

RECENT ADVANCES OF GABA RICE PRODUCTION

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ABSTRACT

Germinated rice has been becoming a popular healthy food because it contains high contents of nutrients and bioactive compounds, especially γ -aminobutyric acid (GABA). GABA provides several advantages to health such as preventing chronic alcohol-related diseases and preventing cancer cell proliferation. The preparation of germinated rice and drying process are important to the final product quality. This article therefore reviewed the effects of germinated rice preparation i.e. brown rice and paddy and fluidized bed drying using hot air and superheated steam on the quality of germinated rice. The quality of GABA rice in terms of GABA content, texture after cooking, crack and starch digestibility will be presented. The study concluded that to obtain good quality of GABA rice the germination preparation in the paddy form and the fluidized bed drying using superheated steam at 130°C should be used. This study provides a guide line for food-related industry.

INTRODUCTION

Germinated rice is conventionally produced by steeping brown rice grains in water for certain period of time to promote germination. After that, it is treated with steam to eliminate microorganisms and dried with a cabinet dryer to moisture content of 16% dry basis (d.b.). This germinated rice is called the germinated brown rice (GBR). Recently, the fluidized bed technique has been applied to dry the GBR [1]. The disadvantage of this drying technique when applied to dry GBR is that some amounts of severely cracked kernels occurs and these crack kernels when cooked lead to poor shape and the corresponding poor textural property. To alleviate the crack problem, it should limit the evaporation rate of moisture from GBR during drying. One of possible methods that limit the moisture evaporation rate can be done by increasing the diffusion resistance [2-3]. To accomplish this, the germination of rice would be prepared in form of paddy instead of brown rice. By this germination method, it may also reduce the number of cracked kernels during which the kernels are soaked in water since the rate of water absorption is limited, due to low stress formation [4]. Drying medium is another important factor which affect the quality of finished rice product especially the cracked kernels and the texture after cooking because the medium strongly influences the gelatinization process. There are two drying media which are

normally applied for fluidized bed drying such as hot air (HA) and superheated steam (SHS). Several studies have been reported about their effects on the degree of starch gelatinization. Taechapiroj et al. (2004) [5] and Soponronnarit et al. (2006) [6] reported that the SHS drying can encourage starch to be gelatinized with a higher degree than HA drying.

Therefore, the objective of this work was to investigate the effects of germinated rice preparation i.e. brown rice and paddy and fluidized bed drying using hot air and superheated steam on the quality of germinated rice. Also, the drying temperature was investigated. The assessment of the dried germinated rice quality was considered in terms of GABA content, texture after cooking, crack and starch digestibility

MATERIALS AND METHODS

Materials

Chai Nat 1 and Phitsanulok 2 rice varieties obtained from the Rice Department, Chai Nat, Thailand were used in this study. The Chai Nat 1 rice was harvested in July 2010 and the Phitsanulok 2 rice was harvested in January 2012. They had already been stored for three months. An initial moisture content of the rice was about 12% (d.b.).

Preparation of germinated sample

The paddy or brown rice was soaked in water at 35°C to promote the germination. After germination, germ in a rice seed obtained by soaking paddy and brown rice had a length of about 0.5-2 mm. The germination percentage was approximately 92-95%. The germinated sample prepared from paddy and brown rice was called GP and GBR, respectively.

Preparation of dried germinated sample

The germinated sample was dried in a fluidized bed dryer. The media of drying used in this study are hot air (HA) and superheated steam (SHS). In the operation of SHS, the boiler produced the saturated steam which was heated by electrical heaters to be a superheated steam at 106 kPa and flowed through drying chamber. For operation of HA, the boiler was not operated and the steam was not introduced into the air.

To obtain the product, the sample was dried at the temperatures of 90-150°C, a bed height of 10 cm and a superficial air velocity of 3.5 m/s for both drying media. A sample dried to a moisture content of 22% (d.b.) was tempered by keeping it in a closed jar for 30 min as recommended by Poomsa-ad et al. (2002) [7]. Finally, the tempered sample was ventilated with ambient air until the sample moisture content reached 13-15% (d.b.). The sample was kept in cold storage at 4-6°C until further analysis.

GABA content determination

GABA content was determined by the method proposed by Lin and Wang (1980) [8].

