

Physical Characteristics of Instant Black Rice (*Oryza sativa* L.) Cempo Ireng Variety, Indigenous of Indonesia

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Abstract. Black rice was well known for its high antioxidant capacity, low calories, and glycaemic index. This rice is widely consumed as a diet for diabetic people or weight loss. It has a hard texture, so it takes a long time for black rice to be served. This research aims to study the physical characteristics of instant black rice produced with several treatments. The treatment given during soaking uses 0%, 5%, and 7% sodium citrate, then soaked at room temperature and 50°C. The process continues with freezing for 24 hours at -4°C, then drying using a food dehydrator and oven for 20 hours. The results showed that the fastest rehydration time was 5.33 minutes. The range of observation parameters, such as bulk density is 0.28 - 0.54 g/mL, expansion volume is 88 - 152%, water absorption capacity is 20 - 62.5%, and rehydration ratio is 180 - 320%. Variations in sodium citrate and soaking temperature decrease the rehydration time. The physical characteristic of Instant rice dried using a food dehydrator is better than an oven.

1 Introduction

Black rice is a type of pigmented rice that is known as a functional food. Its health benefits can prevent cardiovascular disease, reduce the risk of diabetes and obesity, and prevent the spread of cancer cells [1–4]. This advantage is related to the high nutritional content, antioxidant activity, and low glycaemic index. 100 g of black rice contains 11.5 g of protein and 2.7 g of fat [5]. The amino acid components contained are 15.9% higher than ordinary rice, especially lysine, which is 3-3.5 times higher than ordinary rice, and arginine, which is around 2.12 times higher [5–6]. The fat contained in black rice consists of unsaturated fatty

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acids, oleic acid, and linoleic acid. The minerals contained in black rice are quite complete, especially Fe, Zn, Cu, Na, Mg, Ca, and Mn [6].

Cempo Ireng is one of the local Indonesian black rice varieties containing protein, carbohydrates, fat, fiber, and bioactive compounds. Total phenolic compounds in cempo ireng were significantly higher than cianjur and gadog varieties, which are also native to Indonesia. The starch content in cempo ireng was 71.04%, with an amylose content of 22.37% and an amylopectin content of 48.66% [7].

The instantization process is carried out to make it easier to consume black rice. The traditional cooking process takes 1-2 hours to cook black rice, but instant rice only takes a few minutes to be ready to eat after rehydration. The rice instantization process consists of soaking in sodium citrate solution, washing, cooking, freezing, and drying [8–9].

Soaking in sodium solution, cooking, and drying methods affect the physical characteristics of instant rice [8,10]. The best freezing process for rice with moderate amylose (20-25%) at -4°C for 24 hours. However, there is still no study that shows the best concentration of sodium citrate solution, soaking temperature, and drying method for making instant black rice. Therefore, this research aims to find the effect of sodium citrate solution concentration, soaking temperature, and drying method on the physical characteristics of instant black rice.

2 Material and Methods

2.1 Materials

The raw material used in this research was black rice of the cempo ireng variety obtained from farmers in Malang Regency. The chemical used is sodium citrate. The equipment used includes analytical scales, rice cooker (Yong MaTM), freezer (Panasonic), dehydrator (Getra ST-32), oven (Memmert UN110).

2.2 Instant Black Rice Preparation

Instantization of black rice was developed using the sodium citrate method [8–9]. The stages of making instant black rice include 1) Soaked in sodium citrate for 120 minutes, 2) Washed, 3) Cooked using a rice cooker by adding water twice, 4) Froze at -4 °C for 24 hours, and 5) Dried at 50 °C for 20 hours.

The treatments in this study at the soaking stage included sodium citrate concentration (0%, 5%, and 7%) and soaking temperature (room temperature \pm 25 °C and 50 °C). The drying stage of the treatment was carried out using a food dehydrator (50 °C) and oven (50 °C, flap 50%).

2.3 Rehydration Time

5 grams of sample in a container is poured with 20 mL of boiling hot water (1:4). Calculate the time needed for the sample to be completely rehydrated (no parts are still hard). Rehydration time is the time required for the sample to absorb water to obtain a homogeneous texture [9,11].

