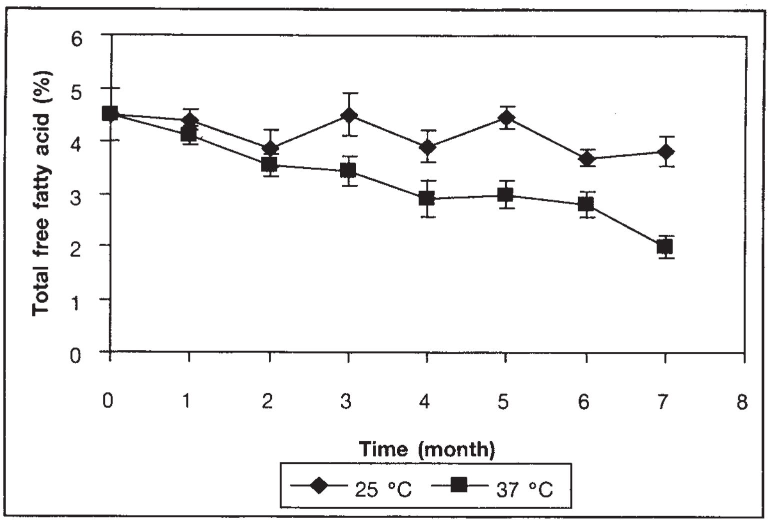

Fig. 2 Effects of storage temperature and time on total free fatty acid content of rice flour. (Error bar denotes ± 1 S.D. from the mean.)

The effect of storage temperature and time on peak viscosity of rice flour is shown in Fig. 3. When stored at the relatively low temperature of 25 °C, there was a slow but gradual increase in peak viscosity. Conversely, when stored at the relatively high temperature of 37 °C, an decrease in peak viscosity occurred after two months storage and reached a minimum value till 7 months.

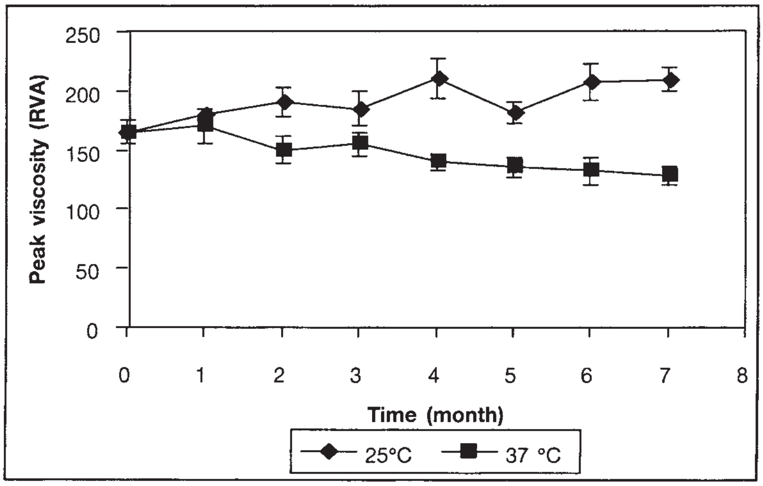

Fig. 3 Effects of storage temperature and time on peak viscosity of rice flour. (Error bar denotes ± 1 S.D. from the mean.)

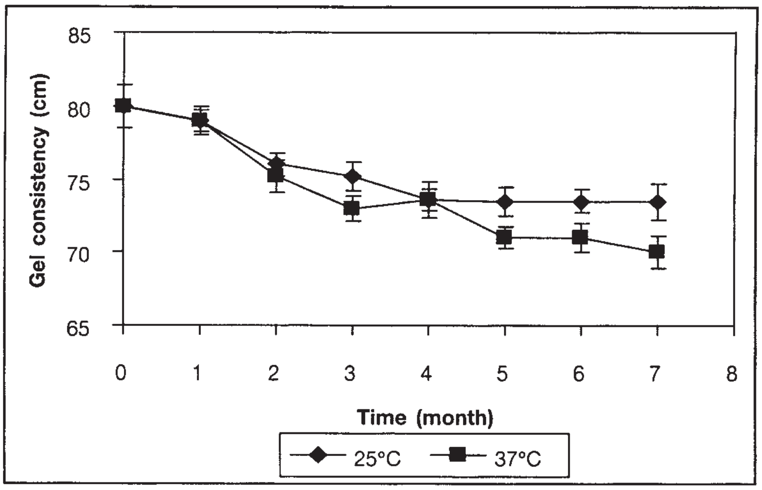

Fig. 4 Effects of storage temperature and time on gel consistency of rice flour. (Error bar denotes ± 1 S.D. from the mean.)

