การเปลี่ยนแปลงคุณสมบัติทางเคมีและเคมีกายภาพของข้าวขาวดอกมะลิสายพันธุ์ 105 ในระหว่างการเก็บรักษาที่อุณหภูมิต่างกัน

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รับเมื่อ 5 กันยายน 2546 ตอบรับเมื่อ 28 พฤษภาคม 2547

บทคัดย่อ

การเปลี่ยนแปลงคุณภาพข้าวในระหว่างการเก็บรักษาเป็นผลมาจากปัจจัยทางกายภาพ ได้แก่ อุณหภูมิ ความชื้น และระยะเวลาของการเก็บรักษา การศึกษาวิจัยนี้มีวัตถุประสงค์เพื่อศึกษาการเปลี่ยนแปลงคุณสมบัติทางเคมี และเคมีกายภาพของข้าวในระหว่างการเก็บรักษาภายหลังการเก็บเกี่ยวในระยะเวลา 7 เดือน ที่อุณหภูมิ 25 และ 37 องศาเซลเซียส ในความชื้นสัมพัทธ์ร้อยละ 40-50 และ 30 ตามลำดับ ในการศึกษาวิจัยได้นำข้าวขาวดอกมะลิสายพันธุ์ 105 ที่เก็บเกี่ยวใหม่มาลดความชื้นให้เหลือร้อยละ 15.12 แล้วนำมาบรรจุไว้ในถุงโพลีโพรพิลีน และเก็บไว้ที่อุณหภูมิ 25 และ 37 องศาเซลเซียส เป็นเวลา 7 เดือน และศึกษาการเปลี่ยนแปลงทางเคมีและเคมีกายภาพของข้าวในระหว่างการเก็บรักษา ผลการทดลองพบว่า น้ำตาลรีดิวส์ของแป้งข้าวสารที่เก็บรักษาที่อุณหภูมิ 37 องศาเซลเซียส มีปริมาณเพิ่มขึ้นจากร้อยละ 0.19 เป็นร้อยละ 0.62 ในขณะที่น้ำตาลรีดิวส์ของข้าวสารลดลงจากร้อยละ 0.19 เหลือร้อยละ 0.14 เมื่อเก็บรักษาข้าวที่อุณหภูมิ 25 องศาเซลเซียส ปริมาณน้ำตาลทั้งหมดและอมิโลสไม่เปลี่ยนแปลง เมื่อเก็บรักษาที่ 25 และ 37 องศาเซลเซียส กิจกรรมของแอลฟาอมิเลสในข้าวกล้องพบว่ามีอยู่ 0.9-7.8 และ 0.9-9.6 U/100 กรัม ระหว่างการเก็บรักษาที่ 25 และ 37 องศาเซลเซียส ตามลำดับ คุณสมบัติความหนืดโดยเครื่องวัดความหนืด RVA ของแป้งข้าวสารพบว่ามีค่าเพิ่มขึ้นระหว่างการเก็บรักษา จากผลการศึกษาวิจัยได้แสดงถึงความสัมพันธ์ระหว่างน้ำตาลรีดิวส์และค่าความหนืดที่เพิ่มขึ้นเมื่อเก็บรักษาข้าวที่อุณหภูมิสูง

คำสำคัญ : ข้าวขาวดอกมะลิ / การเก็บรักษา / อุณหภูมิ / เคมี / เคมีกายภาพ

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Chemical and Physicochemical Changes of Rice cv. Khao Dok Mali 105 during Storage at Different Temperature

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Received 5 September 2003 ; accepted 28 May 2004

