ผลของสภาวะการเริ่มงอกต่อลักษณะโครงร่าง สมบัติทางเนื้อสัมผัส และการทดสอบทางประสาทสัมผัสของข้าวกล้องเริ่มงอก

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บทคัดย่อ

การตรวจสอบผลของสภาวะในการเริ่มงอกต่อการเปลี่ยนแปลงลักษณะโครงร่าง สมบัติทางเนื้อสัมผัสและการทดสอบทางประสาทสัมผัสของข้าวกล้องจากข้าวเปลือกเริ่มงอกของข้าวพันธุ์สันป่าตอง 1 โดยนำข้าวเปลือกแช่น้ำที่อุณหภูมิ 30 องศาเซลเซียสเป็นเวลา 10 ชั่วโมงจากนั้นนำมาบ่ม 2 สภาวะคือบ่มแบบแช่น้ำและแบบไม่แช่น้ำหลังจากนั้นนำข้าวเปลือกเริ่มงอกส่องด้วยกล้องแสดงภาพสามมิติ และกล้องจุลทรรศน์แบบแสงส่องกราดพบว่า สามารถจำแนกการเริ่มงอกของข้าวตามความยาวของคัพภะออกเป็น 3 ระยะคือระยะที่ 1 คัพภะมีความยาว 0.5-1 มิลลิเมตร ที่เวลา 32 ชั่วโมง ระยะที่ 2 คัพภะมีความยาว 1-2 มิลลิเมตร ที่เวลา 38 ชั่วโมง และระยะที่ 3 คัพภะมีความยาว 2-3 มิลลิเมตร ที่เวลา 44 ชั่วโมง ซึ่งข้าวเปลือกเริ่มงอกพันธุ์สันป่าตอง 1 สภาวะการบ่มแบบไม่แช่น้ำนั้นปรากฏลักษณะจากเครื่องเอสอีเอ็มให้เห็นว่า เม็ดสตาร์ชจากข้าวกล้องเริ่มงอกมีการเปลี่ยนแปลงโครงร่างมากกว่าสภาพการบ่มแบบแช่น้ำ ส่วนค่าความแน่นแข็ง และความเกาะติดกันของข้าวกล้องจากข้าวเปลือกเริ่มงอกหุงสุกพันธุ์สันป่าตอง 1 มีค่าลดลง และมีความแตกต่างกันในทางสถิติกับข้าวกล้องปกติ เมื่อนำตัวอย่างข้าวกล้องเริ่มงอกหุงสุกทั้งสองสภาวะให้ผู้ทดสอบชิมจำนวน 20 คน ด้วยวิธี 9-คะแนน ฮีโดนิก ปรากฏผลคะแนนความชอบทางด้านกลิ่น เนื้อสัมผัส และการยอมรับรวม ต่อข้าวกล้องเริ่มงอกหุงสุกพันธุ์สันป่าตอง1 สภาวะการบ่มแบบไม่แช่น้ำมีค่ามากกว่าในสภาพการบ่มแบบแช่น้ำ ดังนั้นจึงสรุปได้ว่าสภาวะการบ่มแบบไม่แช่น้ำเป็นวิธีที่เหมาะสมในการผลิตข้าวกล้องเริ่มงอกจากข้าวเปลือก

คำสำคัญ : ข้าวกล้องเริ่มงอกจากข้าวเปลือก, การเริ่มงอกในสภาพการบ่มแบบไม่แช่น้ำ, การเริ่มงอกในสภาพการบ่มแบบแช่น้ำ, ข้าวพันธุ์สันป่าตอง1

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EFFECT OF PRE-GERMINATE CONDITIONS ON THE MICROSTRUCTURE, TEXTURE PROPERTIES AND SENSORY EVALUATION OF PRE-GERMINATED BROWN RICE

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Abstract

To investigate pre-germinate conditions on the microstructure, texture properties and sensory evaluation of pre-germinated brown rice (PGBR). The PGBR samples were done by using paddy from Sun-Pah-Tawng1 (SPT1) cultivar which were soaked in water at 30°C for 10 h and then the pre-germinated procedure was carried out under two set of conditions: an incubated paddy with water and an incubated paddy without water condition.The stereo microscopy indicated that the 0.5-3 mm embryonic growth length from SPT1 paddy consisted of 3 stages: a minimum stage (0.5-1 mm) at 32 h, optimum stage (1-2 mm) at 38 h and maximum stage (2-3 m) at 44 h. In addition, the SEM indicated that starch granule from SPT1 paddy incubated without water condition was found to have some changes in the features of the starch granule more than an incubated with water condition. The cooked SPT1 PGBR from an incubated paddy without water condition resulted to decrease hardness and cohesiveness and which was significantly ($p<0.05$) when compared to the normal brown rice. The sensory analysis using 9-point hedonic scale and 20 panelists results revealed that the odor, texture and overall acceptability of cooked SPT1 PGBR by incubated without paddy water condition was better than of the PGBR incubated with water condition. This can be concluded that the suitable method to prepare pre-germinated brown rice by incubating paddy without water.

