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Characteristics of instant rice in several corn varieties

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Characteristics of instant rice in several corn varieties

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Abstract. The research aimed to process corn kernels into instant corn rice. Corn kernels are ground into grits then pre-gelatinized by churning for 25 minutes at a temperature of 85-93 ^{0}C with a ratio of grits and water (1: 4) then dried to become instant corn rice. The results showed that pre-gelatinization had an effect on yield and product characteristics such as bulk density, porosity, water absorption rate, dehydration and growth rate. The highest yield of instant corn rice was Manado Kuning at 89%. Cook time ranges from 7-10 minutes and the development rate is 110-130%. Types of varieties and duration of freezing affect the characteristics of instant corn rice. Freezing time increases bulk density, porosity, swelling rate and reduces rehydration ratio and water absorption rate. The best treatment was the Manado Kuning corn variety with a freezing time of 48 hours resulting in the highest bulk density, porosity and dehydration level where the bulk density met US standards for parboiled rice, which was between 0.40 to 0.42 g / ml.

1. Introduction

Instant corn rice or parboiled corn rice is an instant food product in the form of rice. The method of cooking is almost the same as rice. The technology used in making instant corn rice is carried out because the end product has many benefits over ordinary rice, including a long shelf life and resistance to Aflatoxin contamination, a higher digestibility value that prevents stomach irritation, a low glycemic index that is ideal for diabetics and it only takes about 15 minutes to cook in a rice cooker, so that if it is substituted with rice it can simultaneously cook and has a non-acid flavor, as is usual in conventional corn rice processing [1].

Corn is similar to rice in terms of nutritional value. The main component of corn is starch (72-73%), with a ratio of amylose and amylopectin 25-30%: 70-75%. The protein content was higher at 9.5 % compared to rice, which was 7.1 % [2,3]. The composition depends on genetic factors, varieties and growing conditions. Corn from several varieties and local types has a low glycemic index with an average GI < 40. It was also reported Layuk et al., (2017) that the five varieties developed at the Bioindustrial location in North Sulawesi, namely Bisma Corn, Sukmaraga, Srikandi Kuning, Provit A and Manado Kuning, the highest yield of instant corn rice is Manado Kuning (80.78%) [4]. However, the highest protein content was Srikandi Kuning (9.95%) followed by Manado Kuning (7.90%), Provit A (7.10%), Bisma (6.6%) and Sukmaraga (6.1%). Thus corn is an alternative food to substitute for rice which is good for consumption by diabetics because it can stabilize blood glucose. The processed

products can also be substituted with other food ingredients to increase nutritional content and taste, especially for people with diabetes mellitus.

Several alternative technologies for making instant corn rice are using the addition of a microbial starter [1], boiling at 100ºC for 30-60 minutes and freezing at -20 ºC in the freezer for 24 hours [2]. The effect of freezing and drying methods on the characteristics of instant corn grits [5] and optimization of the process technology for making instant corn rice [2,6] and adding fiber to increase the functional properties of instant corn rice, which is beneficial to the body's metabolism [7]. In making instant rice, freezing is known to improve the quality of rice, helping to inhibit starch retrogradation and maintain texture by minimizing damage to rice cell walls [8,9]. Furthermore, Rewthong stated that freezing at -35 C for 12 hours causes the texture of the rice produced to be similar to ordinary rice (not instant rice) [10]. Therefore this study examines the effect of freezing time to the characteristics of several instant corn rice.

2. Research methods

2.1. Place and time
The research was conducted at the Laboratory of the Agricultural Technology Assessment Center (BPTP) North Sulawesi and for analysis it was carried out at the Manado Health Polytechnic Analysis Laboratory. This activity was carried out from January 2018 to June 2018.

2.2. Materials and tools
The study materials were corn grits of Manado Kuning, Srikandi Kuning and Provit A which were obtained from industrial locations in Minahasa district, plastic packaging and other supporting materials. The equipment used are thresher, corn rice grinder, oven, stainless steel pan, wooden spoon, and other aids.

2.3. Method of implementation
Grits were washed and churned for 30 minutes at 95 ^{0}C, stirring continuously. Churning aims to pre-gelatinize the corn rice starch. The ratio of corn rice and water is 1 : 4 [11]. After the churning is complete, the corn rice is steamed and cooled. The cooling process is carried out until there is no hot steam in the corn rice and corn rice is ready to freeze at (-17) - (-20) ^{o}C with freezing time according to the treatment which is 12, 24, 36 and 48 hours. After the freezing process for each treatment completed, the corn rice is then thawed and dried using a cabinet dryer at 60°C until the water content of instant corn rice ranges from 13-14 %.