Textural properties determination

The hardness of cooked sample was measured by a texture analyzer (TA.XT Plus, Stable Micro Systems, Surrey, UK) according to the method of Srisang et al. (2009) [1]. 25 g of germinated rice kernels without any cracks were selected and cooked in a moisture can by steaming using a ratio of rice to water of about 1:2. After cooking the sample was taken out and cooled to room temperature for 1 hour. Twelve cooked germinated rice kernels were arranged in two rows and were placed under a cylindrical probe with a diameter of 50 mm. The kernels were compressed at a pre-test speed of 1 mm/s and post-test speed of 10 mm/s. The hardness value was defined as the maximum compressive force at 85% strain.

Kernel fissures determination

About 100 kernels were randomly chosen. Crack kernels were visually inspected by sorting out the cracked kernels under a fluorescent lamp. The data were presented as the percentage of crack kernels. Inspection of a sample from each drying condition was performed in triplicate and the average value was reported

In-vitro kinetics of starch digestion

The analysis of starch hydrolysis was performed by the method of Goni et al. (1997) [9].

RESULTS AND DISCUSSION

GABA contents

Table 1 shows the GABA contents of GP and GBR after drying by HA and SHS at different temperatures. The GABA content of Chai Nat 1 brown rice was about 4.2±0.3 mg/100 g brown rice, which was significantly higher than that of Phitsanulok 2 brown rice, i.e., 2.2±0.1 mg/100 g brown rice. The larger amount of GABA in Chai Nat 1 brown rice may be related to the different rice varieties [11]. After germination the GABA contents of the shade-dried GP and GBR increased to 27.3±0.4 mg/100 g brown rice and 22.8±1.3 mg/100 g brown rice, respectively. The GABA contents of the germinated samples increased by 5.4-6.5 times in comparison with those of brown rice. The larger amount of GABA in the germinated samples can be explained by the fact that the hydrolytic enzymes such as α -amylase and β -amylase decomposed the high-molecular weight polymers, leading to the generation of bio-functional substances, which resulted in the increase of GABA [10]. As shown in Table 1 germinated rice preparation significantly affected the GABA content; the GABA content of GP was about 19.72-21.36%, which was higher than that of GBR. The higher content of GABA in GP is due to the minerals accumulated in the hull. The higher minerals of GP provided higher activities of enzymes within the seeds and contained higher levels of bioactive compounds, which led to larger production of GABA [12]. Moreover, the drying condition in terms of media and temperature did not affect the GABA content.

Table 1 GABA contents of germinated rice dried by HA and SHS produced at different drying temperatures

Variety	Sample	Drying media	Temperature (°C)	GABA content (mg/100 g brown rice d.b.)
	Brown rice (reference)		-	4.2 ± 0.3 ^b
Chai Nat 1	GP	HA	Shade drying	27.3 ± 0.4 ^c
			90	26.9 ± 0.4 ^c
			110	26.7 ± 1.3 ^c
			130	26.1 ± 0.8 ^c
			150	25.9 ± 1.2 ^c
	GBR	HA	Shade drying	22.8 ± 1.3 ^d
			90	22.2 ± 1.0 ^d
			110	22.0 ± 0.8 ^d
			130	21.8 ± 1.1 ^d
			150	21.5 ± 0.6 ^d
Phitsanulok 2	Brown rice (reference)		-	2.2 ± 0.1 ^a
	GP	SHS	Shade drying	17.6 ± 0.1 ^c
			130	17.4 ± 0.3 ^c
			130	17.5 ± 0.3 ^c

a, b, c, d, e Mean with different superscripts in the same column are significantly different (p<0.05)

Textural property

The hardness results of germinated rice dried by HA and SHS at different temperatures are given in Table 2. It is seen that germination affected the cooked rice texture; the hardness of cooked shade-dried GP and GBR were significantly lower than that of brown rice without germination. This is due to the decomposition of high-molecular weight polymers, i.e., starch, proteins and non-starch polysaccharides [13]. When comparing between shade-dried GP and GBR, the hardness values were insignificantly different. When the

germinated rice samples were dried it was found that the hardness of cooked GP and GBR tended to increase with increased drying temperature; the statistical results, however, showed insignificant difference in the texture. As shown in Table 2 the hardness of the cooked SHS-dried GP was higher significantly than that of cooked shade-dried GP whilst the hardness of the cooked HA-dried GP samples were higher insignificantly. These results indicated the drying media played an important role to hardness property. The significantly higher hardness of the cooked dried GP is due to the complete gelatinization during the SHS drying.