The storage temperature and time affect on gel consistency of rice flour as shown in Fig. 4. When stored at temperature of 25 °C, there was decrease in gel consistency till 4 months and not change on further storage. Storage at 37 °C, an decrease in gel consistency also occurred after storage and reached a minimum value till 7 months.

The storage temperature and time affect on pasting temperature of rice flour as shown in Fig. 5. When stored at temperature of 25 °C, there was decrease in gel consistency till 2 months and then gradual decrease in on further storage. The rice storage at 37 °C showed a slightly increase in pasting temperature after 3 months.

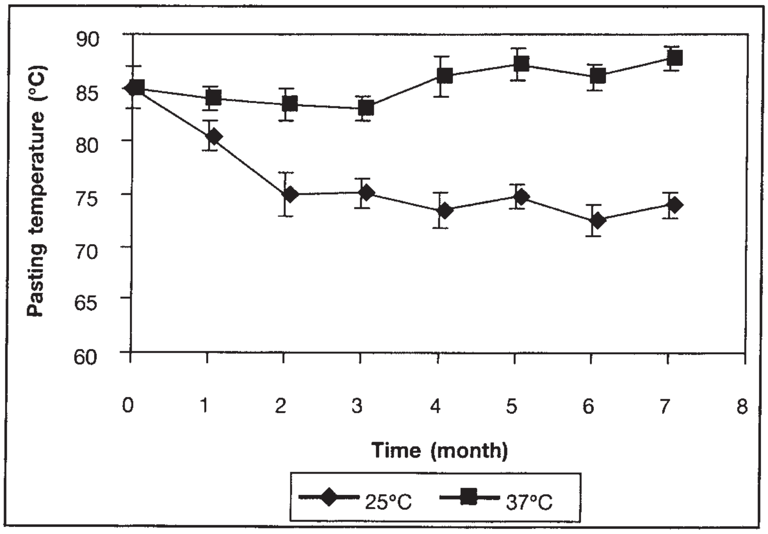

Fig. 5 Effects of storage temperature and time on pasting temperature of rice flour. (Error bar denotes ± 1 S.D. from the mean.)

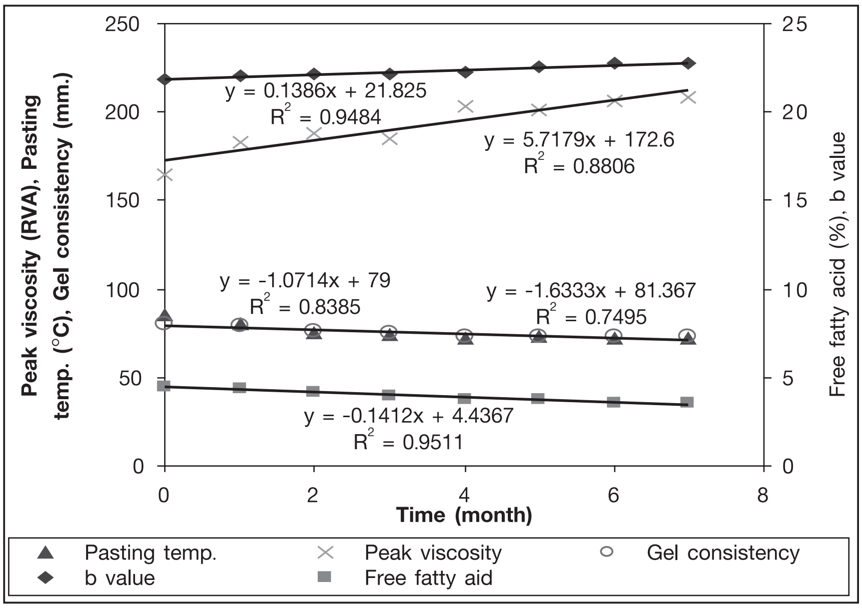

Fig. 6 Relationship between total free fatty acid, b value, pasting properties and time of brown rice stored at 25 °C.