Keywords : Pre-germinated brown rice from paddy, Incubated paddy with water condition, Incubated paddy without water condition, Sun-Pah-Tawng1

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Introduction

Pre-germinated brown rice (PGBR) is basically produced by soaking brown rice or paddy in warm water and allowing slight embryonic growth to a length between 0.5 and 3 mm (Panchan and Naivikul, 2009). In this process, hydrolytic enzyme is activated and decomposed high molecular weight rice compositions lead to bio-functional substances, physicochemical changes and improve nutritional and organoleptic qualities (Ohtsubo *et al*., 2005; Charoenthaikij *et al*., 2009; Mohan *et al*., 2010; Xu *et al*., 2011; Wu *et al*., 2013) due to softening of the texture after cooking, an increased amount of flavor components and several health benefits (Tian *et al*., 2004; Wu *et al.,* 2013). As compares to brown rice, PGBR is richer in rate intensity of attributes in cooked PGBR such as sweeter, softer, more swelled and cohesive (Jiamyangywen and Ooraikul, 2008). Pre-germinate condition induces important changed in the biomodification, physicochemical and sensory characteristics of rice grains, which consumers might have an increased interest in brown rice. It is also additionally value adding to paddy rice.

Objective

To investigate pre-germinate conditions on the structural change in starch granules, texture properties and sensory evaluation of PGBR derived from Thai waxy rice cultivar (Sun-Pah-Tawng1) to compare with normal brown rice.

Materials

Paddy rice of *Oryza sativa* L.*,* cultivar Sun-Pah-Tawng1 (amylose content 1.75%) was purchased from the Chiang Mai Rice Research Center, Chiang Mai, Thailand. Paddy was sorted to remove any foreign matter.

Pre-germination procedure

Before pre-germination, washed paddy rice samples (100 g) of SPT1 cultivar were soaked in steeping water with a grain-to-water ratio of 1:5 (w/v) at 30 °C for 10 h until the paddy had an appropriate moisture content of 30%. The soaking water was changed every 6 h. The pre-germinate procedure was carried out under two sets of conditions: 1) pre-germinate by incubated paddy with water conditions, samples were removed from the soaking water and then again soaked paddy in tap water for pre-germination and samples were collected at specified times (0, 6, 12, 18, 24, 30, 36, 42, 48, 54, 60 and 66 h); and 2) pre-germinate by incubated paddy without water conditions, the moisted paddy was removed from the water and packed separately in plastic boxes with a lid. Moisted paddy was put in the dark at 30 °C and 85 % relative humidity in order to pre-germinate, sample was then collected at specified time (0, 6, 12, 18, 24, 30, 36, 42, 48, 54, 60 and 66 h). After pre-germination had been carried out, the pre-germinated paddy was dried in a dry tray at 40 °C to a moisture content of not

more than 10% wet weight. The dried pre-germinated paddy was dehusked. The pre-germinated brown rice was used for microscopy analysis. The selected pre-germinated brown rice from each stage was kept for further analysis.

Stereo microscopy

The paddy and pre-germinated paddy rice were dehusked by hand and viewed at 10x magnification under a stereo microscopy.

Scanning electron microscopy

All brown rice and pre-germinated brown rice (PGBR) samples were broken and sputter coated with gold and viewed under an LEO 1455VP scanning electron microscope (Oxford Inca EDX, UK) at an accelerating voltage of 20 kV.

Texture properties

The fresh cooked SPT1 PGBR was subjected to texture profile analysis (TPA) using texture analyzer (TA-XT Plus, Stable Micro Systems, Surrey, UK), as the method reported by Tain *et al.* (2004). Before testing, the SPT1 PGBR sample was cleaned and cooked in an electric cooker using a ratio of rice to water of about 1: 1.2 for 30 min, until the switch automatically cut. Samples of the cooked rice were hold in the rice cooker for an additional 15 min. Cooked rice kernel was placed on the center of the cylindrical probe with a diameter of 25 mm was compressed at a pre-test speed 1 mm/s, test-speed 0.5 mm/sec and post test speed 10 mm/s and a trigger force 10 g The deformation level was 70% of the original sample height and the partly broken rice was compressed again. Parameters recorded from the test curves were hardness and cohesiveness. All texture analyzed were replicated at least 10 times for each sample and results are presented as mean value was collected for statistical analysis.

