Malt and wort characteristics of Thai rice varieties cultivated in Kanjanaburi province.

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Abstract

The objective of this research was to study the physical and chemical properties of three local varieties non-sticky paddy rice of Thailand that cultivated in Kanjanaburi province. After malting these paddy rice by a micro-malting method, the characterizations of malts were evaluated and compared to the malted barley. The results showed that at 30°C, the optimal steeping time to produce 95 percent up of germination and the highest level of moisture content for Pathumthani1, Riceberry and RD43 were 60, 72, and 60 hours, respectively. Moreover, the optimal periods for germination giving the highest levels of diastatic power for Pathumthani1, Riceberry, and RD43 were 72, 84, and 72 hours, respectively. The data also indicated the DP activity of fresh malt of Pathumthani1, Riceberry and RD43 were 41.34, 63.07, and 65.96 WK-units, which lower than commercial barley malt. The extracts content from congress mashing of three varieties of Thai rice malt which prepared according to the EBC method were lower than control malted barley. However, quality evaluation of malt and wort showed that their colors were darker than the pale malt standard while their FAN, pH, specific gravity and extract content were less than control barley malt.

Keywords: *Malting, Mashing, Rice malt, Rice wort, Diastatic power, wort extract*

1. Introduction

Thailand is an important country for rice production and has many rice varieties with high biodiversity. Some varieties contain high special nutritional value and bioactive compounds suitable for using as a raw material for healthy food and drink manufacture. For example, germinated brown rice is admired more valuable than normal brown rice since it is not only higher in the basic nutritional components but also has good organoleptic properties after cooking. To prepare germinated brown rice, the brown rice was soaked in water and allowed to slightly germinate (Hagiwara *et al*., 2004). The outer bran layer becomes soft and more prone to water absorption, making it easier to cook. Many researches reported that many constituents of brown rice were affected by germination (Komatsuzaki *et al*., 2007; Jongjareonrak *et al*., 2009; Ohtsubo *et al*., 2005). Moreover, some of its physicochemical properties were changed (Charoenthaikij *et al*.,2009; Mohan *et al*., 2010). Charoenthaikij *et al*. (2009) indicated that brown rice germinated in different conditions had different properties. However, a study on different germinated brown rice varieties produced under different conditions from many countries showed that after germination their functional properties were improved (Hsu *et al*., 2008; Ito *et al*., 2005).

Barley is well-known that would be converted into malt which is the form of germinated cereal for a long time from the year 2800BC. In Germany, wheat and other cereals can be used in their malted form to produce top-fermented beer (Wolfgang, 2010). In Thailand, Indica rice is used to prepare malted rice products for cooking and consuming. The three main steps for the malting process are steeping, germination and kilning. Steeping is the first important step that is done by immersing the grains in water to adsorb the water necessary for germination. Then, the grains start to germinate in step 2. In this step natural enzymes in the grain kernel are produced such as amylase, protease and other enzymes that hydrolyze and modify the grain components and its structure. The final step is heating or kilning at a high temperature to reduce the moisture content of the grains and stop the germination process which resulted in changing color, aroma, and taste of malt. Researches of Puangwerakul in 2010 and 2011 indicated that these changing properties in normal and germinated brown rice were completely different. Sheldon *et al*. (1971) found that enhancement of sweet flavor in malt was enhanced due to the increase of total sugar content. Moreover, they revealed that malty flavor or sweet aroma occurred from the degradation of amino acids in the malt to a compound containing methyl alcohol group. Wolfgang (1999) also found that the Maillard reaction between amino acids and reducing sugar including caramelization reaction of burnt sugar in rice grains during the kilning step resulted in the dark reddish-brown color of malt. Nowadays, the imported volume of barley and malt tended to increase every year. Most of them are used in beer industries but recently, gluten-free malting and brewing product trends for health-conscious consumers are interesting. Since barley contains gluten around 5-8%, therefore there are many attempts to produce beer from Thai rice (Usansa *et al*., 2011). They showed that lager beers from black non-waxy rice and black waxy rice varieties were judged as drinkable and clearly demonstrated that beer using black rice malt as a raw material could be produced with acceptable quality.

Since Pathumthani1, Riceberry, as well as RD43 are famous and high potential Thai rice varieties which can be added more value, therefore the main aim of this research is to get a knowledge of suitable malting conditions including properties of malt and wort from the three rice varieties. In addition, the results of this study can be adjusted to commercial production with low investment.

2. Objectives

To study the suitable germination process including the quality of malt and wort from Thai rice varieties cultivated in Kanjanaburi.

