การเปรียบเทียบสมบัติทางกายภาพ เคมี จุลินทรีย์และประสาทสัมผัสในข้าวสายพันธุ์พิษณุโลก 2 ระหว่างข้าวกล้อง ข้าวมอลต์ และข้าวมอลต์นึ่ง

Comparison of the Physical, Chemical, Microbial and Sensory Properties between Brown Rice, Malted Rice and Parboiled Malted Rice of Rice cv. Phitsanulok 2

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บทคัดย่อ

การศึกษาผลของกระบวนการมอลติ้งและกระบวนการนึ่งที่มีต่อสมบัติทางกายภาพ เคมี จุลินทรีย์และประสาทสัมผัสในการผลิตข้าวรับประทานจากข้าวไทยสายพันธุ์พิษณุโลก 2 ระดับต้นแบบโดยวิสาหกิจชุมชนที่มีกำลังผลิต 1,000 กิโลกรัม/วัน พบว่ากระบวนการมอลติ้งส่งผลต่อกายภาพและเคมี ทำให้เกิดการเปลี่ยนแปลงของสี กลิ่นหอม กลิ่นรสและสมบัติทางโภชนาการอย่างมีนัยสำคัญ โดยพบการเพิ่มขึ้นของน้ำตาลรีดิวส์ทั้งหมด ปริมาณแร่ธาตุ ใยอาหาร วิตามินบี 1 สารกาบา และฟีนอลิกรวม ยิ่งไปกว่านั้น พบการลดลงอย่างมีนัยสำคัญในปริมาณแอมิโลสและกรดไฟติก ในขณะที่กระบวนการนึ่งส่งผลต่อเคมีบางประการโดยเฉพาะการลดลงอย่างมีนัยสำคัญของปริมาณกรดไขมันอิสระ ค่าเพอร์ออกไซด์ รวมถึงปริมาณจุลินทรีย์ปนเปื้อนและจุลินทรีย์ก่อโรค และพบว่าปริมาณวิตามินบี 1 ในผลิตภัณฑ์สุดท้ายข้าวมอลต์นึ่งอยู่ในระดับที่กล่าวอ้างว่าสูงตามเกณฑ์ Thai RDI และใช้เวลาในการหุงต้มที่สั้นลง ผลการทดสอบทางประสาทสัมผัสของข้าวมอลต์นึ่งในด้านความแข็ง ความเหนียว ความเลื่อมมัน กลิ่นหอม กลิ่นรสและความชอบรวม อยู่ในระดับที่สูงกว่ากว่าข้าวมอลต์และข้าวกล้อง

คำสำคัญ: *มอลต์พิษณุโลก 2 ข้าวมอลต์นึ่งข้าวสุขภาพ*

Abstract

Effects of malting and parboiling processes on physical, chemical, microbiological and sensory properties of rice cv. Phitsanulok 2 were investigated at the pilot-community enterprise. This community enterprise had a daily production capacity of about 1000 kilograms rice grain. Results showed that malting process caused significant physical and chemical changes in color, aroma, flavor and nutritional properties of rice. This process induced increase in total reducing sugar, minerals, fiber, vitamin B1, GABA, and total phenolic compounds. On the contrary, the process decreased the amount of amylose and phytic acid. The parboiling process had an effect on some changes in chemical properties. It was found that, free fatty acids, peroxide value, and amount of contaminant and pathogenic microbes were significantly decreased. The amount of vitamin B1 in parboiled malted rice reached the categorized standard of Thai recommended daily intake (Thai RDI) and its cooking time was shortened. The sensory testing of parboiled malted rice in hardness, stickiness, glossiness, aroma, flavor and total preference were higher than malted and brown rice.