2.4. Experiment design and data analysis procedure
The experimental design for this study was a completely randomized design (CRD). The factors tested were (i) corn varieties; and (ii) freezing time, with 4 levels, namely 12, 24, 36 and 48 hours. Each of these treatments was repeated three times.

The data obtained were analyzed by Analysis of Variance (ANOVA) using the SPSS 16.00 for Windows program at the 5 percent level. If there is a real difference, continue with the Duncan test.

2.4.1. Bulk density.
Determination of the density value was carried out using a 50 ml measuring cup. At the initial stage, the measurement and the weight of the empty measuring cup is recorded, then the corn rice is put into a 50 ml measuring cup until it is marked and weighed. The weight of 50 ml of corn rice is determined based on the difference between the weight of the 50 ml measuring cup filled with corn rice and the weight of the empty 50 ml measuring cup. The bulk density is based on the ratio between the weight of 50 ml of corn rice and the volume of a 50 ml measuring cup. Bulk density is calculated by the formula:

$$Bulk\ Density\ (g/ml) = \frac{Corn\ rice\ weight\ 50\ ml\ (g)}{Volume\ measuring\ cup\ (50\ ml)} \tag{1}$$

2.4.2. Porosity. Porosity is calculated by inserting corn grits into a 25 ml measuring cup until it is marked then adding toluene/liquid into the measuring cup until all the grits are immersed then measure the volume of liquid needed. Porosity is calculated by the formula:

$$Porosity = \frac{Liquid\ volume\ (ml)}{Total\ volume\ (ml)}\ x\ 100\% \qquad (2)$$

2.4.3. Rehydration ratio. The rehydration ratio was calculated by entering a sample of 10 g into a beaker, to which 100 ml of aquadest was added. The samples were then put in a water bath and cooked at 80°C for 10 minutes. The results of the cooking are then cooled to room temperature. The rehydrated sample is then weighed. The rehydration ratio is calculated by the formula:

$$Rehydration\ Ratio = \frac{Sample\ weight\ after\ rehydration\ (g)}{Sample\ weight\ before\ rehydration\ (g)} \qquad (3)$$

2.4.4. Water absorption rate. Determination of the water absorption rate of corn rice is determined based on the amount of water absorbed by corn rice during the pretreatment, namely during immersion in cold water (± 27 °C) and immersion in hot water (initial temperature ± 100 °C). The water absorption rate is obtained from the difference between the amount of initial water added to soak the corn rice and the amount of water leftover after soaking for a certain time. The water absorption rate at each immersion time variable was then averaged to produce an average water absorption rate for corn rice. A total of 50 g of corn rice for each size is put in a container that has been filled with water. The initial amount of immersion water used is 100 ml. The corn rice is then soaked with the variable immersion time in cold water is 1 hour, 2 hours, 3 hours, 4 hours and 5 hours, while the soaking time variable in hot water is 10 minutes, 20 minutes, 30 minutes, 40 minutes, 50 minutes and 60 minutes. During immersion in hot water, the water temperature is not maintained at a constant 100 °C. After soaking according to the set time variable, the remaining amount of immersed water is measured again. The water absorption rate is calculated according to the formula:

$$Amount\ Of\ Water\ Absorbed\ (ml) = initial\ amount\ of\ water\ (ml) - final\ amount\ of\ water\ (ml) \qquad (4)$$

$$Water\ Absorption\ Rate = \frac{A}{B} \times 100\% \qquad (5)$$

Information :
A = amount of water absorbed (ml)
B = initial amount of water (ml)

2.4.5. Swelling rate. Corn rice swelling rate is determined by measuring the difference between the height of the initial corn rice (before cooking) and the final height of the rice after cooking using a ruler. A sample of 10 g was put into a beaker and 100 ml of aquadest was added and the height of the corn rice was measured. After that the samples were put in a water bath and cooked at 80°C for 10 minutes. The results of the cooking are then cooled to room temperature and the height is measured again.

$$Swelling\ (cm) = final\ height\ (cm) - initial\ height\ (cm) \qquad (6)$$

$$Swelling\ Rate\ (\%) = \frac{= Development\ (cm)}{Initial\ height\ (cm)} x\ 100\% \qquad (7)$$

3. Results and discussion

3.1. Yield and proximate corn

The highest yield of instant corn was Manado Kuning (90.02%), following Srikandi kuning (86.60) and Provit A (74.00) (table 1).

