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Proximate Characteristics of Low Glycemic Index Instant Rice with Variations in Storage Temperature and Drying Time

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Abstract

Paddy (*Oryza sativa* L.) is the staple food for the Indonesian people, commonly processed into rice. Consumption of rice through the cooking process takes 30 to 40 minutes. With the relatively long preparation process, the idea of instant rice processing is the answer for a shorter rice preparation process. Instant rice processing can be done using the autoclaving-retrogradation method. This study aimed to determine the proximate profile of low glycemic index instant rice, including water, ash, protein, fat and carbohydrate content. The research method was carried out by varying the storage temperature (without cooling, cooling at 4 °C and freezing at -4 °C) and drying time (0, 2, 4, 6, 8 and 10 hours). The proximate average yield of instant rice water content ranged from 60.43% to 10.61%; ash content 0.49% to 0.35%; protein content 9.61% to 7.70%; fat content 0.76% to 0.42% and carbohydrate content 77.27% to 75.19%. Thus, the short rehydration time indicates that the resulting product is included in instant food products because it takes less than 5 minutes to be consumed. In addition, reducing the glycemic index of rice can be done by retrograding starch to obtain resistant starch through a continued pressure cooking process by the cooling process. Reducing starch digestibility and glycemic index in rice through resistant starch formation can reduce the adverse effects of rice consumption as a staple food.

Keywords: drying; instant rice; proximate; rice; storage

INTRODUCTION

Paddy (*Oryza sativa* L.) is the Indonesian people's staple food, usually processed into rice. Rice contains carbohydrates, proteins, fats, vitamins and other nutrients the body needs. The most significant composition in 100 g of rice is carbohydrates ranging from 74.9 to 79.95 g, about 6 to 14 g of protein, 0.5 to 1.08 g of total fat, besides that rice also contains vitamins, namely thiamine (B1) 0.07 to 0.58 mg, riboflavin (B2) 0.04 to 0.26 mg and niacin (B3) around 1.6 to 6.7 mg (Fitriyah et al., 2020). According to Indonesian National Standard (SNI), rice's water content is 14% (Indonesian National Standard of Rice, 2015). Rice has a high glycemic index value with glycemic index variations ranging from 54 to 121 (Atkinson et al., 2008). The glycemic index is an index or level of food that can increase blood sugar values (Noor et al., 2018). Reducing the glycemic index of rice can be done using

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retrogradation of starch so that resistant starch is obtained.

Processing of rice is generally done by boiling with a stove and cooking using a rice cooker (Rianputra et al., 2020). Consumption of rice through the rice cooking process takes 30 to 40 minutes (Waluyo et al., 2021). With a relatively long preparation process, the idea of instant rice processing is the answer for a shorter rice preparation process. Instant rice is the result of processed rice that has been cooked and followed by a drying process so that it can be stored for a long time but can be served in a short time (Luna et al., 2015). Much research on instant rice has been carried out, such as developing instant rice for toddlers (Prapluettrakul et al., 2012). Research on instant rice has also been conducted by Chen et al. (2014) using novel combined drying.

Instant rice processing can be carried out using the autoclaving-retrogradation method, a high-pressure cooking method followed by a retrogradation process to produce resistant starch (Ashwar et al., 2016). Retrogradation causes the closed starch structure to be hydrolyzed by α amylase enzymes, so retrograded starch has low digestibility and glycemic index. The rice cooling process will cause the gelatinized starch to undergo a retrogradation process (Sajilata et al., 2006). Starch granules that have undergone gelatinization cannot return to their original shape. The dry starch is still able to absorb water again in large quantities. This characteristic is used to manufacture instant products so that the resulting instant products can easily absorb water again, namely by using gelatinized starch (Luna et al., 2015). Reheating and cooling starch that has undergone gelatinization further changes the structure, forming new, insoluble crystals in retrograded starch and causing changes in glycemic index values (Haliza et al., 2006).