Keywords: *Phitsanulok 2 malt, parboiled malted rice, nutritious rice*

1. Introduction

Rice is the number one economic crop of Thailand; however, farmers, the majority of the population, have to contend with depressed price problems in selling rice paddy. Consequently, the government has to reallocate billions of baht per annum regularly from the national budget to support rice paddy prices. The reason for the depressed paddy prices is large rice outputs flood the market simultaneously and rice mills take advantage of this fact to bid down prices. If farmers can be encouraged to unite to modify and thereby add higher value to rice products without having to sell to mills, their incomes will rise and subsequently lower the burden on the government.Producing germinated rice can be considered creating value added to edible ricein new granular form that can greatly promote and publicize rice for health in today's high quality rice market. Research groups from renowned institutions in Thailand and Japan both have shown keen interest in "germinated brown rice." It has been reported that germinated brown rice is highly nutritious and possesses many bio-functional compounds, such as feruric acid, phenolic compounds, inositol, oryzanol, total dietary fiber, andγ-aminobutyric acid or GABA, in greater quantities than brown rice that have not undergone germination (Komatsuzaki et al., 2007; Ohtsubo et al., 2005). Moreover, it has also been decreased in some antinutrients, such as phytic acid in germinated rice, sorghum and some legume seeds (Watchararpapaiboon et al., 2010; Ghavidel and Prakash, 2007; Idris et al., 2006). Germinated brown rice exhibits improved sensory feel and flavor over regular brown rice (Tungtrakul et al., 2006), thereby commanding higher prices than other forms of rice. In 2004, Ito and Ishikawa (2004) reported that germinated brown rice and rice breadcould promote greater rice consumption in a period of agricultural slump similar to Taiwan, Malaysia, Singapore, and China. In addition, it was also discovered that food products and sweets made from germinated brown rice were experiencing an uptrend and growing in popularity both in Japan and in other countries in Asia.

Today, germinated rice products manufactured and sold commercially in Thailand can be divided into 2 categories: (1) GABA rice of Japan and Korea, which is germinated brown rice and (2) malted rice, which is brown germinated rice. Both products exhibit different germination patterns.

Germinated brown rice first undergoes milling to remove husks to become brown rice and is thencultivated in a nursery to produce germination. Malted rice, on the other hand,is first germinated as rice paddy and is then milled to produce brown rice. Moreover, the two types of brown rice also differ in cultivation time and controlled conditions while undergoing cultivation. (Puangwerakul, 2011; Puangwerakul, 2010). The similarity in both types of germinated rice is nutritional value, which allows them to be sold for a premium over regular brown rice. Especially, for high amylose and non-aromatic rice varieties.The market price of these rice are11.68 baht/Kglower than low amylose and aromatic rice variety such as KDML105 (20 baht/Kg) (Department of Internal Trade, 2013). Varieties of these rice have lot of quantity, cheap and easily find within the country such as Phitsanulok2, Chainat1,SuphanBuri 1 and LeuangPratew 123, hard, rough and chewy rice, the former research showed that malting process could improve cooking and eating qualities. (Puangwerakul and Puangwerakul, 2010.)

As cultivation of germinated brown rice entails soaking of brown rice seeds for some time in water, this easily increases risks from bacterial contamination and fermentation. This is described in a 2007 report by Komatsuzaki et al., which found up to 100 million cells/gram of bacteria in germinated brown rice prior to parboiling. Similarly, Ohtsubo et al. (2005) found 9.6 x 10^5million cells/gram of bacteria in germinated brown rice flour. To overcome the low storage time limitation and to lower the risk of microbial contamination, the researcher has conducted research modifying the production process to make parboiled malted rice. Moreover, the researcher has expanded the scope of research to persuade the community farming cooperative enterprise honoring His Majesty the King at Thang Yao Village, KlongKwai Sub-District, Sam Khok District, PathumThani Province to produce "parboiled malted rice" for consumption since 2006.The advantage of this research will be to add-up the value of high amylose Thai ricevariety and give new alternatives of rice products for consumption in the country and exporting. Finally, the result of this research will be of the most benefit to farmers by themselves for production the unique product making higher income and improving their standard living.

2. Objectives

The objectives are to present a comparative database of physical, chemical, microbial, cooking time, and consumption properties between brown rice, malted rice, and parboiled malted rice and to prove the excellent points of parboiled malted rice.

3. Materials and Method

3.1 Raw Materialand preparation: Non-sticky rice variety Phitsanulok 2, high amylose non-aromatic long grain rice paddy were harvested from farmers' rice fields in April 2011.

Preparation of brown rice: Lower the moisture level of Phitsanulok 2 brown rice by 13-14 percent and polish at a 70 percent level using rice huller of the community enterprise and again lower the moisture level of brown rice to 11-12 % before packaging, conduct inspections on the following properties: physical, chemical and microbiological properties, cooking time and consumer acceptability test.