Table 1. The average yield of corn and instant corn rice.

Corn Varieties	Instant Corn	
	Yield (%)	Water content (%)
Provit A	74	7.15
Srikandi kuning	86.60	8.01
Manado Kuning	89.02	8.15

The chemical composition of corn affects the characteristics of instant corn produced, such as the composition of carbohydrates, protein and fiber which can affect the bulk density, porosity, water absorption rate, dehydration and the swelling rate of instant corn rice. The results of the chemical content analysis can be seen in table 2.

Table 2. Average results proximate analysis of several varieties of corn rice.

Composition	Srikandi kuning	Manado Kuning	Provit A
Water content (%)	11.3	11.9	11.2
Protein (%)	9.95	7.90	7.10
Fat (%)	0.5	0.60	0.30
Ash content (%)	0.9	0.60	0.80
Carbohydrate (%)	72.70	74.50	74.50
Fiber (%)	4.70	4.50	6.10

3.2. Bulk density

The bulk density value shows the void space which is the number of empty voids between the material particles. The larger the bulk density of an object, the less the amount of void space it will have [12]. Figure 1, the bulk density value of instant corn rice produced ranges from 0.30 - 0.45 (g/ml). At 48 hours of freezing the three varieties of corn, the bulk density decreased. The results of analysis of variance and Duncan's test showed that the treatment of varieties had a significant effect on the bulk density of the instant corn rice produced ($p < 0.05$). The Manado Kuning variety produced a higher bulk density (0.45 g/ml) compared to the other two varieties, following provit A (0.44 g/ml) and Srikandi Kuning (0.40 g/ml) at almost all times of freezing, this is due to the level of sphericity of the rice instant corn increases so that the amount of void space (empty space between particles) decreases. Sadeghi et al., (2010) stated that the higher sphericity of the corn kernels resulted in a more regular arrangement of the kernels so that the hole between the kernels were smaller and resulted in a higher bulk density [13]. Higher densities will reduce the use of packaging materials. The freezing time treatment did not significantly affect the bulk density of instant corn rice. Figure 1 shows that the bulk density treatment decreases with longer freezing time, on the contrary this phenomenon is almost in line with the research of Husain (2006) with the freezing method resulting in lower density of instant corn grits, because according to Singh and Heldman (2001) the density of ice is lower than the density of water so that frozen food products have a lower bulk density than without freezing [5,14]. The material is declared bulk if the density is small, it means that for light weight it requires a large space. The US government's military and defense specifications set standards for post-cooked rice densities ranging from 0.40 to 0.42 g/ml [15]. Post-cooked rice bulk density lower than 0.36 g / ml will result in a soft product such as rice porridge during reconstitution [16].
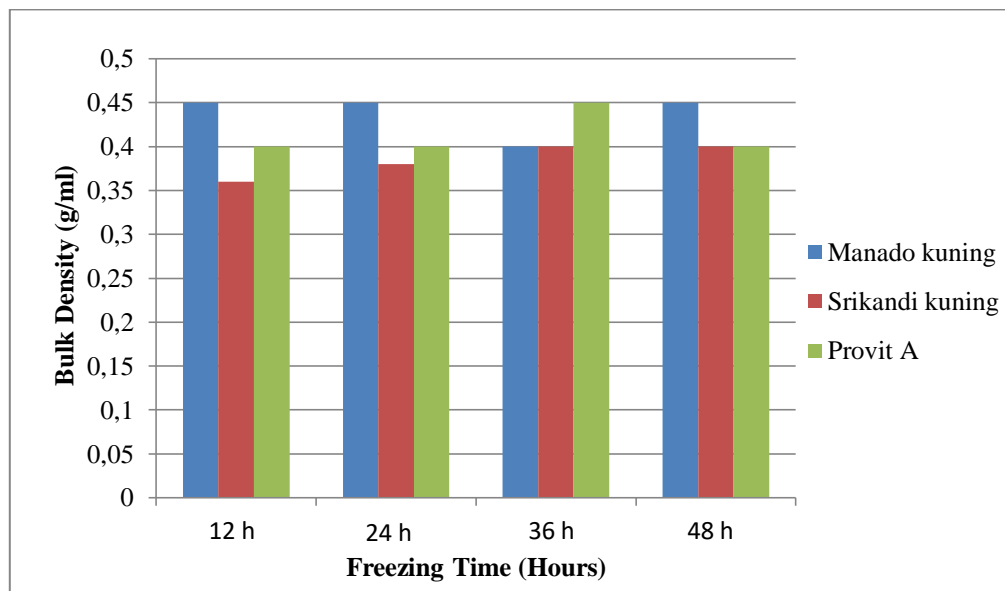
Figure 1. The relationship between freezing time and corn varieties on bulk density of instant corn rice.