Sensory evaluation

SPT1-pre-germinated brown rice samples was cleaned and cooked in an electric cooker using a ratio of rice to water of about 1: 1.2 for 30 min. The sensory evaluation used the panelist's 20 persons from Muslim club at Kasetsart University, Bangkok, Thailand. Sensory evaluation of six pre-germinated brown rice samples was determined to compare with normal brown rice. The five sensory attribute, appearance, odor, hardness and overall acceptability of the products after cooking were evaluated. The panel was performed a 9-point hedonic scale (1=dislike extremely, 3= dislike, 5= like nor dislike, 7= like moderately and 9= like extremely) to evaluate cooked SPT1-PGBR following the method of Mestres et al. (2011).

Statistical analysis

A completely randomized design (CRD) and Randomized complete block design (RCBD) was applied in this study. The SPSS for Windows software program Version 11.0 was employed to analyze the results. Data were subjected to analysis of variance (ANOVA). Significant differences between means were identified using Duncan's multiple-range test (DMRT) at a test level of $p<0.05$.

Results and discussions

Stereo microscopy

The suitable time for pre-germination SPT1 paddy to get each stage can be select by stereo microscope to determine the embryonic growth length. The paddy and brown rice characteristics of the SPT1 cultivar samples during pre-germination are presented in Figure 1, with the paddy and brown rice from SPT1 cultivar before pre-germination in Figure 1a. Three stages were observed (refer to Figures 1b-1d): 1) a minimum stage (0.5-1 mm embryo growth length, 60-70% of pre-germination at 32 h embryonic growth length): , 2) an optimum stage (1-2 mm embryo growth length, 71-80% of pre-germination at 38 h): and, 3) a maximum stage (2-3 mm embryo growth length, more than 80% of pre-germination at 44 h). The pre-germinated paddy from SPT1 for each stage at specific embryonic growth length obtained were similar for both incubated with water and without water conditions, at a minimum stage (0.5-1 mm), optimum stage (1-2 mm) and maximum stage (2-3 mm) to be 32, 38 and 44 h, respectively.

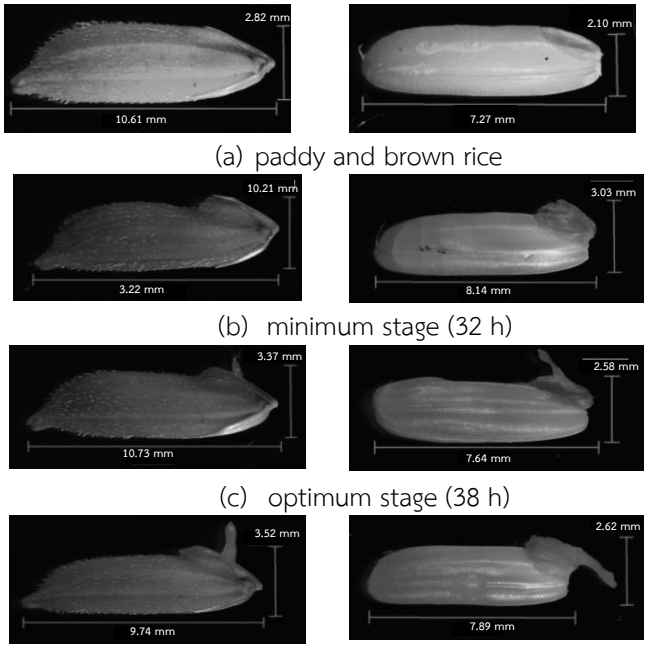

Figure 1 Pre-germinated paddy and brown rice from Sun-Pah-Tawng1, (a) paddy and brown rice, (b) minimum stage (32 h), (c) optimum stage (38 h) and (d) maximum stage (44 h), viewed at 10x under stereo microscope.