Preparation of malted rice :Saturate Phitsanulok 2 rice paddy in a well of 500-kilogram per square meter volume and provide 50-liter per square meter per minute of air for 60 hours. Thereafter, cultivate until germination appears in total darkness for 72 hours by controlling relative moisture at 80-90 %levels by spraying with water and temperatures in the range of 28-34°C. Next, kiln green malt in a tray dryerusing 55°Ctemperature heated airto reduce final moisture content to 13-14 % before milling with a rice huller that has been adjusted for milling brown rice. Finally, remove moisture of malted rice once again to11-12% before packaging and conduct inspections on the following properties: physical, chemical and microbiological properties, cooking time and consumer acceptability test.

Preparation of parboiled malted rice :Boil malted rice paddy in water in a ratio of 1:2 by weight in a steam pot for 15 minutes following the process used by the community farming cooperative enterprise honoring His Majesty the King at Thang Yao Village, PathumThani Province. Next, bake the paddy in a fanned convection oven until dry and the final moisture value is equivalent to 13-14 %before milling with a rice huller that has been adjusted for milling brown rice. Finally, remove moisture of malted rice once again to 11-12 %before packaging and conduct inspections on the following properties: physical, chemical and microbiological properties, cooking time and consumer acceptability test.

3.2 Physical properties : thousand corn weight and moisture content were determined by the method of EBC (EBC, 1987), color L^*,a^*,b^* values was measured by using chroma meter (Minolta CR-10).

3.3 Chemical properties : amylose content was determined by the simplifled assay method of Juliano (1971), protein, lipid, ash, fiber, carbohydrate, total reducing sugar, free fatty acid and peroxide were determined by following AOAC (2000) procedure. Vitamin B 1 was determined by the modified procedure of Liu et al.(2002) by following Watchararpapaiboon et al. (2010) procedure. GABA determined by the modified procedure of Kitaoka and Nakano (1969) by following Watchararpapaiboon et al. (2010) procedure. Total phenolics were determined by the method of folin-ciocalteau phenol test (Singleton and Rossi, 1965). Phytic acid was determined by following the method of Haug and Lantzsch (1983).

3.4 Microbiological properties :Sample for microbiological analysis was prepared by homogenized 25 g with 225 ml sterile peptone water and determined by following AOAC (2000) procedure. Microbiological properties were evaluated for total plate count, yeast and molds, coliforms, Escherichia coli, Clostridium perfringens, Staphylococcus aureus and Salmonella sp.

3.5 Cooking time:Cooking time was conducted using the method of Bhattacharya and Sowbhagya (1971).

Consumer acceptability test : The samples of Phitsanulok 2 three rice forms , brown rice, malted rice and parboiled malted rice, were prepare for panel evaluation. The panelists (n=100) were untrained. For each forms evaluation for tenderness, stickiness, gloss, aroma(malty aroma), flavor (sweetness), color, grain appearance and overall acceptance. Scores were provided on a 5-point hedonic scale where 1 is dislike extremely and 5 is like extremely.

3.6 Statistical analysis

All experiments were conducted in triplicate and the results are expressed as mean±SD. The statistical examination of the data was performed, using the SPSS version 11.5 programme. Mean values of physical properties, chemical properties and consumer acceptability test, within different rice (brown ice, malted rice and parboiled malted rice) were compared, using an analysis of the variance (ANOVA) test. These means were compared, using the Duncan Multiple Range Test and p< 0.05 was applied, in order to establish significant differences.

4. Result and Discussion

4.1 Physical properties

Physical qualities of Phitsanulok 2 rice after undergoing the milling process to become brown rice and after being modified to malted rice and parboiled malted rice until final moisture at a uniform level of 11-12 percent was determined. It was found that modification to malted rice and parboiled malted rice results in significant loss of grain. Thousand corn weight related to give an indication of the modification of the endosperm. With a well modified malt the thousand corn weight decreased as a result of cytolytic, proteolytic and other enzyme degradation (Wolfgang,1999). For the color value, it was also found that malt and parboiled malt have lower transparency values but greater yellow and red hue values when compared with brown rice as a result of reddish-brown color melanoidinesformation from maillard reaction during kilning process(Wolfgang,1999), as illustrated in Table 1.

Table1 Comparison of physical properties of brown rice, malted rice and parboiled malted rice.