3.3. Porosity

One of the factors that plays an important role in the instantization properties of a product is porosity. The porosity of instant corn rice produced ranges from 74 - 78 %. The longer the freezing time the higher the porosity of instant corn rice (figure 2). The gaps or pores that form in instant rice will facilitate the transfer of water and heat during cooking so as to produce softer rice [17]. Types of corn varieties had no effect on porosity but freezing time had a significant effect on porosity of instant corn rice ($p < 0.05$). The highest porosity is the Manado Kuning variety with a freezing time of 48 hours (78%), then Srikandi Kuning (77%) and Proit A (75%). The high porosity of Manado Kuning instant corn rice is due to the gap in the pores covering the dense corn matrix so that the water used in the process of making instant corn rice cannot develop the molecules of corn starch maximally. According to Chan and Toledo (1976) freezing and frozen storage will increase the development of starch molecules through hydrogen bonds, it will release the water contained in the material after the thawing process so that the material has a microsponge (porous) structure [18]. Karathanos et al., (1996) stated that the larger the ice crystals formed during slow freezing, the higher the porous properties of a material [19].
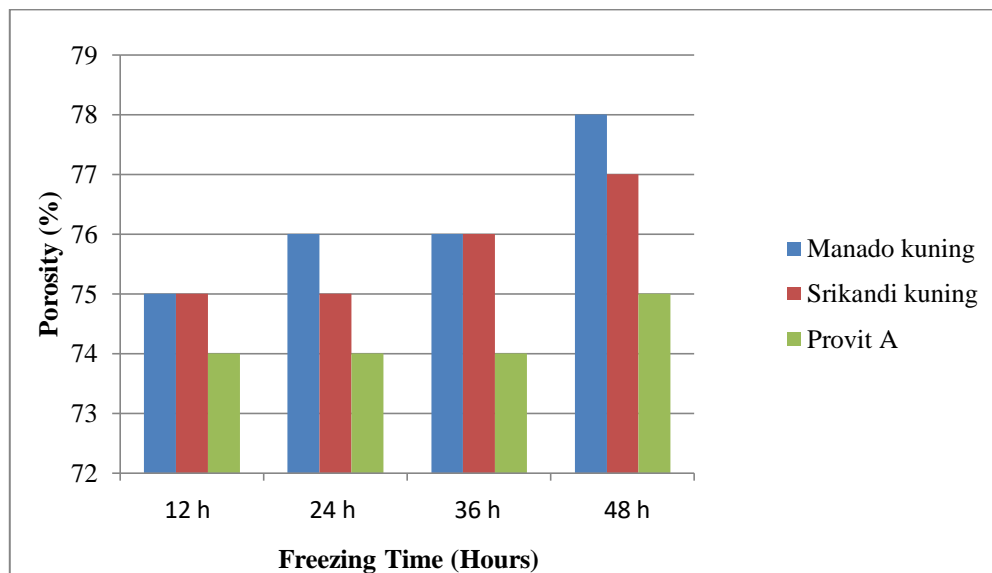
Figure 2. The relationship between freezing and corn varieties on the porosity of instant corn rice.