Abstract

Changing of rice qualities during storage are affected by physical conditions such as temperature, moisture content and storage time. The objectives of this study were to study the changes in chemical and physicochemical properties of post-harvested rice and stored for 7 months at temperatures of 25˚C with 40-50% relative humidity and 37˚C with 30% relative humidity. In this study, the newly harvested paddy cv. Khao Dok Mali 105 was dried to reduce the moisture content to 15.12% and packed in polypropylene bags. The bags were stored at 25˚C and 37˚C for 7 months. It was found that analysis of the reducing sugars of the starch of the milled rice during storage at 37˚C was found to have increased from 0.19 % to 0.62% while the reducing sugars of the starch of the milled rice stored at 25˚C, decreased from 0.19% to 0.14%. The total sugars and amylose contents were analyzed and found no significant changes were found during storage at 25˚C and 37 ˚C. α-Amylase activity in the brown rice was found to be 0.9-7.8 and 0.9-9.6 U/100g during storage at both 25˚C and 37˚C, respectively. The viscosity property by RVA of the milled rice starch was found to have increased during storage under the study conditions. From the results, it might be shown that the relationship between the increase of the reducing sugars when the rice was stored at high temperature and this condition tended to cause the higher viscosity property of the rice starch during storage.

Keywords : Rice cv. Khao Dok Mali / Storage / Temperature / Chemical / Physicochemical

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1. Introduction

Nowadays, Thai rice cutivar Khao Dok Mali “Jasmine rice” 105 is very popular both in the country and abroad due to its special properties, such as stickiness, tenderness and good flavor. Rice qualities, especially, flavor and the texture of milled rice depend on many factors, such as the storage condition of the paddy rice, milling process and packing. Milled rice is quickly aged when stored at 15 °C for 3 to 4 months after harvest. The texture of cooked aged rice becomes more loose and expandable which is desirable for cooking and in producing processed products. Changing of the aged rice properties occur in the inner part of the rice grain because of the chemical reaction between the starch, protein, lipid and the moisture content. Temperature and air percolation may act as catalysts of the reaction which affect the physical, chemical and cooking quality of rice [1]. The objectives of this research are to study the effects of temperature and duration of storage after harvest on the starch composition and content of Khao Dok Mali 105 as affected by including the physicochemical property changes of the aged rice during storage.

2. Materials and Methods

One hundred kilos of the paddy rice, Khao Dok Mali 105 were derived from the Rice Research Center, Pathumthani province and used as experimental 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 placed at 25 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 x 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, chemical and physicochemical properties of rice. In experiment 2, the effects of storage time, 0 - 7 months and storage temperature at 37°C in 30% relative humidity were analyzed for moisture content, 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 α - amylase activity and the milled rice was ground into flour and sieved to 50 mesh powder and analyzed for its chemical and physicochemical properties.

2.1 The moisture content of paddy rice

Five grams of paddy rice was dried at a temperature of 103 ± 2°C for 16 hours and then kept in a desiccator until the rice cooled down and then weighed to determine the moisture content.

2.2 Chemical composition analysis

The total sugars were determined according to the Dubois method [2]. Two milliliters of the sample were measured into a boiling tube, and 0.05 ml of 80% phenol was added. Five milliliters of H_2SO_4 were allowed to flow rapidly onto the liquid surface of the solution. The tubes were allowed to stand for 10 minutes, shaken, and cooled to 25-30 °C for 10-20 minutes. The absorbance of the solution was recorded at 490 nm against a reagent blank, and the carbohydrate content of the sample was read from the calibration graph of absorbance vs. carbohydrate concentration (μg/ml).

Reducing sugar was determined according to the Somogyi method [3]. 0.6 milliliters of sample solution was added into the tube containing 1.0 ml of the Somogyi reagent (Somogyi I : Somogyi II = 4:1), and mixed well. Then the tube was boiled in a boiling water bath for 10 minutes. The tubes were allowed to cool and one milliliter of Nelson reagent was added, and mixed. Two milliliters of distilled water were added. The absorbance of the solution was recorded at 520 nm against a reagent blank, and the reducing sugar content of the sample was read from the calibration graph of absorbance vs. glucose concentration of 50, 100, 150, 200 and 250 μg/ml.

