The changes of moisture content, total phenolic content and pasting profile caused by parboiling process of black rice

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Abstract. Parboiling process of black rice could reduce cooking time and improve texture. However, parboiling process involving heat had the potency to affect moisture content, total phenolic content (TPC), and pasting profile. The aim of this research was to find the effect of parboiling process in the moisture content, TPC and pasting profile of black rice. There were three kinds of black rice. That was parboiled black rice A (3.8% concentration of sodium citrate, 5-minute steaming time, and 3.8 times freezing-thawing cycles), parboiled black rice B (5% concentration of sodium citrate, 15-minute steaming time, and 4 times freezing-thawing cycles) and normal black rice. Analysis of variance (α=5%) showed that there was a significant difference in moisture content and TPC parameter. The changes of black rice moisture content and total phenolic content caused by parboiling process A were bigger than B. Measurement of pasting profile explained that parboiled black rice A and B had lower pasting profile than normal black rice.

Keywords. Black rice, parboiled rice, moisture content, total phenolic content, pasting profile

1. Introduction

As a staple food, rice becomes one of the most important crops in Indonesia. In general, rice is associated with white color. But, there is some cultivar that has pigment, such as black rice. Black rice has any problems that make it’s not as popular as white rice. The problems come from hard texture and long cooking time. This obstacle could be solved by the parboiling process. In parboiling process, the combination of sodium citrate solution soaking, heat treatment, and freeze-thaw cycle give a good impact on texture and reduce the cooking time [1]. On the other hand, the parboiling process had a big potency to change the pasting profile, moisture, and phenolic content.

The starch granules are gelatinized during parboiling process [2]. Even though, the salt solution can inhibit the gelatinization [3]. The starch gelatinization can lead to shape the viscous solution. Native rice starch granules create a unique pasting property during heating and cooling. After heating treatment, the starch granules can be disrupted and created another path of the pasting profile. Parboiling process was observed to lower the pasting profile for some rice cultivar samples in India [4]. In pregelatinized starch, heat treatment could give thermal stress to the granule structure and created new pasting properties [5].
The drying step in parboiling process of rice will remove some moisture content. Parboiled rice drying at 55 °C reduced the moisture content from 28.3% to 14-16% [6]. The addition of sodium citrate as soaking solution can affect rice to have different moisture content than native black rice.

Black rice is popularly known as good antioxidant sources. The sources of antioxidants are coming from phenolic compounds. Some phenolic compounds that already identified were proanthocyanidins glucoside, caffeic acid hexose, procyanidin B2-3-O-gallate hexose, and epiofzelchineepicatechin-O-dimethylgallate [7]. During parboiling process, heat and soaking treatment become the critical factor regarding with loss of phenolic compounds. Most of the phenolic compounds are sensitive to heat stress [8]. Also, the soaking process increased the possibility of dissolving some phenolic antioxidants [9].

2. Materials and methods

2.1. Materials
A sample of Cempo Ireng black rice variety was obtained from a local farmer in Ciampea, Bogor, West Java, Indonesia. The additional processing and analysis materials such as distilled water, sodium citrate, gallic acid, Folin-Ciocalteu reagent, Na2CO3, and ethanol 70% were obtained from Setia Guna chemicals store, Bogor, West Java, Indonesia.

2.2. Methods

2.2.1. Process of making parboiled black rice. The process consisted of soaking, steaming under pressure, freezing, thawing, and drying. Soaking was carried out by using distilled water and sodium citrate solution at a rice/water ratio of 1:2 (w/v) for 30 minutes. Steaming under pressure was done by using Hirayama Hiclave HVE-50 (Hirayama Manufacturing Corp., Saitama, JP) in 1.1 bar pressure. One cycles of freezing was done with LG GR-M712YLA freezer (LG Corp., Seoul, KR) in -20 ± 2 °C for 22 hours and thawing was performed by using LG GR-M712YLA refrigerator (LG Corp., Seoul, KR) in 4 ± 2 °C for 40 minutes then left under running water in room temperature for 20 minute. The drying process was performed with Memmert UF-110 universal oven (Memmert GmbH, Schwabach, DE).

2.2.2. Experimental design. Three kinds of black rice were analyzed. That was parboiled black rice A (3.8% concentration of sodium citrate, 5-minute steaming time, and 3.8 times freezing-thawing cycles), parboiled black rice B (5% concentration of sodium citrate, 15-minute steaming time, and 4 times freezing-thawing cycles) and normal black rice. One way analysis of variance (ANOVA) was used to determine the significant differences between mean values using the SPSS 22.0 Statistical Software Program (SPSS Inc. Chicago, IL, USA).