Physical properties		Phitsanulok 2 riceforms		
		Brown rice	Malted rice	Parboiled malted rice
Thousand Corn Weight		30.35±0.55 [a]	25.61±0.50 [b]	25.20±0.55 [b]
Moisture Content (%)		12.90±1.17 [NS]	13.07±1.15 [NS]	13.00±1.14 [NS]
Color(L^*	L^*	73.20±2.05 [a]	60.70±2.20 [b]	60.75±2.50 [b]
a^*b^*)	a^*	2.85±0.25 [b]	4.25±0.20 [a]	4.30±0.25 [a]
	b^*	1.65±0.65 [b]	19.98±0.65 [a]	20.02±0.55 [a]

[a-c] Different letters in the same row indicated statistical difference (p< 0.05)

4.2 Chemical properties

As for chemical properties of Phitsanulok 2 rice, after milling to brown rice and processed to malted rice and parboiled malted rice in Table 2, it was observed that processing significantly lowered amylose content. The biochemical changes occurring in germination resulted in digestion of starch, which is stored as micro molecular sugars used for synthesizing vitamin enzymes and coenzymes essential for root and sprout growth. The reduction in the level of amylose was likely as a result of the activation of amylase in germinated brown rice (Asma et al, 2011; Harris 1962). Charoenthaikij et al.(2009) had reported that germination increased not only the activity of amylase but also increased reducing sugars supporting the findings of a lower amylose content in malted rice when compared with brown rice that agreed with many reports by other researcher (Mohan et al., 2010; Jiamyangyuen and Ooraikul, 2008). The content of total reducing sugar in malted rice was significantly higher than in brown rice. Palmiano and Juliano (1972) described that the activity of amylase increased progressively during starch degradation by four days of germination. Glucose was the major reducing sugar together with lower amounts of fructose, maltose and maltotriose while the major non-reducing sugar was sucrose together with raffinose. In this study, showed that malting and parboiling process did not affect the content of protein and lipid. Capanzana and Buckle (1997) also observed no significant change of protein content during germination of high amylase rice. On the other hand, several researchers reported improvement in the protein quantity as well as quality during germination of sorghum (Obizoba, 1988), millet (Malleshi and Desikachar, 1986), wheat (Dalby and Tsai, 1976) and maize (Tsai et al., 1975).They observed an increased in limiting amino acids such as lysine and improvement in protein digestibility. Malting and parboiling process did not change the lipid content. This result was similar to the results reported by Watchararpapaiboon et al. (2010). However, It was found that malted rice and parboiled malted rice have higher contents of ash and fiber than brown rice. It was obvious that malting process helped to increase vitamin B1 content up to 1.8 times similar to previous research reported by Watchararpapaiboon et al.(2010). This is because theoretically thiamine is synthesized to function as a co-enzyme in an activity that digests large molecules, especially starch into smaller molecules. Thus, during malting there is accumulation of vitamins in higher content than unmalted brown rice. This is consistent with results reported by Capanzana and Malleshi (1989). Zhang et al.(2005) conducted ongerminated brown rice that found that germination can increase thiamine content by 2.5 times,and Briggs et al.(1981) found that germinated barleycan increase thiamine content up to 2 times. In addition, Ash, soluble fiber and vitamin B1 are highly dissolved in water and can be reabsorbed into the grain through surface cracks of malted rice grains. This results from using heat with moisture in the malting and parboiling processes enabling the aleurone layer to better stick to the surface of the grain thereby making removal of these substances in the milling process more difficult (Bhattacharya,1985). In this study, parboiling does not result in loss of vitamin B1. On the contrary, Luh and Mickus (1980)'s report asserting that parboiled rice has greater vitamin B1 content than non-parboiled rice. This goes to say from our result that it was not clear-cut that parboiling increased vitamin B content or not but steaming time for 15 min was not affect to decrease amount of vitamin B that agreed with Manful et al. (2008). The remaining vitamin B 1 in final parboiled rice malt (equivalent to20% Thai RDI) which was considered in the "high/enrich" categories according to Thai RDI criteria (Ministry of