Storage treatment using a temperature of 4 °C and -4 °C, the rice pores will be filled with ice crystals to form a porous texture during the drying stage. Instantiation of material is caused by the opening of the pores in a material, thereby accelerating the rehydration time (Husain et al., 2006). Dried materials can still absorb water again (rehydrate) in large quantities. This rehydration property is used so that instant rice can absorb water again easily (Widowati, 2007). In this research, analysis of rehydration time and proximate profile, including ash, protein, fat, water and carbohydrate content, were carried out.

MATERIALS AND METHOD

Material

The materials used in this study were a local variety of Solok rice from Alla Sub-district, Enrekang Regency. The other materials used are Selen, water, sulfuric acid, hexane and filter paper. All chemical reagents used are of analytical quality and were bought from a Makassar distribution center.

Soaking rice

In the process of making instant rice, it is necessary to know the temperature and soaking time of the rice to produce a water content of 30% to 35% because the process of gelatinizing rice starch requires a water content in that range (Garibaldi, 1984). The best temperature and soaking time is 40 °C for 10 minutes, with a water content value of 33.58% (Rusdin et al., 2020).

Making instant rice

Wash 500 g of rice thrice and drain it, then soak it in water (1:3) for 10 minutes at 40 °C. After the soaking process, the ratio of rice to water is reduced to 1:1, followed by a pressure-cooking process using an autoclave with a cooking time of 5 minutes using a temperature of 105 °C. After pressure cooking, it is continued with storage at 4 °C (cooling treatment) and -4 °C (freezing treatment) for 24 hours and without cooling treatment. The final stage is the drying process (0, 2, 4, 6, 8 and 10 hours) using a temperature of 60 °C to produce a water content of 14%.

Rehydration time

The instant rice sample is weighed as much as 20 g. Water is added until the instant rice is evenly wet, then put into the steamer when the water in the pot has boiled. The rehydration time was calculated using a stopwatch when the steaming water had boiled until the instant rice was cooked.

Proximate analysis

Water content by oven method (AOAC, 1995)

The first step to analyze the water content is to dry the cup using an oven at 105 °C for 1 hour. The cup was then placed in a desiccator for 15 minutes, cooled, and weighed. Weigh 3 g of rice and put in a cup that has been dried until the weight is obtained. Then the sample and cup were dried in an oven at 105 °C for 6 hours. The cup is cooled in a desiccator for 15 minutes and weighed, then dried again until a constant weight is obtained. Equation 1 is the formula for calculating the water content.

Ash content by Gravimetric Ashing method

The porcelain cup was dried for one hour at 750 °C in a furnace, cooled with a desiccator for 10 minutes, then weighed. A sample of 5 g is put into a cup that has been dried to determine the constant weight. Then the sample is incubated for 3 hours. After 3 hours, the sample is cooled in a desiccator for 10 minutes and then weighed. The test results are calculated using Equation 2.

Protein content by Kjeldahl method (AOAC, 1995)

The first thing to do is prepare the tools and materials to be used for the destruction process. After that, ± 2 g of sample was weighed, then ± 1 g of selen was added to the Kjeldahl tube, and 20 ml of concentrated sulfuric acid (H_2SO_4) was added, then the scrubber and speed digester was turned on, then digested for ± 1 hour and allowed to cool. Next, turn on the chiller, and leave the Kjeldahl master for about 15 minutes—furthermore, the process of distillation, titration, cleaning and protein content results. Protein content is calculated using Equation 3.

Fat content by Soxhlet method (AOAC, 1995)

Analysis of fat content was carried out using the Soxhlet method. The fat flask was dried in an oven at 105 °C, cooled in a desiccator, then weighed. The sample is considered as much as 5 g, then wrapped in filter paper, and then put into the extraction tool (soxhlet) containing hexane solvent. Reflux was carried out for 6 hours. The fat solvent was distilled in the fat flask until all the fat solvent had evaporated, then the fat solvent was dried using an oven at 105 °C, after which the flask was cooled in a desiccator. Drying in the oven is carried out until it reaches a constant weight. Equation 4 is formula for calculating fat content.