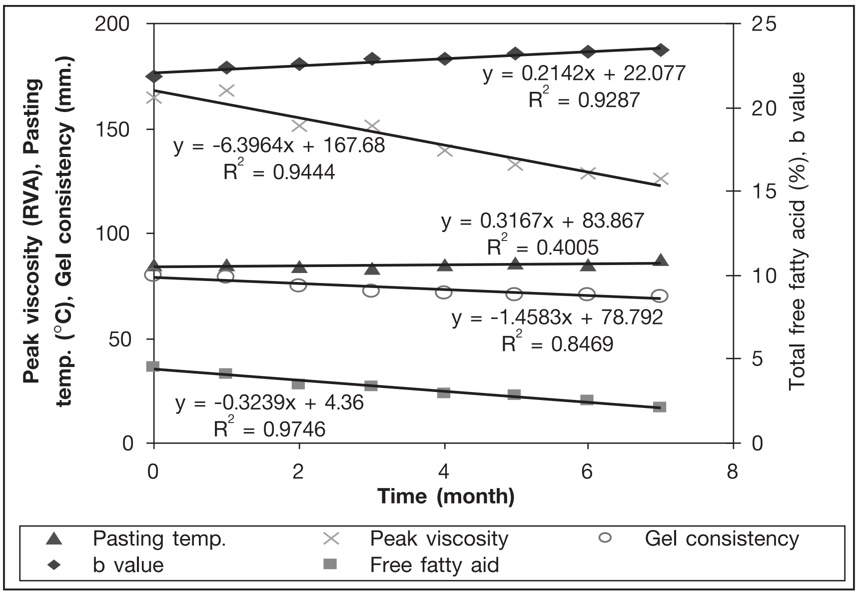

Fig. 7 Relationship between total free fatty acid, b value, pasting properties and time of brown rice stored at 37 °C.

The correlation between pasting temperature, peak viscosity, gel consistency, b value, free fatty acid content and storage time at 25 °C and 37 °C, showed R2 values in Fig. 6 and 7, respectively, which also revealed that lipid component affects rheological properties of pastes. Fig. 8 and 9 shows negative correlation between total free fatty acid and b value of brown rice stored at 37 °C, however there was no correlation between total free fatty acid and b value of brown rice stored at 25 °C (data not shown).

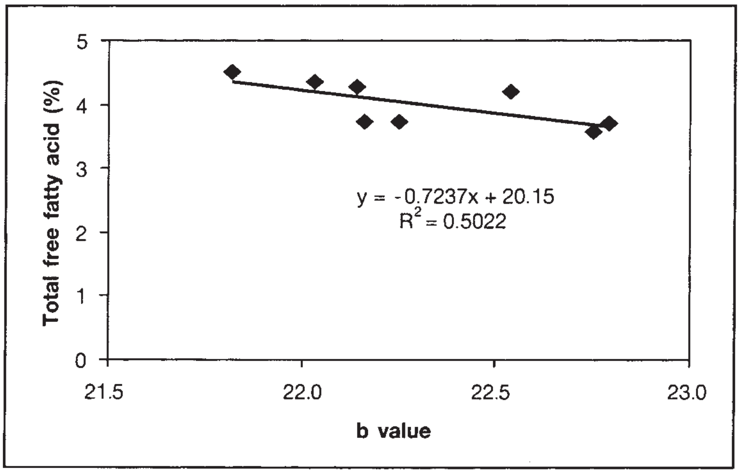

Fig. 8 Relationship between total free fatty acid and b value of brown rice stored at 25 °C.

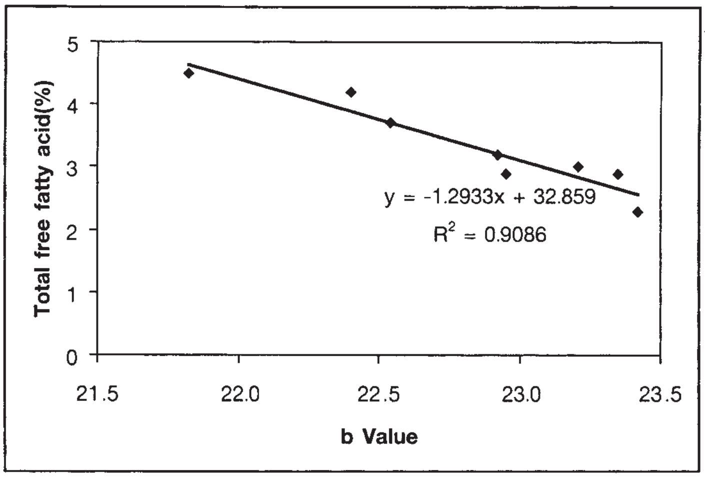

Fig. 9 Relationship between total free fatty acid and total free fatty acid contents of b value of brown rice stored at 37 °C.

