



Effect of steaming condition varying in time and temperature on the quality of dark parboiled rice with germination

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Abstract

In this research, steaming time and steaming temperature were investigated on their effects on reducing sugar, textural property after cooking, head rice yield and color. The steaming time and steaming temperature influenced all considered qualities of GDPR. When the GDPR sample was steamed at times and temperatures, the average reducing sugar value was decreased to 228.32 ± 8.1 mg/100 g when the steaming time or the steaming temperature increased. It was used in the Maillard reaction to generate the color, leading to the decrease of whiteness value in the ranges of 23.33-25.06. Moreover, the increase of steaming time and steaming temperature provided the higher gelatinization, leading to increase in strength of rice and resulting in the higher hardness from 120.95 ± 6.56 to 167.74 ± 13.22 N and head rice yield from 69.92 ± 0.28 to $72.18 \pm 0.29\%$.

Keywords: Dark parboiled rice, Steaming, Maillard reaction, Quality

1. Introduction

Parboiled rice is now popular among healthy food products because of the high nutrient value [1]. It can be divided into two groups based on color such as light and dark parboiled rice. Dark parboiled rice (DPR) has increasingly been interested in many countries, i.e., India, Lao PDR, Vietnam, and Myanmar. The steaming is important treatment which is to achieve partial or complete gelatinization and also to produce the parboiled rice with dark brown color [2]. The color change of parboiled rice can be explained by the Maillard reaction. It is a chemical reaction between an amino acid and a reducing sugar, usually requiring the addition of heat [3]. The reducing sugar is one of important factors affecting the Maillard reaction because it is the substrate in this reaction [4]. The reducing sugars can be easily enhanced by germination process. The large amount of reducing sugars caused the greater Maillard reaction which could easily provide the dark brown color.

Color changes occurring in the parboiled rice during the steaming process depend on many factors. The steaming time and the steaming temperature are two important factors affecting the color change of parboiled rice. However, these factors may provide the adverse effect on the other rice qualities. Moreover, the information of the combined effects of steaming time and steaming temperature on the qualities of germinated dark parboiled rice (GDPR) has been limited. The objective of this work was therefore to investigate the effects of steaming time and steaming temperature on the

quality attributes of GDPR. The assessment of the GDPR quality was considered in terms of reducing sugar, textural property after cooking, head rice yield and color.

2. Materials and methods

2.1 Preparation of GDPR

Suphanburi 1 paddy was soaked in water at 35°C until it had the germination percentage of approximately 92%. For studying the effect of steaming time, the germinated paddy was blown by the saturated steam at temperature of 118°C for three steaming times such as 5, 10 and 15 minutes and dried in hot-air fluidized bed dryer. For studying the steaming temperature, the germinated paddy was blown by the saturated steam at three steaming temperatures such as 103, 110 and 118°C for 15 minutes and dried in hot-air fluidized bed dryer. The reference dark parboiled rice (RDPR) was soaked in hot water with a temperature of 70°C for 5 hours and blown by the saturated steam at temperature of 118°C for 15 minutes. In the last stage, it was dried in hot-air fluidized bed dryer.

2.2 Preparation of dried sample

The sample which was blown by the saturated steam was dried in a batch fluidized bed dryer. The drying conditions were the inlet drying air temperature of 130°C; a bed height of 10 cm; and a superficial air velocity of 3.5 m/s; the exhaust

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air was recycled at 80%. For the determination of their quality, a sample dried to a moisture content of 22% (d.b.) was tempered by keeping it in a closed jar for 30 minutes. Subsequently, the tempered sample was ventilated by ambient air until the moisture content reached 13-15% (d.b.). The sample was kept in cold storage at 4-6°C until further analysis.

2.3 Qualities determination

The head rice yield was defined as the mass of unbroken parboiled rice kernels (a length longer than 3/4 of the whole kernel length) divided by the mass of paddy before milling. A digital whiteness meter (New Agronic, model W-600, Taiwan) was used for measuring the color of sample. The textural properties of cooked DPR were measured by a texture analyzer (TA.XT Plus, Stable Micro Systems, Surrey, UK). The reducing sugar from GDPR was determined using high performance liquid chromatography (HPLC; Agilent 1100 Series, Agilent Technologies, Palo Alto, CA). The degree of starch gelatinization (DG) was measured by Differential Scanning Calorimeter (DSC; Perkin Elmer Co. Ltd., model DSC-7, Norwalk, USA)

3. Results and discussion

3.1 Percentage of germination

The percentage of germinated paddy is shown in Table 1. When the paddy was soaked in the water at 35°C, the germination percentage of paddy was approximately 8% at 24 hours and continuously increased to approximately 92% at 40 hours. Beyond this time, the germination percentage of paddy insignificant changed. Therefore, the germination time of 40 hours was chosen for this study.

Table 1 The germination percentage of paddy at water temperature of 35°C

Germination time (hours)	Germination percentage (%)
24	8.0±1.4 ^c
32	61.5±2.1 ^b
40	92.0±1.4 ^a
48	95.0±2.1 ^a
52	95.0±2.1 ^a

a, b, c Mean with different superscripts are significantly different ($p \leq 0.05$)

3.2 Reducing sugar

The rice without germination had the reducing sugar content of 160.05 ± 6.2 mg/100 g. When the rice was germinated at the temperature of 35°C for 40 hours, the reducing sugar content was increased to 461.52 ± 11.8 mg/100 g. The increase of reducing sugar content can be explained by the fact that the hydrolytic enzymes especially α -amylase and β -amylase decomposed the high-molecular weight polymers into lower molecular weight polymers, leading to the increase of reducing sugar content [5].