Table 2 Hardness of cooked germinated rice dried by HA and SHS produced at different drying temperatures

Variety	Sample	Drying media	Temperature (°C)	Hardness (N)
	Brown rice (reference)		-	152.1 ± 4.3 ^a
Chai Nat 1	GP	HA	Shade drying	134.7 ± 5.8 ^{bc}
			90	137.1 ± 4.5 ^{bc}
			110	138.7 ± 4.2 ^{bc}
			130	140.6 ± 5.2 ^{bc}
			150	142.4 ± 4.9 ^b
	Germinated brown rice (GBR)	HA	Shade drying	133.1 ± 4.9 ^c
			90	135.2 ± 5.8 ^{bc}
			110	137.4 ± 4.6 ^{bc}
			130	138.7 ± 4.7 ^{bc}
			150	140.1 ± 5.1 ^{bc}
Phitsanulok 2	Brown rice (reference)		-	151.33 ± 3.71 ^a
	GP	SHS	Shade drying	136.15 ± 3.43 ^{bc}
			130	139.03 ± 2.68 ^{bc}
			130	147.70 ± 2.12 ^a

a, b, c Mean with different superscripts in the same column are significantly different (p<0.05)

CRACK OF GERMINATED RICE

Table 3 shows the percentage of crack kernels after fluidized bed drying. After germination the percentage of crack kernels was $25.0 \pm 1.7\%$ and $40.3 \pm 2.3\%$ for the shade-dried GP and GBR, respectively. The fissures that mostly occurred on the rice surface, both in the cases of GP and GBR, were a single crack and the crack occurred in the cross-direction of a kernel as shown in Figure 1(a). The amount of fissured GBR kernels relative to that of GP for the shade drying was 61% higher. The larger amount of GBR fissures is related to the rate of water absorption during soaking. The brown rice could absorb water faster than the paddy; this caused larger moisture gradients inside the brown rice kernel and hence higher stresses, leading to more fissured GBR kernels [14].

As mentioned earlier, a sample was taken out of the dryer to examine the fissure when its moisture content decreased to 22% (d.b). As depicted in Table 3 the number of fissured kernels, both in the cases of GP and GBR, when drying at 90 °C was significantly higher than that of the shade-dried sample. The increase in the number of fissured kernels is probably due to the stresses that were induced by moisture gradients during drying [15]. The fissures that appeared on the rice surface at this drying temperature were the multiple cracks along the cross direction of a kernel as shown in Figure 1(b). This is because of grain shrinkage [16]. During drying, the paddy grains shrink in length and thickness. This creates stresses in the longitudinal axis and the short axis of the grain,

leading to the fissure occurrence [17]. The number of crack kernels increased by 29% and 39% in the cases of GP and GBR, respectively. This indicates that drying of germinated rice of paddy could lead to the reduction in the number of crack kernels; this would improve the germinated rice quality, especially in terms of the appearance. The smaller number of crack GP kernels is due to the smaller moisture gradients, leading to lower level of stresses and resulting in the smaller number of crack kernels. When the drying temperature increased to 110 °C or higher, the number of crack kernels, both in the cases of GP and GBR, significantly decreased when compared with that at 90 °C. This result can be attributed to the starch gelatinization. The higher drying temperature provided the higher degree of gelatinization (DG) than the lower drying temperature. The higher DG provides more strengthening of kernel and subsequently withstands the moisture-induced stresses, thus reducing crack kernels. However, the numbers of crack kernel number were still higher than the shade-dried samples. As shown in Table 3 the number of crack kernels in the SHS dried GP samples was increased insignificantly as compared to the fissure of their shade-dried samples whilst the number of crack kernels in the SHS dried GP samples was increased significantly. These results indicated that the drying medium and drying temperature have a significant effect on the crack kernels. The lower crack kernel in the SHS drying is due to the starch gelatinization. The DG of the SHS dried GP sample were higher than that of HA dried GP sample.