The results of Fig. 10 and 11 show the relationship between peak viscosity and total free fatty acid contents of 25 °C and 37 °C storage condition. As for the scatter diagram of peak viscosity and total free fatty acid contents of rice storage at 25 °C represents the linear regression of the increase in total free fatty acid and increase in peak viscosity in the same direction while the rice storage at 37 °C represents the linear regression of total free fatty acid contents and peak viscosity in opposite direction. Fig. 12 shows diagram of pasting temperature and total free fatty acid contents of rice storage at 25 °C represents the linear regression of the increase in total free fatty acid and increase in peak viscosity in the same direction. However, as shown in Fig. 13, the rice storage at 37 °C did not show the correlation between pasting temperature and total free fatty acid.

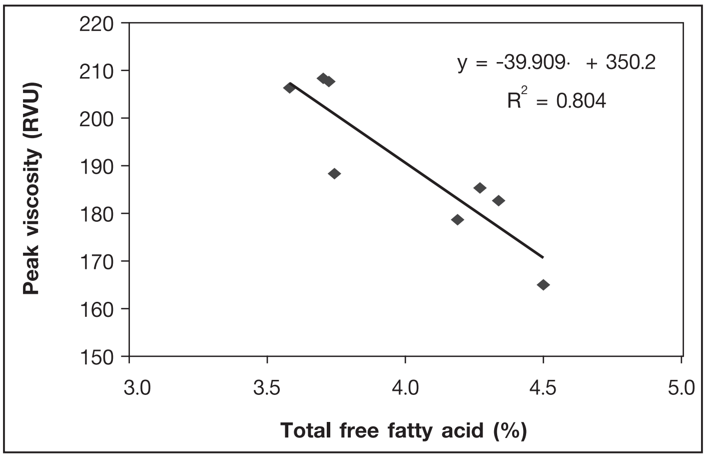

Fig. 10 Relationship between peak viscosity and total free fatty acid contents of rice stored at 25 °C.

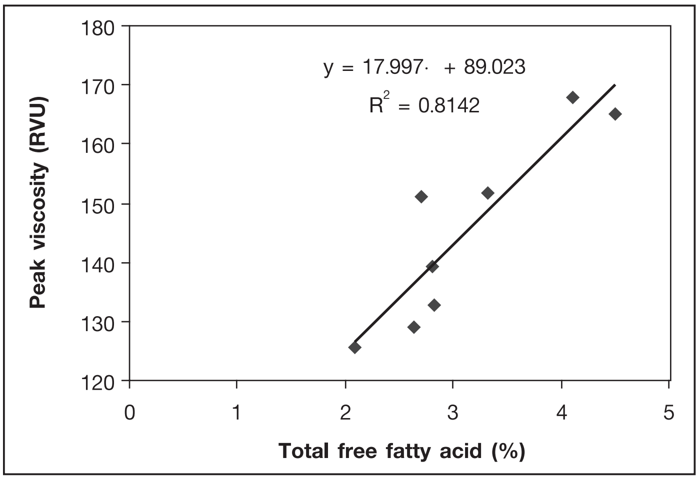

Fig. 11 Relationship between peak viscosity and total free fatty acid contents of rice stored at 37 °C.