Carbohydrates by Difference (AOAC, 1995)

Carbohydrate content was calculated using the by-difference method. Carbohydrates are calculated by subtracting 100% from the percentage of water, ash protein and fat content to obtain carbohydrate content. The measurement of total carbohydrates in the sample is calculated based on Equation 5.

Statistical analysis

Statistical analysis used One Way analysis of variance (ANOVA). If the treatment had a significant effect, it was continued with the Duncan test.

RESULTS AND DISCUSSION

Rehydration time

Rehydration time indicates the length of time a product needs to absorb water after drying (Dewi, 2008). The results of the ANOVA showed that the effect of cooling and without cooling on the rehydration time of instant rice has a significant impact, so it was continued with the Duncan test. Instant rice rehydration time with and without cooling treatment ranged from

$$\text{Water content (\%)} = \frac{\text{Initial weight (g) - Final weight (g)}}{\text{Initial weight (g)}} \times 100\% \quad (1)$$

$$\text{Ash content (\%)} = \frac{\text{Initial weight (g) - Final weight (g)}}{\text{Final weight (g)}} \times 100\% \quad (2)$$

$$\text{Protein content (\%)} = \frac{(V1 - V2) \times N \times 0.014 \times f.k. \times f.p.}{W} \times 100\% \quad (3)$$

Where, W = sample weight (g), V1 = volume of 0.02 N HCL used for titrating the sample, V2 = normality of HCL used for blank titration, N = normality of HCL, f.k. = protein from food in general 6.25, f.p. = dilution factor.

$$\text{Fat content (\%)} = \frac{\text{Erlenmeyer weight + Fat (g) - Empty erlenmeyer (g)}}{\text{Sample weight (g)}} \times 100\% \quad (4)$$

$$\text{\% Carbohydrates} = 100\% - \text{\% (Protein + Fat + Ash + Water)} \quad (5)$$

4 to 9 minutes. The fastest rehydration time was in the cooling treatment (4 minutes 49 seconds), and the slowest rehydration time was in the non-cooling treatment (9 minutes 19 seconds), and the freezing treatment average rehydration time was 6 minutes 35 seconds. The rehydration time for each treatment is shown in Figure 1.

The short rehydration time for instant rice is due to the wide opening of the rice pores, making it easier for rehydration, and a short rehydration time is obtained (Widowati et al., 2009). The rehydration time of the treatment without cooling, cooling, and freezing treatment were significantly different. The longest rehydration time was in the treatment without cooling, while the cooling treatment had a faster rehydration time than the freezing treatment. It was because the freezing process was thawed, causing the ice crystals formed during freezing to melt and the porosity where the ice crystals were closed again, so the freezing treatment had a longer rehydration time than the cooling treatment. The drying process should immediately follow the freezing process to produce porous rice grains, and the rice structure becomes open. This open structure causes it to rehydrate quickly (Hawab, 2004). The difference in rehydration time for each treatment is because porosity plays an essential role in the instantiation of a material because opening the pores of a material makes rehydration easier and speeds up rehydration time (Husain et al., 2006).

Water content test

Water content is an essential component in food ingredients because water content can affect the appearance, texture and taste of food ingredients (Mustofah and Utami, 2019). The average water content of instant rice with drying times of 2, 4, 6, 8 and 10 hours for the freezing treatment was 60.43%; 54.90%; 47.57%; 37.86% and 14.15%. Meanwhile, the water content in the cooling treatment was 51.40%; 31.97%; 19.21%; 14.08% and 10.61%.

The ANOVA showed that the interaction between the effect of temperature and drying time on the water content of instant rice had a significant impact at the 5% confidence level, so it was continued with the Duncan test. The result showed that the addition of drying time caused a decrease in water content. Water content in the freezing (60.43%) and cooling (51.40%) treatment decreased after drying for 2 hours. The profile of changes in water content is shown in Figure 2.