Public Health annunciation,1995). For GABA, it was found that germination increased GABA content up to5 times. This is consistent with researchs by Watchararpapaiboon et al. (2010) conducted on germinated brown rice of the two Thai rice varieties Chainat 1 and KDML105 (increased 4-5 times) and Maeda et al. (2001) conducted on germinated brown rice of Japonica variety (increased 3.4 times). In addition, it was shown that GABA content was not affected by steaming that agreed with report by Komatsuzaki et al. (2007). The phenolic profiles of brown rice and milled rice were dominated by ferrulic and p-coumaric acid with lesser amounts of gallic, vanillic, caffeic and syringic acids (Zhou et al. 2004). Tian et al. (2004) reported that during germination , free phenolic acid content increased significantly; the ferulic acid , sinapinicacod and total content of insoluble phenolic compounds increased 1.5, 10.5 and 1.34 times from brown rice. That supporting the content of total phenolic increased to 4.8 times in malted rice and parboiled malted rice in this study. The content of rancidity parameters in rice products were as followed: brown rice, malted rice and parboiled malted rice, respectively. It was noticeable that thermal in malting process and parboiling process significantly decreased the content of free fatty acid and peroxide content by inactivating lipolytic enzymes. The findings in this study of decreasion of phytic acid contents in malted rice was in agreement with Watchararpapaiboon et al. (2010) conducted on germinated brown rice varieties KDML105 and Chinat 1.The reduction of phytic acid has been due tothe fact that germination activates phytase which hydrolyzes IP6 into IP1-IP5 (Badau et al., 2005; Oloyo, 2004; Oatway et al.,2001). This is important information on parboiled rice malt as a new potential healthy and functional food. From these findings suggested that process of germination and parboiling can be used as a method for improving the level of nutrients present in rice.

Table2 Comparison of chemical properties of brown rice, malted rice and parboiled malted rice.

Chemical properties	Phitsanulok 2 rice forms		
	Brown rice	Malted rice	Parboiled malted rice
Amylose(%)	33.53 ± 0.15^{a}	30.84 ± 0.08^{b}	30.90 ± 0.00^{b}
Total Reducing Sugar (%)	0.28 ± 0.08^{b}	5.35 ± 0.05^{a}	5.37 ± 0.05^{a}
Protein(%)	8.88 ± 0.65^{NS}	8.91 ± 0.55^{NS}	8.90 ± 0.50^{NS}
Lipid(%)	2.86 ± 0.28^{NS}	2.35 ± 0.24^{NS}	2.39 ± 0.25^{NS}
Ash(%)	1.35 ± 0.45^{b}	3.40 ± 0.08^{a}	3.42 ± 0.10^{a}
Fiber (%)	3.54 ± 0.50^{b}	4.85 ± 0.02^{a}	4.85 ± 0.00^{a}
Carbohydrate(%)	70.47 ± 1.05^{a}	67.42 ± 1.25^{b}	67.44 ± 1.23^{b}
Vitamin B1 (mg/100g)	0.16 ± 0.01^{b}	0.29 ± 0.02^{a}	0.29 ± 0.01^{a}
GABA (mg/100g)	2.05 ± 0.15^{b}	10.30 ± 0.15^{a}	10.32 ± 0.10^{a}
Total phenolic (mg/100g)	0.32 ± 0.02^{b}	1.55 ± 0.01^{a}	1.54 ± 0.01^{a}
Free fatty acid (%)	0.85 ± 0.15^{a}	0.45 ± 0.10^{b}	0.22 ± 0.10^{c}
Peroxide (g/kg)	65.5 ± 5.5^{a}	32.5 ± 2.1^{b}	20.0 ± 2.5^{c}
Phytic acid (mg/100g)	505.5 ± 8.5^{a}	482.6 ± 5.55^{b}	485.5 ± 6.1^{b}

[a-c] Different letters in the same row indicated statistical difference ($p< 0.05$)

4.3 Microbial properties

Indicator of microorganisms in food may be classified into two types: (1) spoilage type is used as an index to indicate storage time and (2) pathogenic type is used as an index to indicate danger for consumption (Smoot and Pierson, 1997) Generally, both types and contents of microbes are always found in all dried foods depending on type of food and state of storage that prevent their growth.