Figure 1 Crack feature on germinated rice surface
 a) Crack in cross-direction b) Crack in both cross and longitudinal directions

Table 3 Percentage of crack kernels of germinated rice dried by HA and SHS produced at different drying temperatures

Variety	Sample	Drying media	Temperature (°C)		Percentage of fissured kernels
			Shade drying		25.0 ± 1.7 ^a
Chai Nat 1	GP	HA	90		54.3 ± 1.5 ^e
			110		47.0 ± 1.0 ^d
			130		36.3 ± 1.2 ^c
			150		31.7 ± 1.2 ^b
			Shade drying		40.3 ± 2.3 ^j
Phitsanulok 2	GBR	HA	90		79.7 ± 1.2 ^t
			110		70.3 ± 2.5 ^h
			130		57.7 ± 1.2 ^g
			150		50.7 ± 1.5 ^f
			Shade drying		22 ± 2 ^a
Phitsanulok 2	GP	HA	130		31 ± 2 ^b
		SHS	130		25 ± 3 ^a

a-j Mean with different superscripts in the same column are significantly different (p<0.05)

STARCH HYDROLYSIS

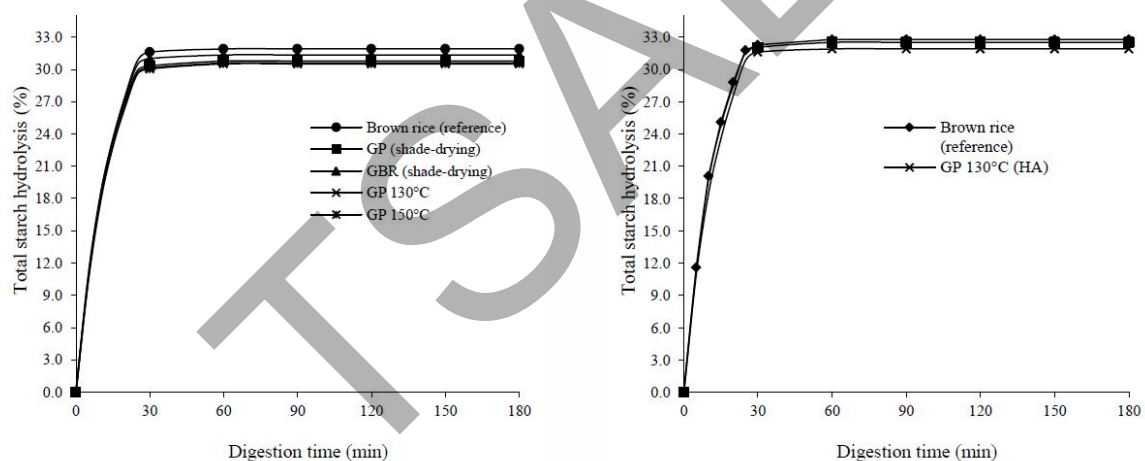


Figure 2 Enzymatic digestion of non-germinated brown rice, shade-dried GP and GBR and dried GP at different conditions

Figure 2 shows the starch hydrolysis patterns of non-germinated brown rice, shade-dried GP and GBR and dried GP. When rice seeds were germinated in form of brown rice or paddy, the starch hydrolysis curves of both shade-dried samples were not different and also were not different from that of the non-germinated brown rice as shown in Figure 2 (a). The resemblance of starch hydrolysis between non-germinated brown rice and shade-dried GP or GBR was due probably to the increase of dietary fibre in the germinated samples [18]. As shown in Figures 2 (a-b), the drying condition in terms of media and temperature did not affect the starch hydrolysis curve.

CONCLUSIONS

Production of germinated rice from paddy (GP) was noted to be more effective than that prepared from brown rice (GBR). GP possessed larger amount of GABA, smaller amount of crack kernels. The superheated steam drying (SHS) provided the smallest number of crack kernels than the hot air drying (HA) since the kernels were more strengthened due to higher degree of rice starch gelatinization. However, the SHS provided the higher hardness of dried GP than HA. When the germinated rice samples were dried at temperatures of 90-150 °C, the number of crack kernels decreased significantly due to starch gelatinization. The drying

temperature insignificantly affected the GABA content, the textural property and the starch digestibility.

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