Extended drying time will cause water evaporation from the inside of the material to be higher. The expected water content after drying ranges from 8% to 14%. The cooling treatment showed a water content value of 14.08% at 8 hours of drying time, and the freezing treatment showed a water content value of 14.15% at 10 hours of drying time. The longer the drying time and the higher the temperature, the greater the effect on the speed of water transfer (Riansyah et al., 2013). The following research (Purwanti et al., 2018) shows that the longer the drying time and the higher the temperature, the higher the decrease in water content. The higher the drying temperature, the greater the heat energy carried by air, so the greater the quantity of liquid mass evaporated from the material's surface. In the research by Widowati et al. (2020), the water

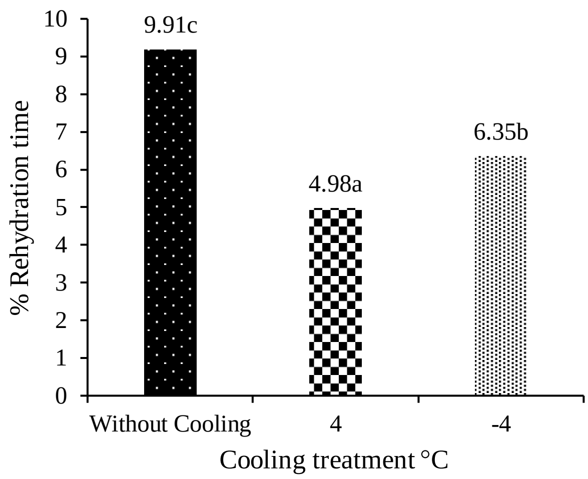

Figure 1. Rehydration time of low glycemic index instant rice

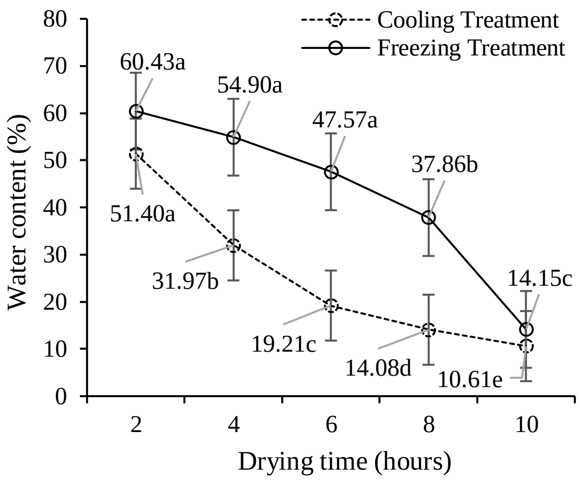

Figure 2. Water content of low glycemic index instant rice

content ranged from 8.90% to 9.95%. The low water content indicates that the dried rice has a porous structure, making rehydrating easier. In addition, the low water content also extends the shelf life because it can inhibit the activity of microorganisms, where microorganisms that can damage food cannot live and develop under conditions of low water content. High water content (> 14%) results shorter shelf life of rice (Widowati, 2007).

Ash content test

Ash content is a proximate analysis to determine the nutritional value of foodstuffs and shows the total minerals contained in these toxic ingredients (Hutomo et al., 2015). The analysis showed that the effect of temperature and drying time on the ash content of instant rice significantly affected at 5% confidence level, so it was continued with the Duncan test. The highest ash content was in the non-cooling treatment (0.49%), and the lowest was in the cooling treatment (0.35%). Meanwhile, the freezing treatment had an average ash content of 0.46%. The ash content of each treatment is shown in Figure 3.

The reduction in ash content can be caused by the soaking process with water before cooking, which can dissolve inorganic substances (Loebis et al., 2017). Besides, it can also be caused by the ash content of food and its composition depending on the material, processing and ashing process (Sundari et al., 2015). Instant rice ash content ranges from 0.41% to 0.82%, indicating a material's mineral content, both organic and inorganic. A high ash content shows a high mineral content in a material (Widowati et al., 2020).