Scanning electron microscopy

Figure 2 shows the starch granules are irregular, mainly polygonal in shapes and have a continuous structure consisting of a smooth surface embedded in the amyloplasts (Fig. 2a). In contrast to what was observed for STP1 PGBR, this continuous structure changed within granules, as starch granules lost their smooth surface after germination and the disruption was increased as germination proceeded. (Figs. 2b, 2c, 2d, 2e, 2f, 2g). After 44 h of germination, the starch granules were rougher and slightly eroded with small irregular fragments (Figs.2d, 2g) and individual polygonal starch granules could still be distinguished and were still normal shaped. The process of grain germination is always accompanied with hydrolysis of enzymes. Ordinarily, enzymes could perforate into the inside granule and then surface cavities and pores were formed with resultant hydrolysis from the hilum region toward the outside (Planchot *et al*.; 1995, Xu *et al*, 2011). During germination, **α**-amylase in the aleurone layer plays an important role in hydrolyzing the endosperm starch into metabolizable sugar, which provides the energy for germination (Kaneko *et al*., 2002). A comparison between brown rice (Fig. 2a) and PGBR by incubated with water conditions (Figs. 2b, 2c, 2d) and incubated without water conditions (Figs. 2e, 2f, 2g) also showed that changes in the morphological properties for the PGBR under

incubated with water and without water conditions were much less pronounced than those for brown rice. After 44 h of germination by incubated without water condition, the starch granules were becoming rougher and eroded with small irregular fragments (Fig. 2g). However, the starch granules were rougher, slightly eroded and individual polygonal starch granules could be distinguished was still normal shaped under PGBR by incubated with water conditions (Fig. 2d).

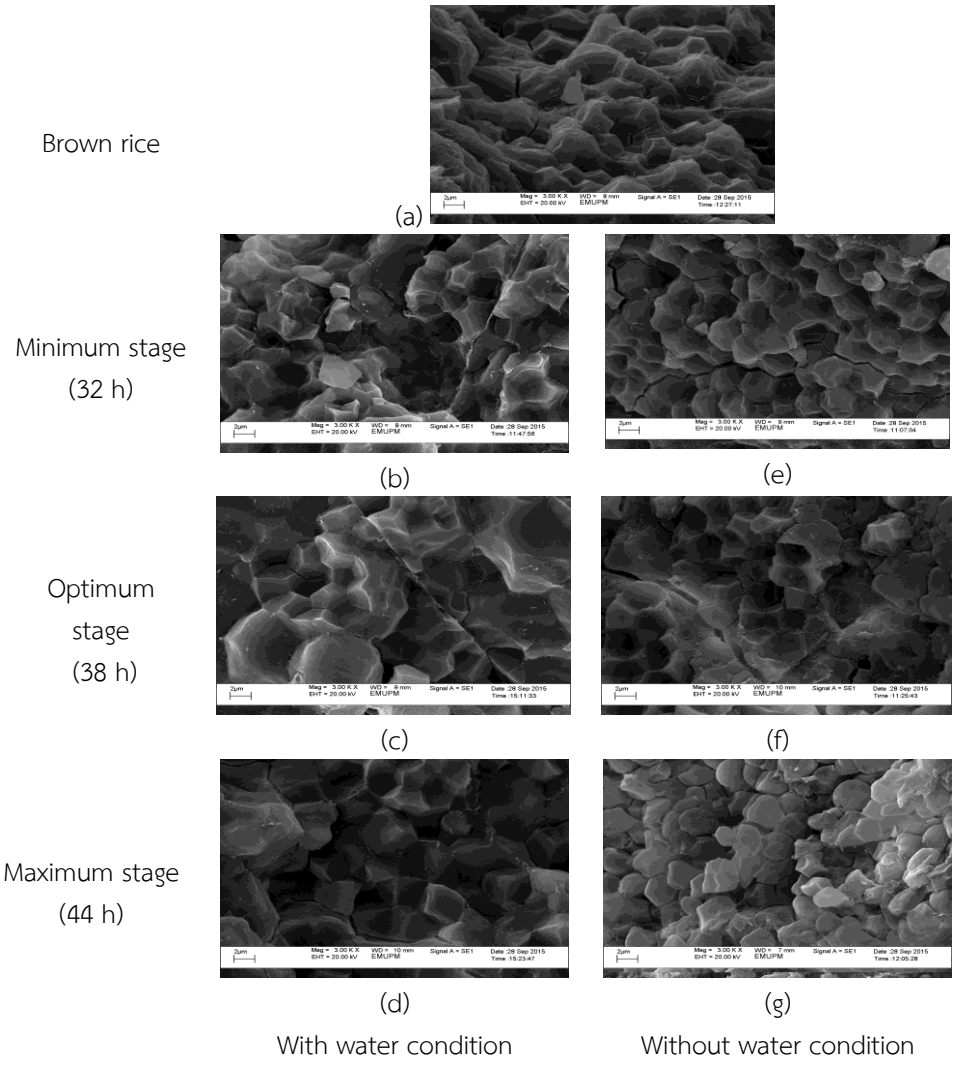

Figure 2 SEMs of starchy endosperm from (a) brown rice and pre-germinated brown rice from SPT1 cultivar incubated paddy with (b, c, d) and without (e, f, g) water pre-germination condition viewed at 3,000x magnification.