However, all microorganisms generally found in milled rice can be completely destroyed when undergoing parboiling. Results of microbial analysis of brown rice found microbes of both types in greater amounts when compared with malted rice and parboiled malted rice that has undergone greater modification. This is due to the fact that many types of microorganisms are destroyed in heat-based modification processes. This is especially the case with malted rice products that upon examination found no disease-carrying microbes, while microbes that cause food spoilage are at levels even lower than standard requirement of TISI 393-2524 products (Ministry of Industry, 1981) as illustrated in Table 3.

Table3 Comparison of microbial properties of brown rice, malted rice and parboiled malted rice

Microorganisms	Phitsanulok 2 rice forms			TISI 393-2524 Product standard
	Brown rice	Malted rice	Parboiled malted rice	
Spoilage Type				
Total count	$2.20x10^4$	$1.90x10^2$	not detected	$\leq 5x10^4$ CFU/g
Yeast and Mold	$1.60x10^2$	15	not detected	$\leq 10^2$ CFU/g
Coliform	1,100	7	not detected	MPN/g <3
Pathogenic Type				
E.coli	$1.05x10^2$	not detected	not detected	not detected/g
Clostridium pefringens	not detected	not detected	not detected	not detected/0.01g
Staphylococcus aureus	$1.10x10^2$	not detected	not detected	not detected/0.01g
Salmonella sp.	not detected	not detected	not detected	not detected/25g

4.4 Cooking time and sensory properties

Comparison of grain quality in terms of cooking time and organoleptic test between brown rice, malted rice, and parboiled malted rice are shown in Table 4 and Figure 1. One quality of cooking rice, which has undergone modification to malted rice and parboiled malted rice, that differentiates it from brown rice is the faster time it takes to cook. This is due to the partial gelatinization from previous hydrothermal process of malting and parboiling, especially steam parboiled malted rice quicker cooking than malted rice. This reduced the time it takes to cook malted rice and parboiled malted rice significantly when compared with brown rice (Puangwerakul, 2012). The finding in this study, the advantage of parboiling on the integral with malting process was in reducing the cooking time that differed from summarizing of the advantages and disadvantages of parboiling from standpoint of the consumer as it well known (Bhattacharya,1985) as illustrated in Table 4.

Table4 Comparison of grain quality in terms of cooking time between brown rice, malted rice and parboiled malted rice.

Grain quality	Phitsanulok 2 rice forms		
	Brown rice	Malted rice	Parboiled malted rice
Cooking time (min.)	22.70±1.55 [a]	15.50±1.05 [b]	10.10±1.50 [c]

[a,b,c,..] Different letters in the same row indicated statistical difference ($p < 0.05$)

Hedonic scores of malted rice and parboiled malted rice for all factors except grain appearance were not different, but were significantly higher when compared with brown rice. From Figure 1, malted rice received the lowest scores for grain appearance relied on the fact that surface of the grain-full of minute cracks during malting was progressively broken down during polishing. Bhattacharya (1985) claimed that parboiling process can solve the milling quality to get a good yield of head rice and improve grain appearance and gross. Parboiled rice grains, which are rather opaque, become glassy and translucent upon parboiling. Any chalky areas in the original rice also become translucent resulting from the gelatinized starch granules and disrupted protein bodies adhere to each other to form a compact mass, reducing light

scattering at the boundaries of the granules. The results imply that cooked parboiled malted rice not only had less time to cook and softer texture, better aroma and flavor but also had overall acceptance than cooked ordinary brown rice as illustrated in Figure 1.