2.4 Bulk Density

The 50 mL measuring cup is weighed empty. Then, it is filled with samples to mark and weigh. Bulk density is a comparison between the weight of a 50 mL sample and a measuring cup (50 mL), so it is presented in g/mL [9].

$$D = \frac{W_s}{V_g} \quad (1)$$

Note:

D = Bulk density (g/mL)

W_s = Sample weight (g)

V_g = Measuring cup volume (mL)

2.5 Water Absorption

5 g of sample was soaked in hot water according to the rehydration time, then removed and drained. Water absorption is based on the amount of water absorbed compared to the initial amount of water, so it is presented in the form of a percentage (%) [9].

$$WA = \frac{W_t}{W_0} \times 100\% \quad (2)$$

Note:

WA = water absorption (%)

W_t = volume of water absorbed (ml)

W₀ = initial water volume (ml)

2.6 Volume Expansion

5 g of sample was put in a measuring cup, and its height was measured. Next, add hot water in a ratio of 1:4, wait for the rehydration time, and measure the final height. Expansion volume is determined by measuring the difference in the final height of instant rice after rehydration compared to before rehydration so that it is presented in percent (%) [9].

$$VE = \frac{H_t}{H_o} \times 100\% \quad (3)$$

Note:

VE = volume expansion (%)

H_t = final height (cm)

H_o = initial height (cm)

2.7 Rehydration Ratio

The rehydration ratio is calculated by comparing the weight of the sample after rehydration with the weight of the sample before rehydration [9].

$$Rr = \frac{W_t}{W_0} \quad (4)$$

Note:

Rr = Rehydration ratio

Wt = sample weight after rehydration (g)
W0 = sample weight before rehydration (g)

2.8 Statistical Analysis

All data were subjected to the analysis of variance (ANOVA) using IBM SPSS statistics 26 version. Differences between mean values were established using Duncan's multiple-range tests at a confidence level of 95%.

3 Results and Discussion

3.1 Rehydration Time

The rehydration time required for instant rice is less than 5 minutes [12]. The rehydration time of instant black rice is shown in Table 1. There were no samples in the range of less than 5 minutes. Rice with high amylose tends to have a longer rehydration time than rice with low amylose [9]. Black rice with an amylose content of 22.37% is classified as medium amylose rice (20-24%). Rehydration is considered complete if there are no white spots in the middle of the sample or if there are still hard parts. Luna et al., 2015 here was an increase in amylose after the process of making instant rice as a result of the breakdown of the amylopectin structure by heat and then reacting with sodium citrate so that the branch bonds became simpler bonds. Rice with high amylose easily experiences retrograde [13]. Retrogradation is the process of recrystallization of starch after gelatinization.

The best rehydration time for samples soaked in sodium citrate solution at a temperature of 50 °C. Soaking rice in sodium citrate will break down the rice protein so that the grains become porous. The addition of sodium citrate is effective if there is heating at a temperature of 50 °C [10,13]. Rice porosity can increase the speed of rehydration time. Apart from soaking with sodium citrate, freezing can also increase the porosity of the rice tissue structure. The increase in rice porosity is shown by decreasing the rehydration time when applied to soaking in sodium citrate at a temperature of 50 °C. This further shows that the instantiation of black rice using sodium citrate requires heating to open the tissue structure of the rice.

Drying using an oven tends to have a longer rehydration time compared to a dehydrator. Product porosity is influenced by the drying method. Drying that is slow and inaccurate causes the sample to not form a porous structure. The most influential factors lie in temperature, relative humidity, and airflow speed during the drying process [14–15]

Table 1. Effect of soaking and drying methods on rehydration time of instant black rice

Soaking Condition		Drying Methods	
		Dehydrator (minutes)	Oven (minutes)
Na0%	25 °C	7.01±0.45 ^{ab}	9.35±4.70 ^{abc}
Na5%		6.04±0.40 ^{ab}	8.93±0.73 ^{abc}
Na7%		22.17±0.00 ^c	9.84±0.47 ^{bcd}
Na5%	50 °C	6.37±1.61 ^{ab}	12.78±0.43 ^{cd}
Na7%		5.50±0.24 ^a	13.08±0.15 ^d

Note: The values in the table are followed by a letter; the same superscript indicates not significantly different based on Duncan's test ($p < 0.05$)

3.2 Bulk Density

Bulk density can indicate empty cavities between particles. Table 2 shows that the combination of increasing the concentration of sodium citrate at room temperature can reduce the bulk density, but on the contrary, it significantly increases when soaked at a temperature of 50 °C. Sodium citrate is a component that can destroy the protein structure in rice so that it becomes more porous and its density decreases [10]. Drying using an oven has a higher bulk density compared to drying using a dehydrator. This shows that the percentage of samples dried using a dehydrator is higher compared to an oven.