Texture of cooked pre-germinated brown rice

The texture analysis data revealed that the cooked SPT1 brown waxy rice had higher hardness and cohesiveness than the cooked SPT1-PGBR (Table 1). The hardness of cooked STP1 was significantly reduced by the germination condition. This decrease might indicate that the PGBR had partial degradation of cell walls by xylanases (Mohan *et al*, 2010), starch granules hydrolyzed by **α**-amylase and the degradation of protein by protease enzyme (Mohan *et al*., 2010; Kaosa-ard and Songsermpong, 2012).

Table 1 Texture properties of cooked pre-germinated brown rice from Sun-Pah-Tawng1 cultivar with different pre-germination condition.

Treatments	Hardness[1] (N)	Cohesiveness[1]
Brown rice	5.48±0.60a	0.54 ±0.04a
PGBR-W (32 h)-min stage	5.16±0.57a	0.50±0.23b
PGBR-W (38 h)-opt stage	4.95±0.52b	0.49±0.02c
PGBR-W (44 h)-max stage	4.68±0.63c	0.48±0.23c
PGBR-OW (32 h)-min stage	5.42±0.70a	0.51±0.05b
PGBR-OW (38 h)-opt stage	4.51±0.95c	0.50±0.06b
PGBR-OW (44 h)-max stage	4.69±0.29c	0.48±0.37c

[1]Means for each characteristics followed by the different small letter within the same column are significantly different ($p \leq 0.05$). PGBR-W = pre-germinated brown rice procedure by incubated with water condition; PGBR-OW = pre-germinated brown rice procedure by incubated without water condition.

Sensory evaluation

The sensory evaluation of cooked SPT1 PGBR was significantly ($p \leq 0.05$) acceptability as the different pre-germination as shown in Table 2. The pre-germination by incubated without water condition could improve the texture and odor of PGBR as indicated by the higher score than that of PGBR by incubated with water condition and brown rice. As compared to other PGBR by incubated without water condition, the germination at an optimum stage (38 h) provided the highest score for cooked rice in term of appearance, odor, texture and overall acceptability. Some panelists gave the comment that the odor of cooked PGBR by incubated with water condition was too fermented odor. Hence, the cooked PGBR obtained from the incubated with water condition at different stage showed the lowest score of odor and overall acceptability.

Table 2 Mean value of sensory evaluation score in each attribute of cooked PGBR from Sun-Pah-Tawng1 after soaking and per-germinating process

[1]Means for each characteristics followed by the different small latter within the same column are significantly different ($p \leq 0.05$). PGBR-W = pre-germinated brown rice procedure by incubated with water condition; PGBR-OW = pre-germinated brown rice procedure by incubated without water condition (1= disliked extremely; 5 = neither like nor dislike and 9= like extremely).

Treatments	Appearance[1]	Odor[1]	Hardness[1]	Overall acceptability[1]
Brown rice	6.40±0.68c	6.65±0.813b	6.15±0.23c	6.20±0.61c
PGBR-W (32 h)-min stage	6.45±0.09c	5.75±0.91c	5.70±0.27d	6.10±0.65c
PGBR-W (38 h)-opt stage	6.35±0.98c	4.80±0.89d	6.00±0.25d	6.05±0.62d
PGBR-W (44 h)-max stage	6.75±0.29bc	4.20±0.05e	6.15±0.82c	5.80±0.87d
PGBR-OW (32 h)-min stage	7.00±0.91b	7.20±0.89ab	7.15±0.91b	7.15±1.04b
PGBR-OW (38 h)-opt stage	7.65±0.87a	7.60±0.75a	7.50±0.56a	7.60±0.81a
PGBR-OW (44 h)-max stage	7.10±0.24b	6.65±0.74b	7.20±0.59b	7.30±0.76b

Conclusions

This study found a significant change in the microstructure of SPT1 brown rice occurred during the process of germination. The pre-germination stages obtained were different for both incubated with water and incubated without water conditions. The starch granules of SPT1 PGBR lost their smooth surface and become slightly eroded, had small irregular fragments and polygonal shapes. The cooked SPT1 PGBR under both incubated with water and incubated without water conditions showed decreased hardness, which were significantly different from SPT1 brown rice. From the sensory evaluation, the overall acceptability of cooked SPT1 PGBR by incubated without water condition with an optimum stage was better than that of PGBR by incubated with water condition. The cooked SPT1 PGBR by incubated with water condition provided the poorer quality of cooked PGBR in terms of odor whilst the fermented odor was obtained

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