Protein content test

Protein is the main ingredient in cell formation, repair and functions in the body's metabolic processes. The protein content, amylose and lipids can determine the taste of rice (Fitriyah et al., 2020). The results of ANOVA showed that the effect of unrestricted treatment and restriction treatment on instant rice protein levels had a marked impact at 5% confidence level, so it was continued with Duncan's further test. The highest protein content of instant rice was in the treatment without cooling (9.61%) and the lowest was in the cooling treatment (7.70%). Meanwhile, freezing treatment had an average protein content of 9.50%. The protein content of each treatment is shown in Figure 4.

Differences in protein content can be caused by the presence of soluble protein when soaking the rice and the wasted protein when reducing the soaking water before the autoclave process. It is because the denaturation process can damage the tertiary and secondary structures of the protein, which causes the protein to become easily soluble in water (Sasmitaloka et al., 2019). Changes in protein content are also caused by particle size. The ratio of amylose and amylopectin is low and contains a high amount of protein due to changes in the linear or branched fraction of starch molecules. In addition, it can be caused by temperature treatment. The higher the temperature, the greater the amount of denatured protein (Sari et al., 2013). Research conducted by Widowati et al. (2020) resulted in protein levels ranging from 8.63% to 9.70%. The amount of protein in rice tends to be minor, even though rice protein can produce 40% to 80% of calories.

