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EFFECT OF SUPERHEATED STEAM FLUIDIZATION TECHNIQUE ON QUALITY OF BLACK GLUTINOUS RICE

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ABSTRACT

Black glutinous rice is one of pigmented rice and becoming popular with health conscious food consumers because it contains high amount of anthocyanin. Good milling quality, e.g., high percentage of head rice yield prefer for producer requirement. Previous study, soaked rice with high temperature of water and drying with superheated steam could be improve head rice yield. Therefore, in this study, effects of drying temperature of superheated steam fluidization technique on black glutinous rice were investigated. Rough black glutinous rice was soaked in hot water at 70ºC for 3 h. The soaked black glutinous rice had initial moisture contents of around 50-52% (d.b.) and was dried by superheated steam in a batch fluidized bed dryer (0.25 kg of soaked black glutinous rice per batch) at temperatures of 110, 130 and 150ºC until the moisture content reduced to 23% (d.b.). The rice was further dried in shade until its moisture content reduced to 16% (d.b.). The qualities of black glutinous rice (i.e., head rice yield, color, microstructure, and thermal property) were evaluated. Drying temperatures over 110ºC yielded fully gelatinization of black glutinous rice as observed by a scanning electron microscope (SEM), and a higher degree of gelatinization led to greater head rice yield. The highest head rice yield of 67% was obtained when drying temperature was 150ºC. The degree of gelatinization of black glutinous rice at 110, 130 and 150ºC were 87, 100 and 100%, respectively. In addition, increasing drying temperature slightly increased the color quality of black glutinous rice in terms of L*, a* and b* as comparing to the reference sample and the total color difference were 0.7, possibly due to maillard browning reaction. This finding helps for choosing the suitable drying condition to test quality such as texture property and glycemic index in the future work.

Keywords: Black glutinous rice; Fluidization; Quality; Superheated steam

INTRODUCTION

Pigmented rice or colored rice (*Oryza sativa L.*) is distinguished by the rice grain having red brown or dark purple color in its covering layers [1]. It has been consumed for a long time in Asia, i.e., China, Japan, Korea, and many countries in Southeast Asia, including Thailand [2]. Black glutinous rice is one of pigmented rice and becoming popular with health conscious food consumers because it contains high amount of anthocyanin which display a variety of effects on blood vessels, platelets and lipoproteins able to reduce the risk of coronary heart diseases [3]. High percentage of head rice yield in good milling quality prefer for producer requirement. The parboiling process is a hydro-thermal treatment of paddy that improves the milling, nutritional, and organoleptic attributes of rice. The process also prolongs rice storage by resisting spoilage caused by insects and mold. Further, it reduces broken grains leading to higher head rice yield [4-6]. The parboiling process consists of 3 steps: soaking, steaming and drying. Drying with Superheated steam in a fluidized bed dryer can include the steaming and drying step in parboiling process. It can save drying time and prevent the yellowing of rice grains, which easily occurs at high temperature. Previous study, soaked rice with high temperature of water and drying with superheated steam could be improve head rice yield [7]. Despite many researchers having reported the advantages of the parboiling rice process and fluidized bed

drying but information on parboiling black glutinous rice is very limited. Therefore, the aim of this study was to investigate the effect of superheated steam fluidization technique on quality of black glutinous rice. The quality of black glutinous rice, i.e., head brown rice yield, thermal analysis, microstructure and color were also examined.

MATERIALS AND METHODS

Materials

Black Glutinous Rice (BGR) was provided by the Rice Research Institute, Sakon Nakhon province, Thailand. The initial moisture content was 12-13% (d.b.). The paddy was soaked in hot water at a temperature of 70 ± 5 ^{O}C in an insulated tank. The ratio between paddy and hot water was 1:1.3 and soaking time was 3 h. Then it was drained and stored at room temperature (27±1^{O}C) for 30 min. The moisture content of soaked paddy was about 50-52% (d.b.).

Drying conditions

Samples, each of which weighed 0.25 kg, were dried by a superheated steam fluidized bed dryer with temperatures of 110, 130 and 150 ^{O}C at a superficial air velocity of 2.3 m/s until its moisture content reached to around 23% (d.b.) after that, the sample was shade-dried until the final moisture content of the sample was around

16% (d.b.). It was kept in a sealed plastic bag at 4-6 ^{O}C for 2 weeks before quality analysis.

Head brown rice yield

The head brown rice yield was calculated from the mass of brown glutinous rice after dehulled and separated by an indent cylinder divided by the mass of the paddy sample.

Degree of gelatinization

Thermal analysis of black glutinous rice flour was performed using a differential scanning calorimeter (Perkin Elmer, model DSC-7, Norwalk, CT). 3 mg of black glutinous rice flour was accurately weighed and placed into an aluminum DSC pan; 10 ^{o}L of distilled water was added, and the pan was hermetically sealed. The sample was left to stand for 1 h at room temper-ature (25 °C) before DSC scanning. Indium was used to calibrate the DSC and an empty pan was used as a reference. All samples were heated from 40 to 100 °C at a scanning rate of 10 °C/min. The major parameters of each DSC profile were described as onset temperature, peak temperature and conclusion temperature. From the DSC profile, the transition enthalpy was determined and the degree of gelatinization of glutinous rice flour was then calculated by the following equation:

$$DG(\%) = \left(1 - \left[\frac{\Delta H}{\Delta H_c}\right]\right) \times 100 \quad \ldots(1)$$

Where DG is the degree of gelatinization, ΔH is the transition enthalpy of treated glutinous rice (J/g (dry matter)) and ΔHc is the transition enthalpy of raw glutinous rice (J/g (dry matter)). All experiments were performed in duplicate and the average values were reported.