α-Amylase was determined using the HUMAZYM-Enzymatic colorimetric test of Human reagent kit. The reagent contained modified nitrophenylmaltoheptaoside as a substrate. The terminal glucose unit was bonded to a blocking substituent which inhibited cleavage by exoenzymes like glucosidase. After cleavage of internal bonds by α-amylase, an endoenzyme, the exoenzymes could cause the ultimate release of the chromophore ρ-nitrophenol. The increase of absorbance per minute at 405 nm was directly proportional to the α-amylase activity in the sample.

Amylose was determined by dissolving the sample in 5 ml 1 M KOH and 5 ml distilled water was added and 1 ml of this solution was neutralised with 5 ml 0.1 M HCl, an iodine reagent of 20 μg/ml (0.5 ml) was added and the volume increased with 50 ml of distilled water. The absorbance values was measured at 15 minutes after the iodine reagent was added [4]. The assays were carried out at room temperature. Analysis of the physicochemical property of gel viscosity was determined by a Rapid Visco Analyser (RVA) Model RVA - 4 from Newport Scientific.

2.3 Statistical analysis

Statistical analyses primarily consisted of summarizing statistics, including means and standard deviations. The data were analysed by a one-way analysis of variance by mean comparisons using least significant difference (LSD). Pearson correlation coefficients between the biochemical compositions were determined on storage time and temperature separately.

3. Results

The moisture content of the rice packed in the polypropylene plastic bags at 37°C decreased more than those at 25°C storage (Table 1). The flour of composition of the rice cv. Khao Dok Mali 105 was analyzed for total sugar and amylose and no significant changes are found after 7 months of storage. The concentrations of the total sugar ranged from 60-72% and 65-74% for the rice stored at 25 and 37 °C, respectively. Amylose concentrations were 12.1-12.4% and 12.3-12.6% for the rice stored at 25 and 37°C, respectively (Table 2).

Reducing sugar and amylase activity were analyzed from the flour Khao Dok Mali 105 and it was found that were changed during 7 months of storage. The concentrations of the reducing sugar of the rice stored at 25°C decreased from 0.19 to 0.14% while the reducing sugar of the rice stored at 37°C increased from 0.19 to 0.62 %. However the amylase activity of the starch from the brown rice seemed to increase during storage, both at 25 and 37°C. At 25°C, amylase activity increased from 0.9 to 7.8 U/100g and at 37 °C, amylase activity increased from 0.9 to 9.6 U/100g. Amylase activity, reducing sugars, of rice flour storage at 25 and 37°C were significantly different by $p < 0.05$ (Table 3). Amylase activity at 25 and 37 °C correlated with storage time by the value of 0.972, 0.984 Pearson correlation significantly at $p < 0.001$ level, respectively. Reducing sugars at 25 °C correlated with storage time by the value of -0.805 Pearson correlation significantly at $p < 0.05$ level (Fig.1).

Table 1 Moisture content of stored paddy rice cv. Khao Dok Mali 105 during storage at 25 and 37°C

Storage duration (month)	Moisture content (%)*	
	25°C	37°C
0	15.12 ^{bc} (0.37)	15.12 ^{bc} (0.37)
1	15.63 ^{a} (0.19)	14.62 ^{d} (0.16)
2	15.88 ^{a} (0.14)	14.87 ^{bcd} (0.08)
3	15.80 ^{a} (0.30)	13.65 ^{c} (0.05)
4	14.85 ^{bcd} (0.13)	13.13 ^{f} (0.13)
5	15.15 ^{bc} (0.20)	12.82 ^{fg} (0.71)
6	14.73 ^{cd} (0.03)	12.45 ^{gh} (0.18)
7	15.18 ^{b} (0.18)	12.12 ^{h} (0.10)

* Means and standard deviations for n = 3. Numbers in parentheses are standard deviations. Means with the same alphabet label are not significanlly different at $p \leq 0.05$ as determined by LSD.