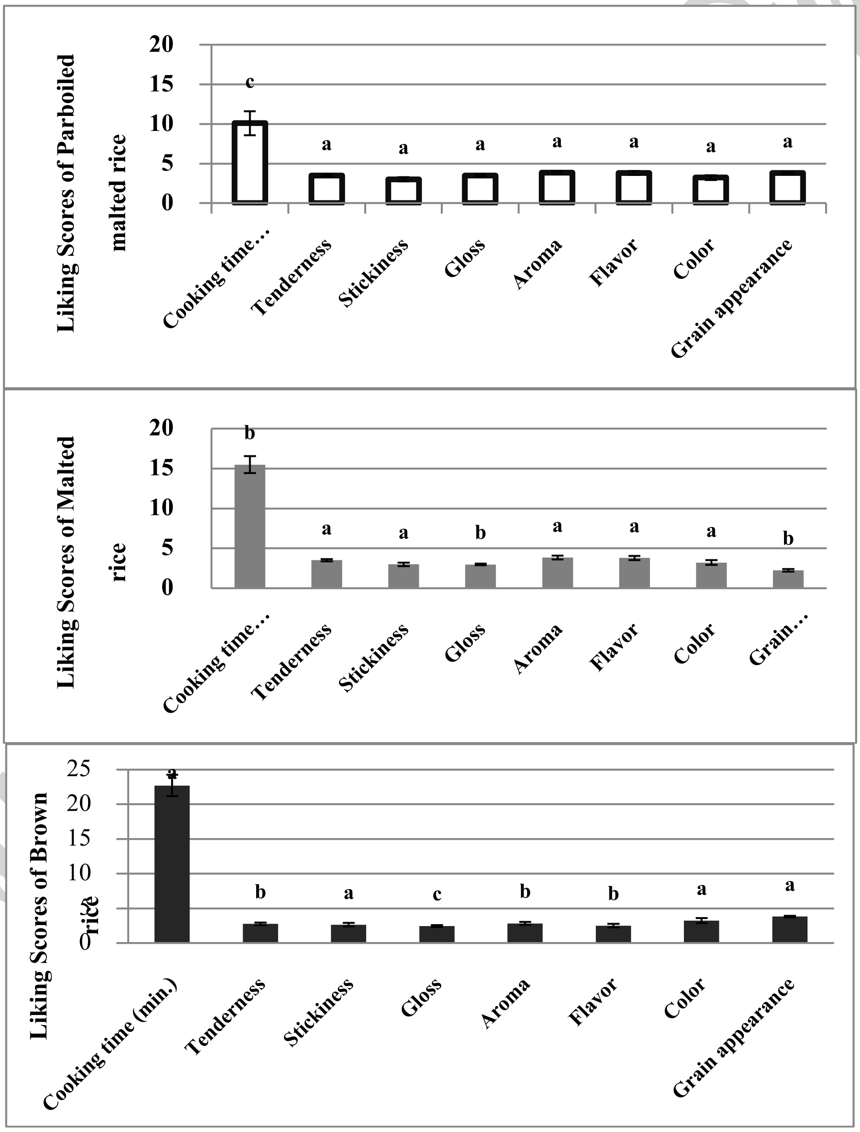

Figure 1 Comparison of organoleptic test between brown rice, malted rice and parboiled malted rice.

5. Discussion

It is evident that consumers can tell the difference in consumption quality that modification to malted rice and parboiled malted rice affected levels of tenderness and stickiness because of the decreasion of amylose content. Suwannaporn et al. (2007) described that amylose content plays a significant role in determining rice eating quality and it used as a parameter for the texture of cooked rice and so its reduction in germinated rice would bring about a softer texture than ungerminated rice. Additionally Juliano (1992) and Windham et al.(1997) reported that amylose content have a positive correlation with hardness and a negative correlation with stickiness. It suggested that germination could actually reduce the hardness and increase the stickiness of brown rice so malted rice and parboiled malted rice would be more palatable than brown rice. However, it has direct affects on aroma and flavor that the consumer prefers in malted rice and parboiled malted rice over brown rice. It was found that malted rice has the lowest scores of preference in terms of color, grain quality, and gloss due to inferior attributes as brittle, cracked, broken, and imperfect grain, and uneven distribution of color. Nonetheless, it was showed that after modification to parboiled malted rice, preference levels increased significantly. This is because parboiling causes starch to gelatinize completely, filling cracks, reducing broken grains, and helping to distribute color uniformly over the grain. It was showed that parboiled malted rice has combined preference scores higher than other types of rice, as illustrated in Table 4.

6. Conclusions

Producing germinated rice in the form of malting process combined with parboiled rice process can help increase nutrients in terms of ash, fiber, vitamin B1, GABA and total phenolic content in rice grains and help extend storage time by reducing spoilage, help reduce cooking time, and help distinguish the product from other rice products in the market in terms of aroma and taste. The quality of parboiled malted rice prepared from Phitsanulok 2 rice, that has upgraded production to the industrial level of 1,000 kilograms/day by community enterprise, it was found that control could be enabled regarding physical, chemical, microbial, and sensory qualities that are an improvement over brown rice. Finally, the advantage of this study would be to add-up the value of high amylose Thai rice varieties and give new alternatives of health-related benefits rice products for consumption in the country and exporting.

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