3.4. Water absorption rate

The resulting water absorption rate ranges from 310 - 450 % (figure 3). From the results of **Analysis of Variance**, it is known that the type of variety has an effect on the absorption rate ($p < 0.05$). The absorption rate of instant corn rice Manado Kuning variety is significantly different from Srikandi kuning and Provit A ($p < 0.05$). The duration of freezing did not significantly affect the absorption rate ($p > 0.05$). Likewise, there was no interaction between varieties and freezing time ($p > 0.05$). The absorption rate of Manado Kuning corn rice is higher than Srikandi Kuning and Provit A (figure 3). This is because Manado Kuning contains lower fiber which can reduce the water absorption rate in corn rice. In addition, the level of water absorption in corn rice is influenced by the quality of starch, especially the particle size and the level of starch gelatinization [11,20]. Fiber has the ability to absorb water depending on the structure, particle size and the number of sides that can bind water to the fiber [21]. As a result of corn rice being covered with fiber, water absorption is hindered so that the water absorption rate is low. The expected water absorption rate is the high water absorption rate obtained from the treatment of fiber-free corn rice. According to Houson and Ayenor (2002) high water absorption ensures the cohesiveness of food products [22].
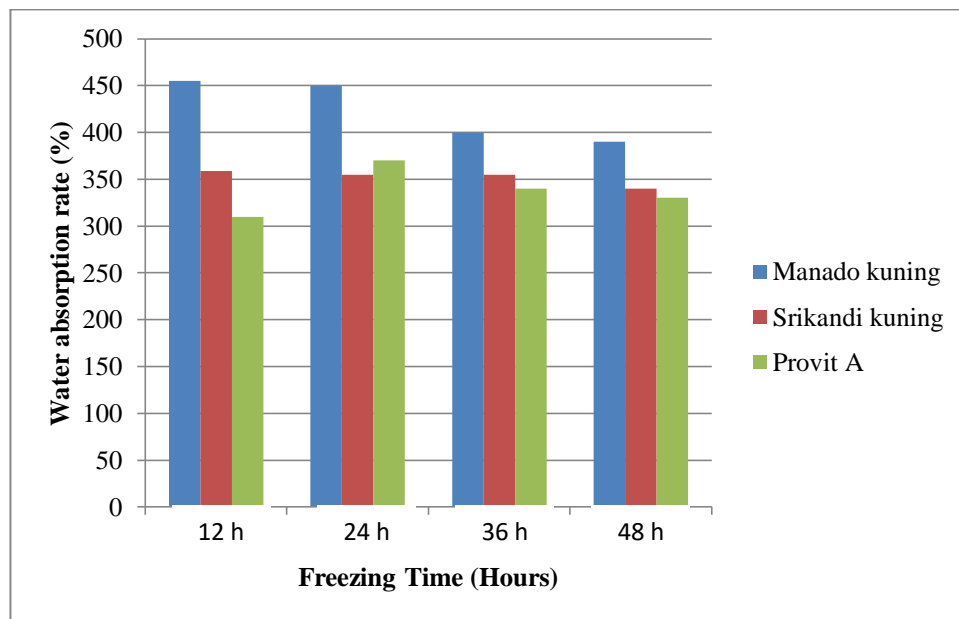
Figure 3. The relationship between freezing time and corn varieties on the water absorption rate of instant corn rice.

3.5. Swelling rate

The swelling rate of instant corn rice produced ranged from 110 - 130 %. The longer the freezing time, the greater the swelling rate (figure 4). Manado Kuning has the highest swelling rate (130%) followed by Provit A (95%) and Srikandi Kuning (89%). From the results of Analysis of Variance, it is known that the type of variety affects the swelling rate of instant corn rice ($p < 0.05$). The swelling rate of Provit A instant corn rice was significantly different from the other two, namely Srikandi Kuning and Manado Kuning. However, the length of freezing has no significant effect on the swelling rate. According to Muramatsu et al., (2005) during the water absorption process there is a change in the shape of rice particles as a result of swelling [23].
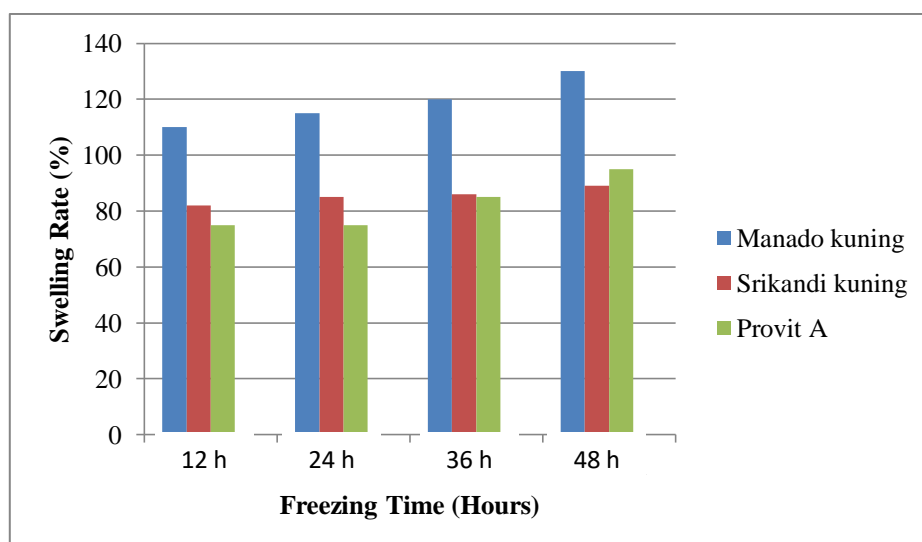

Figure 4. The relationship between freezing time and corn varieties to the swelling rate of instant corn rice.