Table 2 Total sugar and amylose contents of the flour Khao Dok Mali 105 during storage at 25 and 37˚C

Storage duration (month)	Total sugars (%)*		Amylose (%)*	
	25˚C	37˚C	25˚C	37˚C
0	64.95^{af}(3.25)	64.95^{gl}(3.25)	12.43(1.56)	12.43(1.56)
1	72.41^{acf}(2.84)	68.18^{gil}(1.28)	12.51(0.21)	12.41(0.24)
2	68.81^{b}(3.80)	73.87^{h}(1.35)	12.53(0.39)	12.25(0.34)
3	65.39^{df}(3.03)	68.95^{jl}(3.55)	12.08(0.52)	12.47(0.46)
4	60.43^{a}(1.68)	64.57^{g}(1.49)	12.17(0.83)	12.37(0.62)
5	66.95^{bd}(1.78)	73.26^{hj}(3.36)	12.32(0.21)	12.53(0.54)
6	63.40^{aef}(1.27)	66.92^{gkl}(1.39)	12.26(0.39)	12.48(0.61)
7	67.95^{bcde}(1.79)	70.65^{hijk}(2.84)	12.65(0.22)	12.58(0.34)

* Means and standard deviations for n = 3. Numbers in parentheses are standard deviations. Means with the same alphabet label are not significanlly different at $p \leq 0.05$ as determined by LSD.

The physicochemical properties of the starch of rice stored at 25 and 37˚C changed during the 7 months. The setback values of that stored at 37˚C increased more than that at 25˚C. The setback values might depend on temperature and storage duration and these values might also indicate the quality of cooked starch. The final viscosity and peak viscosity values increased during 7 months of storage and these values of the storage at 37˚C were more than those at 25˚C. However the pasting temperature of the storage at 25 and 37˚C decreased during the 7 months of storage (Table 4).

3.1 The physical changes of paddy and unpolished rice

Temperature and storage duration affected to the moisture content and the yield of milling process. The moisture content of the paddy rice stored at 37˚C decreased more than those at 25˚C. The yield of unpolished rice after the milling process that was stored at 37˚C was more than that stored at 25˚C. Temperature and storage duration affected to the viscosity of the paddy rice starch (Table 4).

Table 3 Reducing sugars content of flour of milled rice and α-amylase activity of starch in brown rice cv. Khao Dok Mali 105 during storage.

Storage duration (month)	Reducing sugars (%)*		α-Amylose (%)* activity (U/100)*	
	25˚C	37˚C	25˚C	37˚C
0	0.19^{ad}(0.02)	0.19^{a}(0.02)	0.94^{a}(0.01)	0.94^{a}(0.01)
1	0.22^{cd}(0.02)	0.58^{b}(0.01)	0.91^{a}(0.01)	1.42^{b}(0.13)
2	0.17^{ade}(0.06)	0.48^{c}(0.01)	1.14^{b}(0.01)	1.93^{c}(0.11)
3	0.14^{bef}(0.02)	0.37^{d}(0.01)	2.84^{c}(0.08)	3.33^{d}(0.06)
4	0.15^{af}(0.02)	0.56^{be}(0.02)	5.01^{d}(0.01)	4.73^{e}(0.02)
5	0.13^{bef}(0.03)	0.45^{c}(0.02)	5.13^{e}(0.13)	6.07^{f}(0.01)
6	0.14^{bef}(0.01)	0.55^{e}(0.01)	6.27^{d}(0.12)	7.48^{g}(0.31)
7	0.14^{bef} (0.01)	0.62^{f}(0.01)	7.78^{f}(0.12)	9.57^{h}(0.13)

* Means and standard deviations for n = 3. Numbers in parentheses are standard deviations. Means with the same alphabet label within reducing sugar or α – amylase activity are not significanlly different at $p \leq 0.05$ as determined by LSD.

Peak viscosity of rice stored at 25˚C increased throughout storage but the rice stored at 37˚C caused the value to increase in the first month but later the value decreased. The pasting temperature, set back and final viscosity values increased according to the duration of storage and the storage at 37˚C showed higher values than that at 25˚C (Table 4).