3. Materials and Methods

The 3 varieties of non-sticky indica rice: Pathumthani1 (PTT1), Riceberry (RBR), and RD43 derived from Nong Sarai Farming Community Enterprise Group, Kanchanaburi Province were selected to use in malt cultivation. They are harvested in January 2019. Their paddy rice was kept for 4 weeks until passed the seed dormancy period with the final moisture content of 11%. Barley was supplied by San Miguel Beer (Thailand) Co., Ltd. All reagents were of analytical grade, obtained from Merck (Darmstadt, Germany).

3.1 Study of suitable time for the malting of paddy rice.

Five kilograms of paddy rice from each variety were cleaned and defective seeds were removed by soaking in water at 30°C for 5 minutes. The perfect grains were collected and soaked in new water again for 12 hours then were air-dried for 1 hour. The soaking and air-dried processes were repeated 6 times. Random sampling was done during the process at 12, 24, 36, 48, 60 and 72. A sampling of 5 grams was collected to analyzed moisture content according to EBC (1987) method and of 100 grams to study germination. The sprouting efficiency of rice grains was done according to the method of BRF by placing 100 grams of rice grains in petri dish plate lining with Whatman No.1 of 90 mm diameter and cultivated in a dark cabinet at 30°C for 72 hours then took out to count the sprouting grains and reported sprouting efficiency as % germinative energy.

To study the malt quality, the paddy seeds of each rice variety were soaked in water at a suitable time, then the seeds were divided into 10 parts (100 grams/ part) to spread on plastic perforated basket 26 cm. wide x 36 cm. long and were brought to germinate in the dark chamber cabinet at a controlled temperature of 30°C and relative humidity of 90% for 120 hours. Every 12 hours the fresh malt were sampling to count their sprouts and calculate % germinative energy, then 50 grams of the sprouts were kept to analyze diastatic activity (WK units) according to EBC (1987). The remaining malts were kilned by tray dryer at 55°C for 24 hours to stop the activity of malt enzymes. Their roots were cut off and kept to analyze the quality of dried malt and wort. According to barley malt control, the steeping and germination processes were done at 20°C.

3.2 Study of malts and wort quality

Fresh malt from each variety was divided into three parts. The first part was analyzed for Diastatic Power (DP) by the method of EBC (1987). The second part after drying to stop its enzyme activity was analyzed for moisture, amylose and protein content. The third part of dried malt was ground and then boiled at adjusted temperature to prepare congress wort. The free amino nitrogen (FAN), specific gravity, pH, color and extract substances of wort were analyzed according to the EBC (1987) method.

4. Results and Discussion

4.1 Suitable time for the malting of paddy rice

After rice seed was steeping for 72 hours, the growth development could be observed. It was found that the water absorption by germinating rice increased to the maximum value and then stable (Figure 1).