3.6. Rehydration ratio

The rehydration ratio shows the re-absorption of water by the product that has been dried. A high rehydration ratio is desirable for dry products. Rehydration value is strongly influenced by cell wall elasticity, loss of differential permeability in the protoplasmic membrane, loss of cell turgor pressure, protein denaturation, starch crystallinity and macromolecular hydrogen bonds [24]. The rehydration ratio of instant corn rice produced ranged from 390 - 555 % (figure 5). From the results of Analysis of Variance, it is known that the type of corn variety and the duration of freezing significantly influence the rehydration ratio ($p < 0.05$). The presence of components, especially protein, may block the water needed for corn starch to develop the starch structure and reshape the cell wall arrangement. This trend can be clearly observed from the rehydration ratio of Manado Kuning which is higher than Srikandi Kuning and Provit A instant corn rice (figure 5). This is due to the lack of fiber covering the corn matrix, which causes the corn starch to gelatinize easily during the process of making instant corn rice. The presence of gelatinized starch increases water absorption due to the breaking of hydrogen bonds between starch molecules so that water can easily enter the starch molecules [25]. The duration of freezing did not significantly affect the rehydration ratio ($p > 0.05$), because the porosity of the products formed was not significantly different in several varieties and freezing time. The porosity of the instant product greatly affects the rehydration time and the swelling rate. According to Husain et al., (2006) porosity has an important role in the instantization of a material because the opening of the pores of a material will facilitate rehydration and speed up rehydration time [5]. Prasert and Suwannaporn (2009) stated that the value of the rehydration ratio has a negative correlation with its density [17]. The rehydration process occurs faster due to the increase in surface area which coincides with the increase in volume. In this study, a similar phenomenon also occurred in which the rehydration ratio of Manado Kuning instant corn rice is higher than Srikandi Kuning and Provit A. Good rehydration in instant products is a high rehydration rate and a fast time.
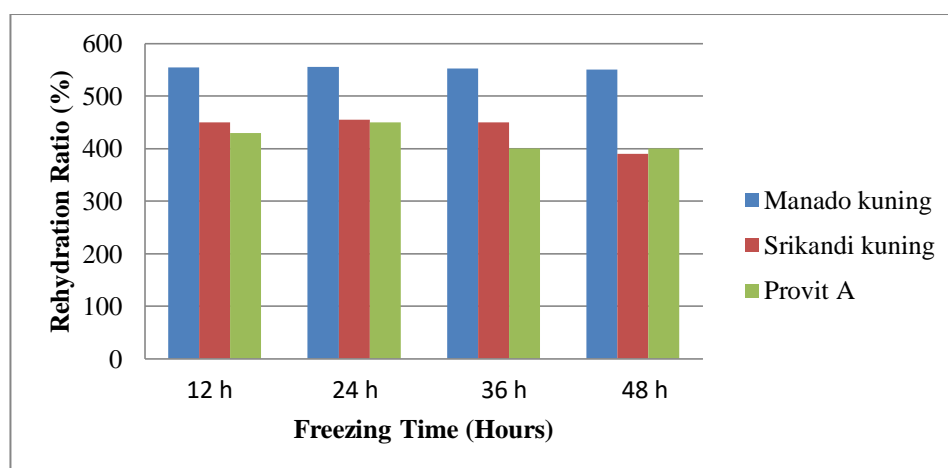

Figure 5. The relationship between freezing time and corn varieties to the rehydration ratio of instant corn rice

4. Conclusion

The type of variety and the duration of freezing affect the characteristics of instant corn rice. The duration of freezing increases the porosity, the swelling rate, decreases the rehydration ratio and water absorption rate. The best treatment is the Manado Kuning variety with a freezing time of 48 hours resulting in the highest bulk density, porosity and dehydration level where the bulk density met US standards for parboiled rice, which was between 0.40 to 0.42 g/ml.

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