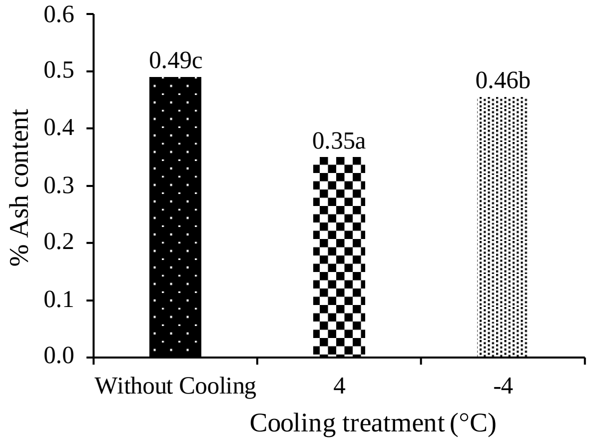

Figure 3. Ash content of low glycemic index instant rice

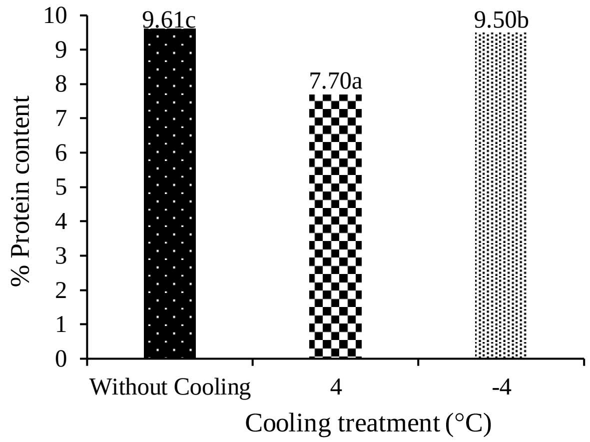

Figure 4. Protein content of low glycemic index instant rice

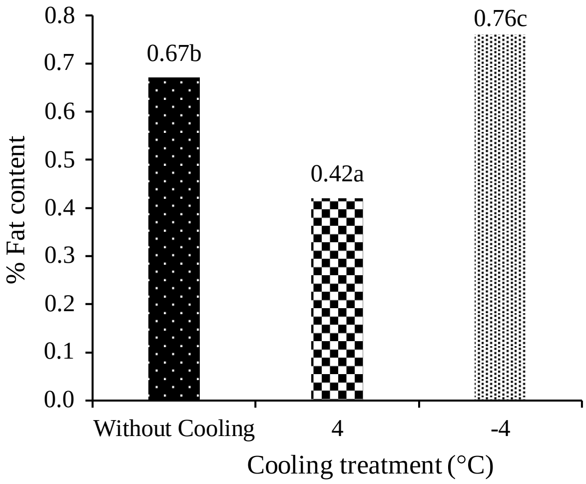

Figure 5. Fat content of low glycemic index instant rice

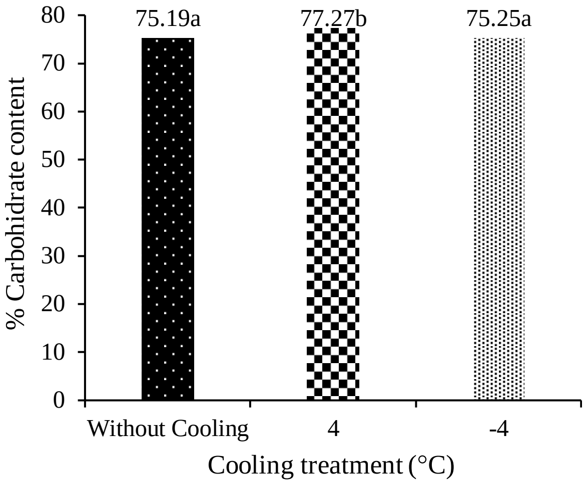

Figure 6. Carbohydrate content of low glycemic index instant rice

Fat content test

Fat is a complex molecule that must undergo a metabolic process before use (Sutera et al., 2022). Fat, a body's energy source, is digested and absorbed more slowly than carbohydrates. The analysis showed that each treatment's effect on fat content of instant rice had a significant impact at the 5% confidence level, so it was continued with Duncan's further test. The highest fat content was in the freezing treatment (0.76%), and the lowest was in the cooling treatment (0.42%). Meanwhile, the average fat content of instant rice in the treatment without cooling was 0.67%. The fat content of each treatment is shown in Figure 5.

Fat in food after processing will experience damage to the fat contained therein (Ramadhani et al., 2012). The fat content of the treatment without cooling, cooling, and freezing was significantly different. It was because the fat content continued to increase with the length of drying time, in line with Bau et al. (2021) stating that the increase in fat content takes place with the longer time used during the drying process. Prolonging heat breaks the double bonds in the fat so that the fat will be decomposed into glycerol and fatty acids. Each temperature treatment has a different fat content but is included in the low-fat food category. According to the research that has been done (Azis et al., 2015) maximum fat content of 3% is included in the low-fat food category.

Carbohydrate content test

The main component of rice is carbohydrates, and most carbohydrates in rice are starch. Carbohydrates are known to make up about 80% of the nutritional content of rice, but this amount may vary depending on the variety of rice tested (Verma and Srivastav, 2017). The ANOVA showed that each treatment's effect on carbohydrate content of instant rice had a significant impact at the 5% confidence level, so it was continued with Duncan's further test. The highest carbohydrate content was in the cooling treatment (77.27%), and the lowest was in the non-cooling treatment (75.19%), and in freezing treatment, the average carbohydrate content was 75.25%. The carbohydrate content of each treatment is shown in Figure 6.

The soaking process can cause changes in carbohydrate content. During soaking, soluble substances such as carbohydrates and vitamins dissolve (Suarti et al., 2013). In addition, higher temperatures can develop starch granules that swell even more, dissolving the low amylose fraction and then breaking down the starch granules and spreading them evenly. In this case, the polymer will be hydrolyzed and broken to cause damage to carbohydrates, resulting in a decrease in carbohydrate levels (Kurniawan et al., 2015). The resulting carbohydrate content is above 70%. The most significant composition contained in rice is carbohydrates, equal to 79% (Haryadi, 2008).

CONCLUSIONS

The instant rice obtained is included in instant food products because it takes less than 5 minutes to be consumed. Reducing the glycemic index of rice can be done by retrograding starch to obtain resistant starch through a pressure cooking process followed by a cooling process. Reducing starch digestibility and glycemic index in rice through resistant starch formation can reduce the adverse effects of consuming rice as a staple food. Making instant rice with the stages of soaking, cooling, and drying treatment produces instant rice with a water content ranging from 60.43% to 10.61%, ash content 0.49% to 0.35%, protein content 9.61% to 7.70%, fat content 0.76% to 0.42% and carbohydrate content 77.27% to 75.19%.

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