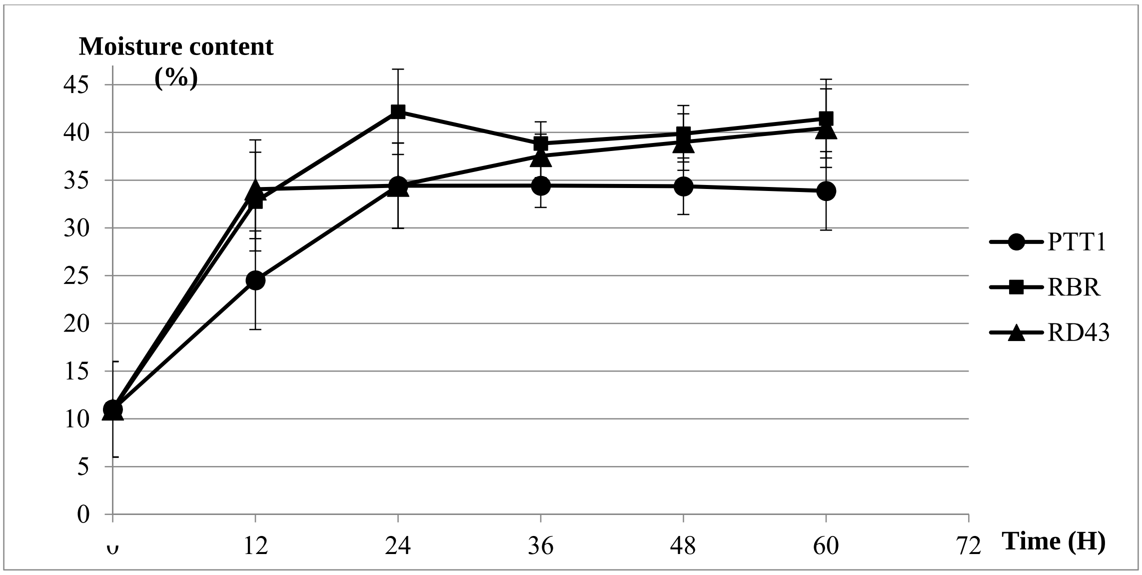

Figure 1 Steeping curve

From Fig.1, All varieties had a similar pattern of steeping curve but were different in the content of water uptake. The results found that water uptake occurred rapidly at first and gradually slowed down with time.

During germination, the elongation of the root was developed and progressively increased with germination time. Moreover, the shortest of root length was observed as shown in Table 1 because the value of malting loss increased with germination time. These data were similar to the study of Usansa (2008). According to the meaning of malting losses, rootlet losses are the major item (Briggs, 1998). Therefore, in the germination step, beyond the maximum of diastatic power of enzyme (Data not showed), the optimal malting with short germination time that gave low malting losses in Table 1 should be considered.

Table 1 Root length of malt from three rice varieties during 120 hours germination

Time (hours)	Rice varieties		
	Pathumthani1	Riceberry	RD43
12	17.91±3.5d	6.61±2.5e	15.52±4.1d
24	23.32±6.5d	14.92±5.7d	22.50±6.1c
36	32.65±5.5cd	21.42±6.8cd	28.64±2.5c
48	37.24±4.8c	27.85±4.4c	36.18±3.5b
60	54.57±5.4b	30.17±2.2c	41.85±6.2ab
72	56.57±6.9b	36.80±3.8b	40.51±8.3ab
84	52.91±5.5b	41.42±3.3b	41.36±5.6ab
96	46.04±5.4b	44.37±5.4b	45.24±5.4a
108	65.54±6.1a	53.63±6.5a	52.55±5.9a
120	73.10±10.6a	61.60±8.8a	55.52±5.5a

a-e: means within the same column with different letters are significantly different ($p \leq 0.05$)

Suitable condition for malting

The data from Table 2 showed that paddy grains of the three varieties sprouted well at the moisture content of 34-46% or between 60-70 hours of steeping time depending on the variety. There was also the relationship between the moisture content of malt and suitable soaking time. As the soaking time was increased, the moisture content of the grains was increased until the maximum level and then stable. However, it depended on the variety of rice. For Riceberry malt, the longer soaking time at 72 hours is required to obtain 45.54% maximum moisture content due to its thick and hard seed coat. While Pathumtani1 and RD43 malt needed lesser time to increase maximum moisture content up to 33.87% and 37.66% respectively. Compared with barley malt which required soaking time at 48 hours to obtain maximum moisture content of 40.05%. It was noticed that malt from indica rice such as Pathumthani1 and RD43 required longer steeping time but lower moisture content than control. Wolfgang (2010) also indicated that each rice variety needed different sprouting periods because of their different chemical and physical properties which affected to the different absorption rates. The suitable sprouting period selected by mean of Diastatic Power was 72-84 hours depending on the variety. The results also showed that Thai rice had lower DP value than control barley malt. The DP value of malt from three rice varieties was shown in Table 2.

Table 2 Suitable conditions for the malting of three rice varieties compare with control barley malt.

Varieties	Measured parameters					
	Steeping time (hrs)	%Germinative energy	%Moisture content	Germination time (hrs)	Length of rootlet(mm)	DP (WK units)
Pathumthani1	60	96.67a	33.87b	72	56.57a	41.34c
Riceberry	72	95.00a	45.54a	84	36.80b	63.07b
RD 43	60	95.67a	37.66ab	72	40.51b	65.96b
Control barley malt	48	97.85a	40.05ab	60	37.00b	174.82a

a-c: means within the same column with different letters are significantly different ($p \leq 0.05$)

According to Table 2, the DP activity of malt from three rice varieties was between 41-66 WK-units which consistent with research conducted on Thai rice by Puangwerakul (2007). There was data showed that the DP activity of fresh malt in Indica rice and Japonica rice were between 52-159 WK-units, lower than wheat malt and barley malt which were in a range of 166-184 WK-units. Naivikul (2007) explained that in barley, beta-amylase was accumulating in seed at the beginning so during steeping, both of alpha-amylase and beta-amylase would be activated to increase together while rice had no beta-amylase accumulation in seed like barley. Therefore, both of them were activated and started to synthesis after the grain was steeped. These could be the reason that the DP activity which is the total combined activity of alpha- and beta-amylase of malted rice were lower than control barley malt.