Microstructure

The microstructure of each sample was observed by a scanning electron microscope (SEM) (JSM-5600, model no.JSM-5600LV, Tokyo, Japan). The black glutinous rice kernel was cut along its cross-se tional axis, attached toan SEM stub, and coated with gold by a sputter-coater. The coated sample was then photographed at an accelerated voltage of 15 kV. The inspected location of the kernel was between the kernel surface and the endosperm centre.

Color

The color of each sample was measured by a Hunter Lab Color Flex (Reston, VA), using a D65 and a 10^{o} standard observer. The color values were expressed as L* (lightness/-darkness), a*(redness/greenness) and b* (yellowness/blueness). The L* value measu-res lightness and

varies from 100 for a perfect white and 0 for black, a* and b* when positive measure redness and yellowness, respectively but negative measure mean greenness and blueness, respectively. The measurement was performed in triplicate. The total color difference (Δ E*) from a reference color (L_1^*, a_1^*, b_1^*) to a target color (L_0^*, a_0^*, b_0^*) in the CIELAB space is given by:

$$\Delta E^* = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2} \ldots(2)$$

RESULTS AND DISCUSSION

Head brown rice yield

Table 1 replied head brown rice yield of glutinous rice at various drying temperatures.

Head brown rice yield of reference black glutinous rice was 40%, after drying by super-heated steam, head brown rice yield increased and it showed highest yield of 67% at temperature of 150ºC. Increasing of head brown rice yield due to gelatinization occurred as can be seen in Table 2 and Figure 1.

Table 1. Head brown rice yield of black glutinous rice at different drying conditions.

Drying conditions	Head brown rice yield (%)
Reference, BGR	40.0±2.0
SHS 110 ºC, BGR	59.5±1.2
SHS 130 ºC, BGR	61.9±1.7
SHS 150 ºC, BGR	67.0±0.7

Thermal property and microstructure

The gelatinization temperature *T*o, *T*p, *T*c endothermic enthalpy and degree of gelatinization of brown glutinous rice flour are summarized in Table 2. The transition temperature such as *T*o, *T*p, *T*c and enthalpy (Δ*H*) of reference brown black glutinous rice showed 69.8, 75.3, 82.2ºC and 10.0 J/g (dry matter), respectively. Super-heated steam drying at 110ºC gave higher *T*o while *T*p somewhat constant but *T*c and Δ*H* decreased.

In addition the degree of gelatinization of brown black glutinous rice flour was 87%. The result implied that starch granule remained partial in the kernel as illustrated in Fig.1. Drying at 130 and 150ºC displayed fully starch gelatinization whereas the transi-tion temperature and enthalpy disappeared as well as the degree of gelatinization was 100% as can depicted in Table.2 and Fig.1. The fully gelatinization resulted in a smaller fraction of broken rice kernels.

Colors

Color changes of brown black glutinous rice (BGR) cultivars under drying various conditions are listed in Table 3. Color represented in terms of L*-, a*- and b*-value of drying samples are minor different from the reference sample. Higher drying temperature provided a L* -, a*- and b* value slightly increased as well as the total color difference were 0.7, possibly due to maillard browning reaction.

Table 2. Thermal property of brown black glutinous rice flour at different drying conditions.

Drying conditions	Transition temperature (°C)			ΔH (J/g)	DG (%)
	To	Tp	Tc		
Reference before soaking, BGR	69.8	75.3	82.2	10.0	0
SHS 110 ºC, BGR	72.0	75.9	80.5	1.3	87
SHS 130 ºC, BGR	-	-	-	-	100
SHS 130 ºC, BGR	-	-	-	-	100

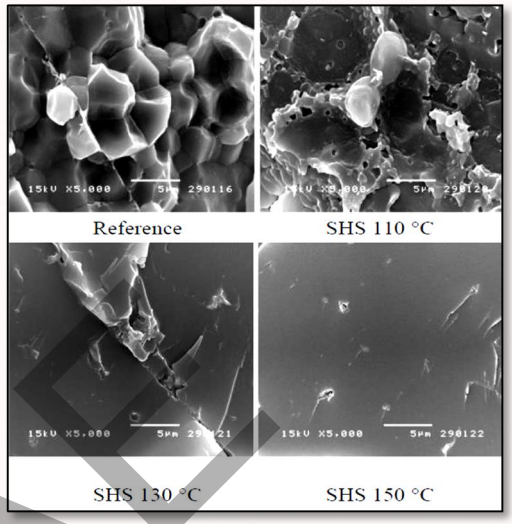

Fig. 1. Microstructure of brown black glutinous rice at difference drying conditions.

Table 3. Colors of brown black glutinous rice at various drying conditions.

Drying conditions	L*	a*	b*
Reference, BGR	21.7±0.0	2.7±0.1	0.9±0.2
SHS 110 ºC, BGR	21.6±0.1	3.1±0.3	1.2±0.1
SHS 130 ºC, BGR	21.7±0.2	21.7±0.2	21.7±0.2
SHS 150 ºC, BGR	22.7±0.6	3.3±0.6	1.6±0.6

CONCLUSION

High temperature of superheated steam fluidized bed could be improved head rice yield of black glutinous rice due to starch gelatinization occurred. Upper drying of 130 ºC showed fully starch gelatinization and at 150 ºC revealed the highest head brown rice yield of black glutinous rice. Higher drying temperature provided a L* -, a*- and b* value slightly increased as well as the total color difference were 0.7. This finding helps for choosing the suitable drying condition to test quality such as texture property and glycemic index in the future work.

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