Table 4 The changes of pasting temperature, peak viscosity, setback and final viscosity of starch of rice cv. Khao Dok Mali 105 during storage.

Temperature (°C)	Storage duration (month)	Pasting temperature (°C)*	Peak viscosity (RVU)*	Setback (RVU)*	Final viscosity (RVU)*
25 °C	0	78.39^{a} (1.66)	195.97^{b} (9.64)	63.68^{j} (0.28)	150.09^{g} (1.78)
	1	75.37^{b}(0.93)	241.10 ^{gf}(8.86)	73.39 ^{f}(1.25)	180.17 ^{f}(0.59)
	2	70.69^{cde}(0.56)	279.95d(9.84)	84.11^{h}(0.67)	200.92 ^{e}(2.57)
	3	70.39^{cdef}(0.96)	264.64 ^{e}(4.52)	85.28 ^{h}(0.71)	201.96 ^{e}(1.22)
	4	70.58^{cde}(1.13)	251.36 ^{f}(11.12)	84.05 ^{h}(3.65)	200.68 ^{e}(3.93)
	5	69.80 ^{cdef}(0.75)	319.46^{ab}(1.77)	95.25 ^{g}(1.90)	223.60 ^{cd}(3.11)
	6	70.53^{cde}(0.26)	327.89^{a}(12.75)	95.93 ^{g}(0.90)	236.79 ^{bc}(2.57)
	7	71.17^{cd}(0.90)	278.88^{d}(7.11)	92.33 ^{g}(1.52)	226.97 ^{c}(2.59)
37 °C	0	78.39^{a}(1.66)	195.97^{b}(9.64)	63.68 ^{j}(0.28)	150.09 ^{g}(1.78)
	1	78.79^{a}(0.58)	238.14^{g}(3.29)	87.68 ^{h}0.89)	210.15 ^{df}(1.57)
	2	71.19^{c}(0.47)	263.85 ^{e}(2.68)	106.65 ^{e}(0.99)	245.06 ^{b}(3.87)
	3	69.40^{ef}(0.20)	303.99 ^{c}(3.36)	109.57 ^{d}(0.51)	250.07 ^{b}(0.85)
	4	69.76 ^{def}(0.33)	300.67^{c} (5.87)	113.85 ^{c}(6.69)	245.54 ^{b}(6.96)
	5	69.11^{f}(0.45)	251.46 ^{f}3.39)	128.60 ^{b}(0.71)	267.86 ^{a}(15.09)
	6	69.49^{ef}(0.22)	240.13 ^{fg}(5.27)	133.78 ^{a}(11.24)	279.36 ^{a}(2.56)
	7	69.89^{cdef}(0.53)	309.79 ^{bc}(2.69)	100.39 ^{f}(0.54)	244.97 ^{b}(29.55)

* Means and standard deviations for n = 3. Numbers in parentheses are standard deviations. Means in the same column with the same alphabet label are not significanlly different at $p \leq 0.05$ as determined by LSD mean comparison.