As shown in Figure 1, it was found that the steaming time and steaming temperature significantly affected the reducing sugar content. The reducing sugar content was lower when the steaming time and steaming temperature increased. This is because the reducing sugar was used in the Maillard reaction which occurs during hydrothermal treatment.

3.3 Textural property and degree of gelatinization

The results of hardness of GDPR steamed at different steaming conditions are shown in Table 2. It was found that the hardness of cooked RDPR was 180.34 ± 7.97 N. When the rice was germinated before producing the DPR, the hardness of cooked GDPR at the same steaming condition tended to decrease when comparing with RDPR. The lower hardness values of GDPR were correlated with the decrease of starch content during germination [6]. When the germinated samples were steamed at steaming times and steaming temperatures, it was found that the hardness of cooked GDPR tended to be increased with increasing steaming times and steaming temperatures. This is because the longer steaming time and higher steaming temperature provided the higher gelatinization as shown in Table 2, leading to the harder texture.

3.4 Head rice yield and color

Table 3 shows the effects of steaming time and steaming temperature on the head rice yield and color of GDPR. The head rice yield of reference rice was approximately 51.39%. When the rice was performed in steaming process at various conditions, the head rice yield percentages of all samples were significantly higher than that of reference rice. This is because the steaming process provided the starch to be gelatinized, leading to the higher head rice percentage. Moreover, it was found that the head rice yield of GDPR significantly increased with increased steaming time and steaming temperature

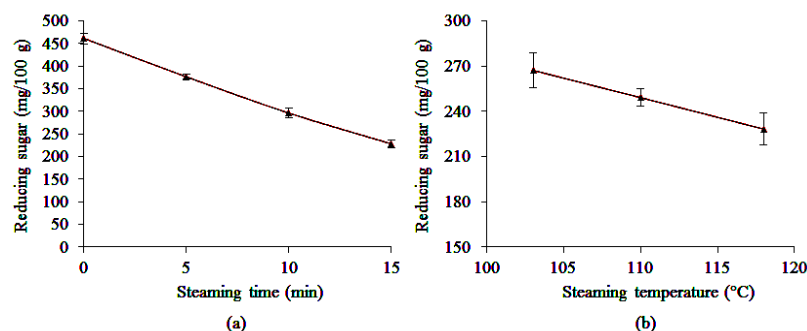


Figure 1 Effects of (a) steaming time at steaming temperature of 118°C and (b) steaming temperature at steaming time of 15 min on reducing sugar content

Table 2 The hardness value and degree of gelatinization of GDPR at different steaming times and steaming temperatures

Sample	Steaming temp. (°C)	Steaming time (min)	Drying temp. (°C)	Hardness (N)	DG (%)
RDPR	118	15	130	180.34±7.97 ^a	100.0±0.0
		5		137.48±7.82 ^c	82.1±0.3
	118	10	130	155.93±11.87 ^b	100.0±0.0
		15		167.74±13.22 ^{ab}	100.0±0.0
GDPR90	103			120.95±6.56 ^d	86.0±0.2
	110	15	130	142.47±8.85 ^{bc}	100.0±0.0
	118			167.74±13.22 ^{ab}	100.0±0.0

^{a-d} Mean with different superscripts are significantly different ($p \leq 0.05$)

Table 3 The head rice yield and color of GDPR at different steaming times and steaming temperatures

Sample	Steaming temp. (°C)	Steaming time (min)	Head rice yield (%)	Whiteness value
Rice	-	-	51.39±0.37 ^f	47.07±0.15 ^a
RDPR	118	15	69.92±0.28 ^d	23.70±0.10 ^e
	103		67.84±0.26 ^e	25.06±0.25 ^b
	110	15	70.54±0.20 ^c	24.23±0.15 ^{cd}
	118		72.18±0.29 ^a	23.33±0.15 ^f
GDPR		5	69.45±0.33 ^d	24.53±0.25 ^c
	118	10	71.54±0.14 ^b	24.03±0.12 ^d
		15	72.18±0.29 ^a	23.33±0.15 ^f

^{a-f} Mean with different superscripts are significantly different ($p \leq 0.05$)

As shown in Table 3, the whiteness value of RDPR was approximately 23.70±0.10. This was in the range of the acceptable whiteness values of dark color parboiled rice in commercial market which is about 22.0-24.5. When the paddy was germinated before steaming, it was found that the color of parboiled rice significantly changed in a way that the whiteness value was decreased with increasing steaming time and steaming temperature. This is because the long steaming time and higher steaming temperature could produce more Maillard browning reactions [7].

4. Conclusions

The steaming time and steaming temperature strongly affected the quality of GDPR. It caused changes in the reducing sugar content and gelatinization. During the course of steaming at long time and high temperature, the reducing sugar content and gelatinization were insignificantly changed. The reducing sugar content was decreased from the average value of 461.52±11.8 to 228.32±8.1 mg/100 g while the degree of starch gelatinization was increased to the average value of 100.05±0.0. The average values of hardness and head rice yield were also changed with the GDPR from longer steaming time or higher steaming temperature. The average hardness value was changed from 120.95±6.56 to 167.74±13.22 N. The average head rice yield value was increased from 69.92±0.28 to 72.18±0.29%. Moreover, the longer steaming time and higher steaming temperature provided the lower whiteness value of the GDPR. Their whiteness value were in the ranges of 23.33-25.06.

5. Acknowledgements

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6. References

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