2.2.3. Total Phenolic Content (TPC). TPC was determined by using Folin-Ciocalteu method [10]. Gallic acid standard was prepared with 1000 mg/L concentration and 12.5-200 mg/L dilution. Briefly, 1 g sample was added to 10 mL 70% ethanol in the sampling tube then mixed in 55 °C for 3.5 hours. Then, the tube was centrifuged in 3000 rpm for 10 minutes. 1 mL of supernatant and 1 mL of standard as each concentration were collected in the reaction tube then added with 4 mL 7.5% Na2CO3 and 0.2 mL Folin-Ciocalteu reagent. The mixture was added with distilled water until 10 mL of total volume and incubated in dark condition for 1 hour. Then, the mixture was measured the absorbance at 725 nm with a spectrophotometer.

2.2.4. Moisture content. The moisture content was measured by using air oven method. Five grams sample in the dish was dried using the oven at 105 °C for 3 hours until constant. The dish was stored in the desiccator, then it was weighed until constant.

2.2.5. Pasting profile with Rapid Visco Analyzer (RVA). The pasting profile of the black rice samples was analyzed using a Rapid Visco Analyser (RVA) (Newport Scientific, Warriewood, Australia). The
sample (10 g) was milled and sieved to 100 mesh flour. Based on the moisture content of the sample, the instrument suggested the sample and distilled water amount. Then, the sample and distilled water were put together in the canister. A programmed heating and cooling cycle used in this analysis were held at 50 °C, heated to 95 °C in 9 min at 6 °C/min (PV), held at 95 °C for 5 min (TV) before cooling to 50 °C for 8.7 min (FV). Setback (SB) (FV-TV) was recorded.

3. Results and discussion
The normal black rice had a moisture content of 11.98 ± 0.63 %. Parboiling process decreased the moisture content to 6.95 ± 0.27 % (A) and 10.16 ± 0.21 % (B) (figure 1). Moisture content decrease of parboiled black rice A was bigger than B. The difference of sodium citrate concentration caused different rice ability to absorb the water. Parboiled black rice B could absorb more water than A. Increasing sodium citrate concentration from 1% to 5% could increase the water holding and absorbing capacity [11].

![Figure 1. TPC and Moisture Content Comparation Between Normal Black Rice, Parboiled Black Rice A, and Parboiled Black Rice B.](image)

TPC of normal black rice was 12.22 ± 1.05 gGAE/100g db. After parboiling process, the TPC was decreasing to 7.67 ± 0.33 gGAE/100g db (A) and 9.52 ± 0.32 gGAE/100g db (B) (figure 1). Heat treatment during parboiling process destroyed some phenolic compounds in black rice. Most of the phenolic content was unstable and easy destructed by heat, light, and oxygen presence [8]. The addition of citric acid helped rice to retain phenolic contents. Sodium citrate addition on parboiled black rice B was higher than A. Anthocyanins cyanidin-3-O-β-D-glucoside and peonidin-3-O-β-D-glucoside are the primary phenolic compounds of black rice [12]. Citric acid could reduce the pH value so that prevented anthocyanin degradation into no color form [13]. Also, acid could reduce the hydration rate as of increase the anthocyanin stability [14].

**Table 1. Pasting profile comparation.**

| Parameter             | Normal Black Rice | Parboiled Black Rice A | Parboiled Black Rice B |
|-----------------------|-------------------|------------------------|------------------------|
| Peak viscosity (cP)   | 2524              | 63                     | 61                     |
| Hot-paste viscosity   | 1388              | 62                     | 58                     |
| (cP)                  |                   |                        |                        |
| Breakdown (cP)        | 1136              | 1                      | 3                      |
| Final viscosity (cP)  | 3736              | 77                     | 81                     |
| Setback (cP)          | 2348              | 15                     | 23                     |
| Setback ratio         | 0.63              | 0.19                   | 0.28                   |
Acid soaking and heat treatment during parboiling process had big potency causing damage to starch granules. The damage of starch granules gave an impact to pasting profile. Figure 2 showed that parboiling process caused black rice losing the ability to swell and created a viscous solution. The addition of organic acid (ex.citric acid) could reduce peak viscosity, breakdown and final viscosity significantly [15]. Starch heating with limited water (Heat Moisture Treatment) could increase the interaction between amylose and amyllopectin, reduce the swelling power, and lower the viscosity [16]. After parboiling, the setback ratio of black rice flour was a decrease from 0.63 to 0.19 (A) and 0.28 (B) (table 1). The setback ratio could give information about the retrogradation potency of starch [17]. Parboiling process could reduce the retrogradation potency of black rice starch.

![Figure 2](image-url) Viscogram of black rice flour (Temperature changes based on time ( ), normal black rice ( ), parboiled black rice A ( ), and Parboiled black rice B ( )).

4. Conclusion
Parboiling process could reduce the total phenolic and moisture content of black rice. Parboiled black rice A had a bigger reduction than B. The pasting profile of black rice after parboiling was lower than before. Parboiled black rice had lower potency of starch retrogradation than normal black rice.

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