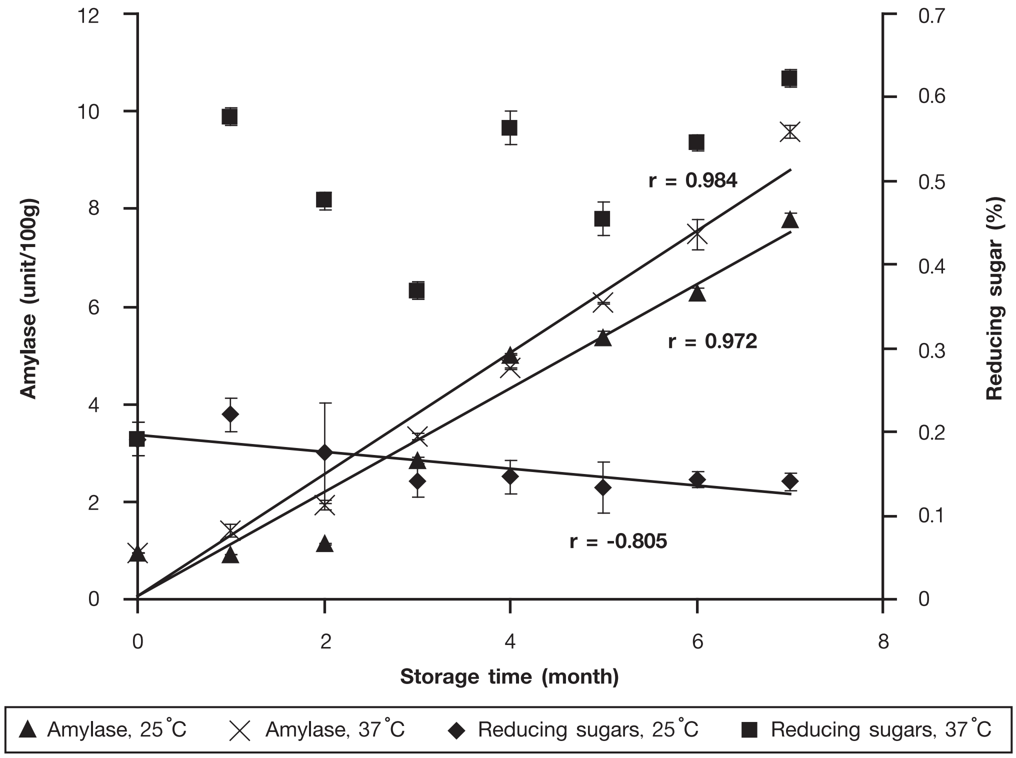

Fig. 1. Relationship between amylase, reducing sugar contents of rice flour and storage time at at 25 and 37˚C

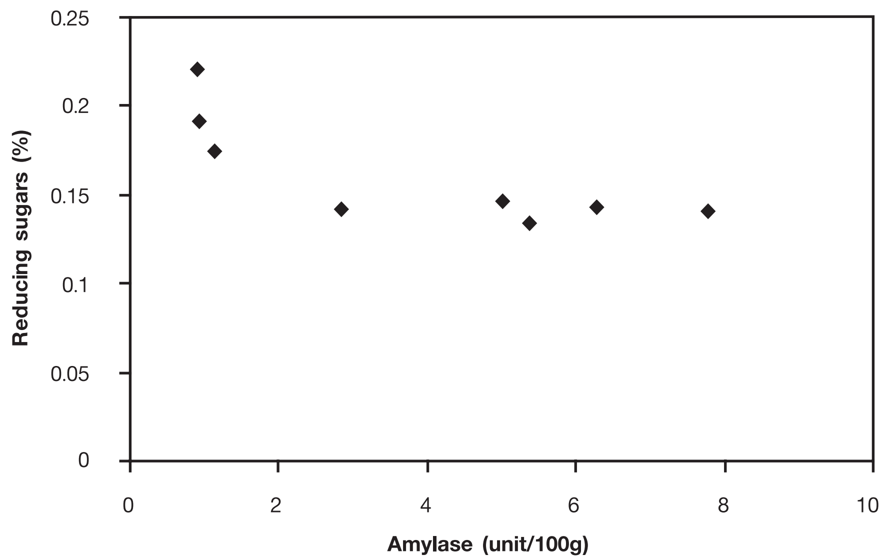

Fig. 2. Relationship between reducing sugars and amylase contents of rice flour during storage at 25˚C