4.2 Malt and wort quality

Amylose contents in three Thai rice malt were in the same range which was categorized as intermediate gelatinization temperature 70-74°C (Capanzana and Buckle, 1977) while EBC mashing temperature stood at 70°C. It was possible that only diastatic enzymes in rice malt played an important role in seed modification during germination and affected to extract yield more than the role in the mashing step. One factor that influences the selection of mashing programs is the gelatinization temperature of starch from different sources. Starch from three Thai rice varieties in this research had gelatinization temperature at 70-74°C which closed to the optimal temperature of alpha- and beta-amylase (Wolfgang, 2010) while barley starch had lower gelatinization temperature at 55-59°C (Goode, Halbert and Arend, 2002). As compared to the extract substance from control barley malt for beer manufacturing which was between 75-85% (Taylor and Boyd,1986) no variety was found to be up to the standard (Table 3). The volume of extracted substance and the specific gravity of all varieties were varied according to the DP enzyme and FAN. However, the pH of worts was close to the standard pH criteria and moisture content of dry malt was lower than 5%. These indicated the good preparation of wort. In addition, the FAN value was lower than the standard value (120-190 mg/l). It is noticed that the FAN value of standard criteria is in a wide range according to the different protein content of malt which depends on each breed as described by Briggs (1998). For wort appearance, it was noticeable that malt from Thai rice was darker than pale malt standard as recommended at 4.0-6.5 degree EBC. The darker color was resulted from the Maillard reaction varying by amino acid and reducing sugar in each modified malt. Moreover, the pigment in the seed coat of each Thai rice variety especially of Riceberry was responsible for the higher °EBC value as shown in Table 3

Table 3 Malt and wort quality of three rice varieties compare with control barley malt and standard criteria

Varieties	Measured parameters								
	Malt analysis			Wort analysis					
	%amylose	%moisture content	%protein	Diastatic Power (WKunits)	FAN (mg/1)	pH	Specific gravity	Color (°EBC)	Extract (%w/w)
Pathumthani1	17.50	3.55	7.25	63.70	109	5.15	1.0379	6.40	50.28
Riceberry	16.80	4.17	7.34	116.60	114	5.35	1.0473	7.95	60.20
RD43	18.15	3.59	7.40	107.20	117	5.42	1.0440	6.25	63.47
Control barley malt	38.15	5.00	10.85	264.10	168	6.02	1.0852	5.14	81.25
Standard criteria	-	3.0-5.0	9.5-11.0	260-300	120-190	5.6-5.9	1.06-1.09	4.0-6.5	79-82

From "Congress mashing" a standard mashing program, extract yield is one of the most important quality indexes of the malt extract. During the mashing process, amylolytic and proteolytic enzymes were activated resulting in hydrolyzed fermentable substance in the wort. The extract yield is calculated for a uniform 0% moisture content (% dry basis) which indicates the amount of maximum soluble substances possible for malt. The higher extract yield, the more soluble substances and the less husk and protein. Any base malt that doesn't give at least 78% extract yield is substandard. The extract from the three rice malts was in a range between 50-63% (w/w) which are slightly low because rice grain contained husk approximately 20 (%w/w) (Juliano, 1985) and 30% husk was detected in malted rice. On the other hand, barley has higher starch in endosperm approximately 82% (Briggs, 1998). The lower extract yield also related to the calculation method of EBC. Since the weight of husk was taken into account for gram of malt, whereas it did not contribute to the specific gravity of wort (Wijngaard and Ulmer, 2005). Moreover, the gelatinization temperature of rice starch was higher than 70 °C which was higher than the liquefaction temperature in congress mashing. For this reason, the low amount of extract content found in rice malt was not a surprise and acceptable.

5. Conclusion

Malt and wort characteristics of three Thai rice varieties cultivated in Kanjanaburi province were evaluated. The optimal steeping time for Pathumthani1, Riceberry and RD43 were 60, 72 and 60 hours, respectively and the optimal germination time were 72, 84 and 72 hours, respectively. For wort quality, the content of FAN, pH, specific gravities and extract yields of three Thai rice malts were less than control barley malt. Although extract yield in wort from Thai rice malt was poorer than barley malt, the modification in the mashing step might help increasing yield by adjusting the optimal temperature to increase the rate of starch degradation.

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