Table 2. Effect of soaking and drying methods on the density of instant black rice

Soaking Condition		Drying Methods	
		Dehydrator (g/mL)	Oven (g/mL)
Na0%	25 °C	0.40±0.00 ^{bcd}	0.44±0.06 ^{de}
Na5%		0.35±0.01 ^b	0.41±0.01 ^{cde}
Na7%		0.35±0.01 ^b	0.38±0.00 ^{bc}
Na5%	50 °C	0.26±0.03 ^a	0.40±0.03 ^{bcd}
Na7%		0.46±0.00 ^c	0.53±0.01 ^f

Note: The values in the table are followed by a letter; the same superscript indicates not significantly different based on Duncan's test ($p < 0.05$)

3.3 Water Absorption

The water absorption capacity of instant black rice ranges from 20–67.5%. The greater the level of water absorption, the greater the water needed for rehydration [9]. Table 3 shows that the increase in sodium citrate concentration is directly proportional to the water absorption capacity. On the other hand, increasing the soaking temperature and drying using an oven actually reduces the sample's ability to absorb water. Water absorption is influenced by starch gelatinization. High amylose rice absorbs water faster than the low ones at a temperature of 70 °C [16]. The high bulk density is directly proportional to the increase in water absorption ability.

Table 3. Effect of soaking and drying methods on water Absorption of instant black rice

Soaking Condition		Drying Methods	
		Dehydrator (%)	Oven (%)
Na0%	25 °C	41.25±8.84 ^{bc}	50.00±17.68 ^c
Na5%		40.00±0.00 ^{bc}	20.00±0.00 ^a
Na7%		67.50±7.07 ^d	27.50±3.54 ^{ab}
Na5%	50 °C	31.25±1.77 ^{ab}	18.75±1.74 ^a
Na7%		35.00±0.00 ^{abc}	22.50±3.54 ^b

Note: The values in the table are followed by a letter; the same superscript indicates not significantly different based on Duncan's test ($p < 0.05$)

3.4 Volume Expansion

Volume expansion indicates the increase in volume caused by water absorption during rehydration. The amount of expansion volume is directly proportional to the porosity and water absorption capacity. Apart from that, the low amylose content also reduces the expansion volume [9]. Table 4 shows that variations in sodium citrate have a significant

effect on the swelling volume when accompanied by heating at a temperature of 50 °C. Increasing the concentration of sodium citrate tends to reduce the swelling volume of instant rice. The drying method does not have a significant effect on the expansion volume. The role of sodium citrate is to increase the porosity of rice, but if it is too long, it can cause the cooked rice to become wetter. The effect is that when it is cured and dried, it will be stickier and the final result will be slightly denser [17].

Table 4. Effect of soaking and drying methods on volume expansion of instant black rice

Soaking Condition		Drying Methods	
		Dehydrator (%)	Oven (%)
Na0%	25 °C	149.04±5.08 ^{ab}	120.03±2.62 ^{ab}
Na5%		137.02±2.65 ^{ab}	130.75±19.91 ^{ab}
Na7%		137.26±5.55 ^{ab}	136.39±2.93 ^{ab}
Na5%	50 °C	212.16±1.324 ^b	102.13±18.73 ^a
Na7%		115.97±2.38 ^{ab}	97.23±7.86 ^a

Note: The values in the table are followed by a letter; the same superscript indicates not significantly different based on Duncan's test ($p < 0.05$)

3.5 Rehydration Ratio

The rehydration ratio is influenced by water absorption capacity [9]. The higher the water absorption, the higher the rehydration ratio. The highest rehydration ratio was soaked without sodium citrate, which was dried using a dehydrator. Drying using an oven has no real effect. Drying using a dehydrator was quite varied and significantly different ($p < 0.05$), with a ratio value of 2.3-2.7.

Table 5. Effect of soaking and drying methods on rehydration ratio of instant black rice

Soaking Condition		Drying Methods	
		Dehydrator	Oven
Na0%	25 °C	2.70±0.71 ^b	2.30±0.14 ^{ab}
Na5%		2.70±0.00 ^b	1.80±0.28 ^a
Na7%		2.40±0.00 ^{ab}	1.90±0.14 ^a
Na5%	50 °C	2.30±0.14 ^{ab}	1.80±0.00 ^a
Na7%		2.40±0.00 ^{ab}	1.80±0.00 ^a

Note: The values in the table are followed by a letter; the same superscript indicates not significantly different based on Duncan's test ($p < 0.05$)

4 Conclusions

The results showed that the combination of sodium citrate concentration, soaking temperature and drying method had a significant effect on the physical characteristics of instant black rice. In general, to produce instant black rice with the fastest rehydration time and still physically acceptable, the Cempo Ireng variety of black rice is processed by soaking in 7% sodium citrate at a temperature of 50 °C and drying using a food dehydrator.

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