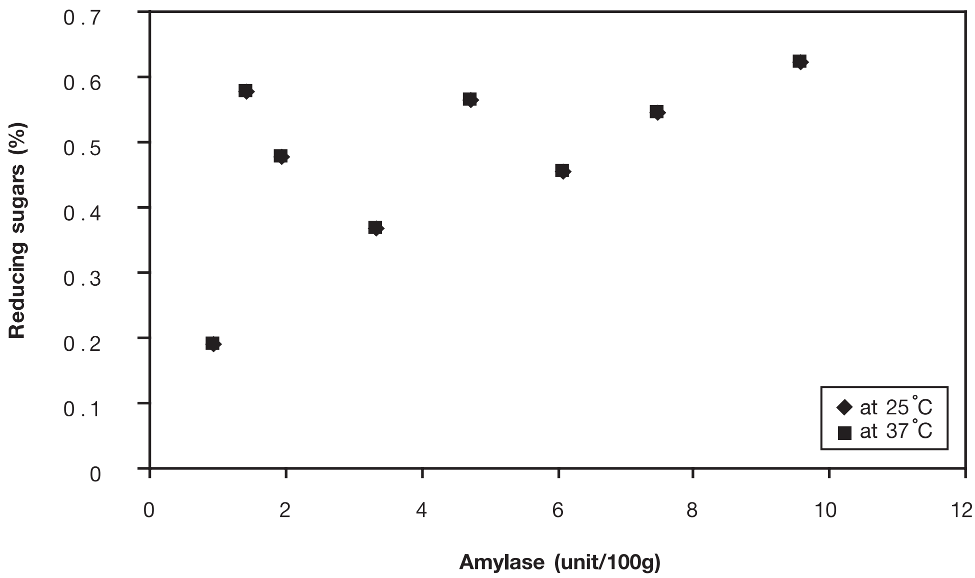

Fig. 3. Relationship between reducing sugars and amylase contents of rice flour during storage at 25 and 37˚C.

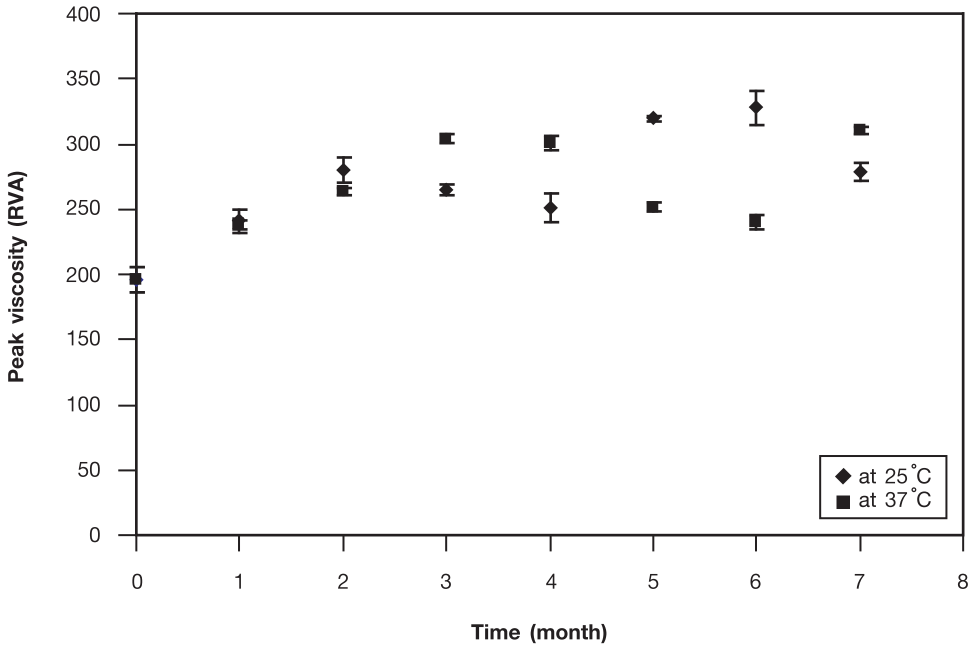

Fig. 4. Relationship between peak viscosity of rice flour and storage time at 25 and 37˚C

4. Discussion

Under condition study of different storage time and temperature with different relative humidity. The moisture contents of the paddy rice cv. Khaw Dok Mali 105 that were stored at 25 and 37˚C were different significantly. The moisture content of that stored at 25˚C was more than that at 37˚C. It might be due to the rice grain could exchange the moisture with the air inside the bag and the air outside the bag [5] and it might occur due to higher temperatures, which are better than lower temperatures. These results corresponded with the experiments of Dhaliwal, et al. [6] and Chrastil, et al. [7]. The moisture content might take part in the reaction of the enzyme and combination between the other biomolecular compositions and the starch compositions which mostly consisted in the rice grain.