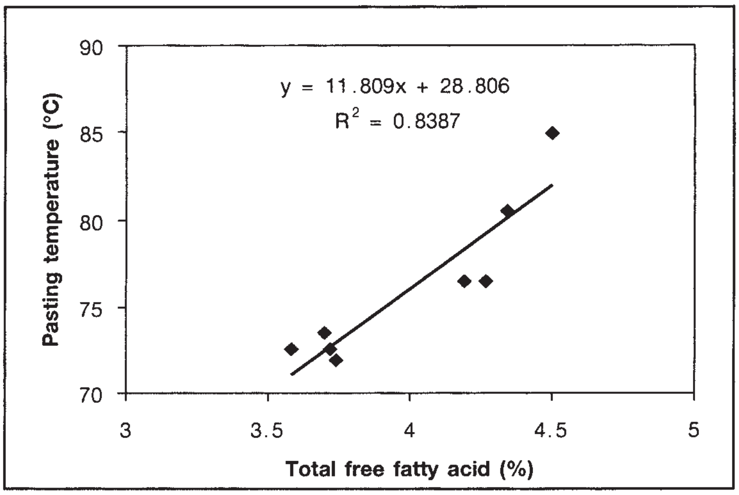

Fig. 12 Relationship between pasting temperature and total free fatty acid contents of rice stored at 25 °C.

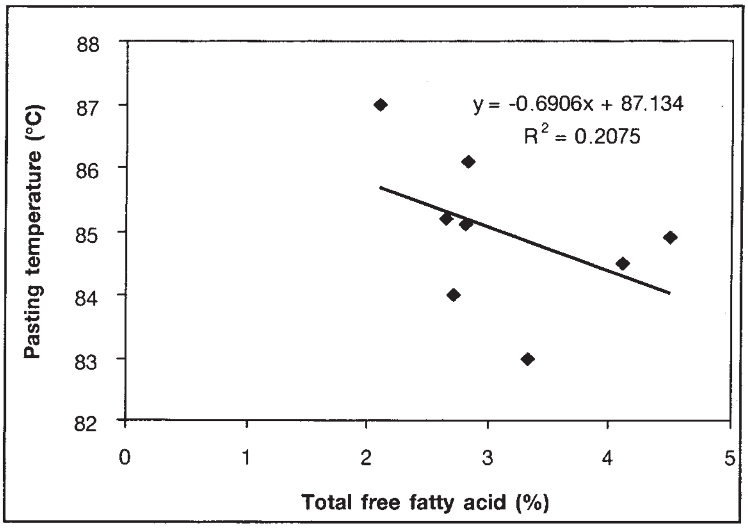

Fig. 13 Relationship between pasting temperature and total free fatty acid contents of rice stored at 37 °C.

4. Discussion

The storage of rice caused increasing in b value that came from brown pigments increased during storage. Brown pigments increasing provides an index for evaluating the intensity of browning reactions that was caused by Maillard reaction. The reaction can be achieved by the determination of furosine (e-N-(furoylmethyl L-lysine), an amino acid formed during acid hydrolysis of the Amadori compound fructosyl-lysine, lactulosyl-lysine and maltulosyl-lysine produced by reaction of e-amino groups of lysine with glucose, lactose and maltose, respectively [9, 10]. The Maillard reaction is one of the most important modifications in cereals that contain proteins and reducing carbohydrates. The decrease in total free fatty acid while b value increased during storage at 37 °C might be come from certain free fatty acid reacted with certain components to form complex resulting in increase of brown color. This result indicates browning reaction occurred during storage due to it was induced by heating and long storage conditions. Many indices based on Maillard reaction products have been proposed to assess the effects of heat treatment and long storage on foods. The Maillard reaction can be enhanced by the drying step [10] and can continue during the storage.

Decrease of peak viscosity values of rice stored at 37 °C might be due to oxidation leads to a reduction in both the total and free fatty acid content [11]. Thus, changes in the extent of amylose lipid complexation may be associated with the storage of rice. The effect of high temperature might be accelerate the oxidation of fatty acid more than low temperature. The total free fatty acid contents and peak viscosity of rice storage at 25 °C were higher than that of at 37 °C. Under condition studies lipids do not undergo oxidation during storage, as reflected by a constant total lipid content due to the paddy rice being packed in polyethylene bag. However, It can be concluded that it is non-starch lipids (free fatty acids) that are primarily involved in hydrolysis and oxidation reactions.

This study suggests that free fatty acid might be involved in pasting properties by form complex with the component of rice during storage causing decrease in peak viscosity by slightly increase in pasting temperature at 37 °C while the storage at 25 °C increase peak viscosity but decrease in pasting temperature. These data form part to investigate the changes in rice composition and functionality associated with storage that seeks to clarify the roles of lipid in regulating the aging process.

5. References

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