Effect of cooking and freezing time on physical properties of instant germinated red rice

A N F Rahman, R R Al-Wahab and N Suwandi
Agricultural Technology Department, Faculty of Agriculture, Hasanuddin University, Makassar 90245, South Sulawesi, Indonesia
E-mail: faidah83@yahoo.com

Abstract. Red rice is more nutritious than white rice due to the content of low glycemic index and high fiber, which can help to reduce blood LDL concentrations. In addition, germinated red rice more nutritious than non-germinated rice because it contains more fiber, essential amino acids, vitamins, and antioxidants. However, this rice has a hard texture, so it requires a long cooking time. Instantization process of rice is one technique to accelerate the cooking process. Instant rice, or called quick-cooking rice, is processed rice that has been cooked and dried so that it can be stored for a long time but can be served at a faster time. The purpose of this research was to analyze the effect of cooking and freezing time on the physical properties of instant germinated red rice. The method used in this research divided into two stages: first, determining the best condition to make instant germinated red rice. The second was to analyze the physical properties of instant germinated red rice. Statistical analysis of this study used a complete randomized design method with two replications. The result showed that 10 minutes of cooking time and 48 hours freezing time was the best treatment based on a physical test of instant germinated red rice.

1. Introduction
Rice (*Oryza sativa* L.) is the main staple food source for most Indonesians. Based on the color of rice, there are several types of rice in Indonesia, such as white rice, black rice, glutinous rice, brown and red rice. Red rice is rice with red color because its aleurone contains genes that are thought to produce anthocyanin compounds or other compounds that cause red or purple color.

The advantage of red rice over white rice lies in its nutritional composition. Several nutrient components such as crude fiber, essential fatty acids, vitamin B complex, and minerals are found in the rice bran [1]. Crude fiber is useful for digestive health, helps reduce LDL concentrations in the blood, and reduces the risk of chronic diseases such as diabetes, obesity, coronary heart disease, and diverticulitis. Vitamin B complex plays a role in preventing the occurrence of peripheral neuropathy, fatigue complaints, anorexia, degeneration of the cardiovascular, neurological, and muscular systems [2]. On the other hand, the weakness of red rice is the hard texture compared to white rice, so it requires a longer cooking process.

The manufacture of instant germinated red rice is one of the food product innovations that can accelerate the cooking process of red rice. Instant rice, or called quick-cooking rice, is processed rice that has been cooked and dried so that it can be stored for a long time but can be served in a shorter time.

Germinated rice is generally made from a process of soaking, germination, and drying. In addition, germinated rice can also be produced from the process of grain germination by soaking the grain,
germination, drying, and milling. Germinated grain is not well known to the Indonesian people compared to germinated rice. Based on the results of a study, germinated rice contains higher levels of protein, ash, and vitamin B1 than non germinated rice [3]. In addition, rice from germinated grain has higher levels of vitamin B6 and B9 compared to rice that is not germinated [4]. While rice from rice germination contains 4 times more fiber, 3 times more vitamins B1, B2, and essential amino acids, and 10 times more GABA (gamma-aminobutyric acid), which is an inhibitor that regulates visual nerves, motor movement, depression, insomnia, and epilepsy [5]. In addition, germinated rice contains higher antioxidants than milled rice [6].

Some factors that affect the quality of instant rice produced are cooking and freezing time. The freezing process was carried out to produce high porosity properties so that the rehydration time was shorter [7]. Meanwhile, the cooking time aims to achieve gelatinization in the rice as well as to increase the absorption of water in the instant rice produced [8]. Therefore, in this research, we analyzed the effect of various cooking and freezing times on the physical quality of instant germinated red rice produced.

2. Materials and methods

2.1. Material

The grain (Ciherang variety) was taken from Sidrap, South Sulawesi, Indonesia. And some chemicals for analysis were purchased from a chemical shop in Makassar, South Sulawesi, Indonesia.

2.2. Methods

This research was carried out in 2 stages and the first stage was grain germination, in which grain was germinated around 0.1-0.2 cm, followed by the second stage, namely, making instant germinated red rice using cooking and freezing time treatments. The instant germinated red rice was then analyzed based on the physical test of rice.

2.2.1. Sample preparation. The grain with 14% of moisture content was soaked in water with a ratio of water and grain, 1:2 (w/v) for 48 hours at room temperature. The grain was then drained and germinated in a closed sack until the grain germinates with an average sprout length of 0.1-0.2 cm. Germinated grain was then dried until 14% moisture content was reached and milled into the rice. Instant germinated red rice was made by cooking the germinated red rice using an autoclave (105°C) for 8, 10, and 12 minutes. Then, germinated rice was frozen for 24 and 48 hours at -4°C. The frozen germinated rice was then dried using an oven at 90°C for 4 hours until 7-11% of moisture content was reached.

2.2.2. Rehydration time. As much as 100 grams of sample was weighed then poured into 300 mL of water, with a water and product ratio of 3:1. After that, it was boiled. Then the time when the rice grains were completely hydrated was calculated. Rehydration time was the time that takes for the material to re-absorb water so that a homogeneous texture was obtained [9].