Total sugars and amylose content were determined and it was found to be 60-74% and 12.3-12.6%, respectively. These compositions seemed to undergo no changes during storage and were not affected during the temperature studies. However, reducing sugars and amylase activities were found to increase during storage. This might suggest that some part of the starch composition might be degraded to form complexes with other biomolecular compositions, resulting increase in strength in the grains, that affected the physiochemical properties of the starch. This study seems to be corres ponded to the experiment of Juliano [8] who found that the storage of rice at temperature higher than 15˚C and the increase of the storage duration caused a higher yield of milled and unpolished rice.

The experiment showed that the broken paddy rice stored for 10 months at a temperature of 37˚C was less than that of at 4 and 25˚C. This also corresponded with the experiment of Villarea, et al [9]. This might be due to the higher temperature causing the stronger bonding within the rice grain. The increase of amylase activity in brown rice might be due to the enzyme retained in the grain during storage after dehulling; more than that of post harvest. From the studies of Plangpin [10] and Lamul [11], it was found that the increase in the yellow color of the paddy, unpolished rice and milled rice might confirm this experiment. The results showed that the yellow color increased according to the increase of the storage duration time and a temperature of 37˚C increased the yellow color more than that at a temperature of 25˚C. This result might be due to the biochemical reactions in the rice grain. However this might suggest that the high temperature caused a decrease in the amount of a certain amino acid, lysine and might occur in the brown pigment of melanoidin [7].

Chemical changes during the storage were slightly decreased reducing sugars at 25˚C storage and increased reducing sugars at 37˚C storage while amylase activity was incresased both 25 and 37 ˚C storage. Relationships between reducing sugars and amylase contents of rice flour during storage at 25 and 37˚C as shown in Fig. 2 and Fig. 3 seem to be different. The accumulation of the reducing sugars might be dependent on the relative difference in rate constants corresponding to amylase activity and glycolytic/respiratory capacity of the grains.

The viscosity of rice paste increased after storage of paddy rice. These changes depended on storage temperature and duration. Peak viscosity flour pastes generally increased with both temperature and time of storage, but reached a plateau within 3 months of storage (Fig. 4). Fresh flour paste exhibited lower peak viscosity. The peak viscosity, set back and final viscosity values of the rice stored at 37 ˚C were higher than that at 25 ˚C. It was shown that the starch of the milled rice stored at 37 ˚C was more consistent than at 25 ˚C and longer storage duration resulted in higher viscosity, final viscosity and set back values. It might also be shown that the storage of rice at 37˚C retrodegrades better than the rice stored of at 25 ˚C. This might be due to the changing of the solubility and the gelatinization of the starch and protein in the grain after storage to produce more stable substances and less solubility resulted in a harder rice grain. The increase in peak viscosity shows that the starch granules stored rice are more resistant to swelling than those of fresh rice and indicates that the capacity of the starch granules to rupture after cooking is reduced significantly by ageing of the granules [12]. The pasting temperature of the rice stored at 37˚C was higher than that at 25˚C, which might be due to the hydrogen bonds more within starch at 37 ˚C than at 25 ˚C.

The experiments showed that the increase of reducing sugars and amylase activity might have resulted from the complex formation of certain chemical compositions of the rice during storage at 25 and 37˚C with 40-50% and 30% relative humidity, respectively, which caused the changes in physico chemical properties; such as viscosity, pasting temperature, setback and final viscosity, while the total amount of sugars and amylose did not change.

5. References

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