2.2.3. Water absorption. As much as 10 mL of water was put into a test tube and heated in a water bath at a temperature of 80°C. After that, 1 g of instant germinated red rice was put into the test tube and heated for 5 minutes. The water that was not absorbed was then transferred to a centrifuge tube and was centrifuged for 15 minutes at a speed of 2000 rpm. The percentage of water absorbed was calculated using the formula [10]:
2.2.4. Bulk density. The sample was put into a measuring cup and compacted until its volume reached 100 mL. All materials from the measuring cup were removed and weighed. The bulk was expressed in g/mL and was calculated using the following formula [11]:

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\text{Bulk Density (g/mL)} = \frac{\text{Sample Weight (g)}}{\text{Sample Volume (mL)}}
\]

2.3. Statistical analysis
The experimental was designed using standard deviation and factorial randomized complete random (RAL) with two replications, and the data were analyzed using SPSS ver. 22. If the data was significantly different, then proceeded to the Duncan test.

3. Results and discussion

3.1. Rehydration time
Figure 1 showed the interaction between cooking and freezing time with the rehydration time of instant germinated red rice. Rehydration time was the time it took for the rice to become ready to eat. Rehydration time for all treatments was between 189 - 318 seconds, whereas rehydration time for non-instant rice was 2,182 seconds. The result showed that the instantization process of red rice could speed up cooking time up to 30 minutes. Instant germinated red rice with 10 minutes cooking time and 48 hours freezing time (C10:F48) has the fastest rehydration time that was 189 seconds, whereas the treatment for 10 minutes cooking and not freezing (C10:F0) has the longest rehydration time that was 318 seconds. One of the best criteria of instant products was to have a fast rehydration time [12]. The 10 minutes cooking and 48 hours freezing treatment was the best treatment because it had the shortest rehydration time compared to other treatments. The freezing process was conducted to produce high porosity properties so that the rehydration time was shorter [7]. The Treatment C8:F24; C8:F48; C10:F48; C12:F24, and C12:F48 fulfilled the requirements as instant rice because it had a rehydration time of fewer than 300 seconds (5 minutes). However, C8:F0; C10:F0; C10:F24 treatments did not meet the requirements because they had a rehydration time of more than 5 minutes [13].

Based on a statistical analysis of variance, it showed that treatment of cooking and freezing time significantly affected the rehydration time at the level of 1%. And based on the Duncan test, it was found that instant germinated red rice with 10 minutes cooking time and 48 hours freezing time was the same with treatments C8:F24; C8:F48; C12:F24 and C12:F48, but differ from C8:F0; C10:F0; C10:F24 and C12:F0.
3.2. Water absorption (%)

Figure 2 showed the interaction between cooking and freezing time with water absorption of instant germinated red rice. Water absorption of instant rice increased with increasing freezing time. The longer the freezing time, the higher the water absorption capacity of the instant rice. While the non-freezing treatment showed low water absorption capacity. Temperature and freezing time can affect water absorption [14], the highest water absorption value was found in treatment C12:F48 that was 348%, and the lowest was found in treatment C10:F0 that was 235%. The freezing process was conducted to produce high porosity properties so that the rehydration time was shorter because of the high water absorption ability [7]. Water absorption will be optimal when the starch granule structure was open and hollow (porous) [15].

Based on the statistical analysis of variance, it showed that treatment of cooking and freezing time significantly affected the water imbibition ability at the level of 1%. The highest water absorption value was found in treatment C12:F48 that is 348% and based on the Duncan test. It was not different from C8:F24; C8:F48, and C10:F48 that were 320, 341, and 312%, respectively.
3.3. Bulk density (g/mL)

The bulk density is the ratio of the weight of the material to the volume it occupies. The bulk density shows the void space, which is the number of empty hollows between the particles of material. The lower the bulk density, the more void space a substance can occupy (the more porous) and reverse [16]. However, bulk density below 0.36 g/mL will result in a mushy instant rice product after rehydration [17]. Figure 3 showed an interaction between cooking and freezing time with a bulk density of instant germinated red rice. Bulk density for all treatments was between 0.36–0.54 g/mL. The lowest bulk density was found in C10:F48 that is 0.36 g/mL but based on Duncan’s test, and it was found that the value was not different from C8:F24; C8:F48; C12:F24, and C12:F48 that were 0.40; 0.38; 0.45; and 0.37 g/mL, respectively. Bulk density values for all treatments were above 0.36 g/mL, which indicated that the texture of instant rice produced was soft.

Rice that was not frozen has a high bulk density and decreased with increasing freezing time. The freezing method can produce a lower bulk density [13], because the bulk density of ice was lower than the bulk density of water, so that food products that underwent a freezing process will have a lower bulk density [18].

The results of statistical analysis of variance showed that the bulk density content in the treatment of cooking and freezing time significantly affected at the level of 1%, so the Duncan test was carried out.
Figure 3. Interaction between cooking and freezing time to bulk density of instant germinated red rice.

4. Conclusions
Instant red rice made from germinated grain has good physical quality with increasing freezing time. The cooking treatment of 10 minutes and freezing time of 48 hours was the best treatment based on physical tests (rehydration time, water absorption, and bulk density) of instant germinated red rice.

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