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Effect of porang flour substitution and drying time on the characteristics of instant yellow rice

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Abstract

Instant yellow rice is an alternative breakfast menu with a short serving time while preserving traditional cuisine. Rice as the main ingredient of yellow rice is difficult to replace and has little nutritional content. Making instant yellow rice using the autoclaving-freezing method requires fast drying to minimize nutrient degradation and maximize rehydration time. The study used local tuber substitution of porang as a source of minerals while increasing the nutritional content of instant yellow rice. This study aimed to determine the effect of porang flour substitution and drying time on physical, chemical, and sensory characteristics and to determine the best formula for instant yellow rice with porang flour substitution. This study was conducted using the completely randomized design (CRD) method with two factors, namely variations in the concentration of porang flour (2%, 3% and 4%) and variations in drying time (5 hrs, 6 hrs and 7 hrs). The results of the analysis showed that the concentration of porang flour and drying time showed a significant effect ($p<0.05$) on the physical, chemical, and sensory characteristics of instant yellow rice. Porang flour substitution and drying time significantly affected rehydration time, expansion volume, moisture content, ash, protein, fat, carbohydrates, and panelists' preference for color attributes. And it has no significant effect on the bulk density and panelists' preferences on aroma, taste, texture, and overall. The best treatment was instant yellow rice with 2% porang flour substitution and drying at 60℃ for 6 hrs. With a high proximate nutritional content, good physical properties, and is well received by the sensory panelists.

1. Introduction

Instant yellow rice is one type of traditional food with a characteristic yellow color and an appetizing aroma and taste that is served in a short time. The process of making yellow rice dishes is relatively long and the use of coconut milk solution makes the shelf life lower so instantiation is an alternative that can be applied. Coconut milk contributes to the savory taste and aromatic due to the presence of fat and nonyl-methyl ketone compounds (Rahayu, 2017). In addition, instant yellow rice is a solution to preserving the existence of traditional culinary, as emergency food logistics and buffer stock in areas of Indonesia that are not rice producers. However, the increase in rice consumption is of particular concern to the threat of a food security crisis in the world, especially in Indonesia. So, it is necessary to modify the manufacture of instant yellow rice with substitution from local food sources. The program to increase product diversification from local food looks effective in realizing sustainable food security (Suryana, 2014).

Porang tubers (*Amorphophallus muelleri* Blume) are a type of tuber that has the advantage of high glucomannan content (up to 65%) compared to other tubers and high minerals. On the other hand, physical characteristics include brownish yellow color due to high carotene content, neutral taste, and phytochemical content of alkaloid compounds that have bacterial activity against *Pseudomonas aeruginosa*, *Staphylococcus aureus* and *Escherichia coli* (Hashemi and Dornoush, 2020; Erlina and Muhtadi, 2021). Its use

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is only in the form of chips and flour so it becomes a focal point to be improved because the potential benefits of porang tubers are very large (Sulistiyo *et al*., 2015). Porang flour can be used in the manufacture of noodles, tofu, and vegan meat for consumption (Grasso *et al.*, 2014). In addition, it can be used in the health sector such as anti-obesity, anti-diabetes (Shah *et al*., 2015), anti-tumor (Li *et al*., 2020), anti-cholesterol, prebiotic (Li *et al*., 2021), enhance immunity, cough, asthma and other diseases (Du *et al*., 2021). Also, glucomannan in porang can be used in the cosmetic and chemical industries such as coatings, films and membranes, surfactants, and emulsifiers (Yanuari *et al*., 2017; Amyranti 2020).

According to Rewthong *et al*. (2011), there are several drying techniques to maintain the quality of instantiated foodstuffs such as solar energy and heat and time difference treatment. Temperature and drying time play an important role in the quality and shelf life of the product (Onwude *et al*., 2019). If using high temperatures in drying, there can be nutritional degradation and a decrease in the sensory quality of the product. Meanwhile, the use of a drying temperature that is too low can cause the resulting product to be non-durable and reduce the quality (Muthukumar *et al*., 2022). In the drying process using high temperatures and too long a time is an undesirable drying process. This will cause damage to the sensory and nutritional quality, especially protein and mineral nutrients which then have an impact on the quality and marketability of the product. In addition, according to Singh *et al*. (2012), the disadvantages of improper drying are poor physical appearance, reduced vitamins, loss of volatile flavor, and cause charred aroma. Kraithong *et al*. (2021) reported that drying that is not fast and precise can cause no porous structure to form on the material.

The right drying method determines the characteristics of the drying results (Dehghannya *et al*., 2018). The research of Widowati *et al.* (2020), related to instant yellow rice with the drying method, namely the cabinet dryer method at a temperature of 50-55^{o}C for 8 hrs, produces instant yellow rice that is more porous so that the product has a short rehydration time, but the value of the expansion volume is still small making the quality not maximal. Research is needed on drying time which aims not only to achieve dried product but also to maintain the maximum nutritional content to obtain the best results. This is reinforced by the statement of Rewthong *et al*. (2011), that the faster the product is dried, the better the quality will be.

Therefore, the drying time of the cabinet dryer method is the second treatment factor using a temperature of 60°C with three-time levels, namely 5, 6 and 7 hrs. Meanwhile, the first factor is the substitution of porang flour with three concentration levels of 2, 3, and 4% based on the research of analog rice with mocaf and porang flour by Yuwono *et al.* (2013) and to increase the nutrition of instant rice because the instant rice. The instant research by Ali *et al*. (2012) showed that the nutritional value of low crude fiber ranges from 0.22%. The final objective was to determine the effect of porang flour substitution and drying time to produce the right product and acceptable to consumers through organoleptic, physical, and chemical properties of instant yellow rice.

2. Materials and methods

2.1 Materials

The ingredients used in making instant yellow rice substituted for porang flour are "Hasil Bumiku" brand and Sintanur rice, coconut milk (Sasa brand), turmeric, ginger, galangal, shallots, bay leaves, pandan leaves, lemongrass, salt (Refina brand) and sugar (Rose brand) obtained from the local market. While the analytical materials include Kjeldahl tablets, H_2SO_4, 5% NaOH, $Na_2S_2O_3$, H_3BO_3, MRMB indicator, 0.01N HCl. distilled water and benzene.

2.2 Instant yellow rice preparation

The process of preparing instant yellow rice with porang flour substitution involves several steps. First, the sintanur variety rice is soaked in a 5% sodium citrate solution for 2 hrs, followed by thorough rice washing. The rice is then combined with a mixture of yellow rice seasoning, which includes shallots (3%), turmeric (2%), ginger (2%), galangal (2%), coconut milk (13%), bay leaves (0.7%), pandan leaves (0.8%), lemongrass (2%), sugar (0.86%), and salt (2.6%) as specified by Widowati *et al*. (2020). Additionally, porang flour is added at different concentration levels: 2%, 3% and 4%. The mixture is stirred for 5 mins.

Subsequently, the prepared mixture is cooked using a pressure cooker at 1 atm and 60°C for a duration of 12 mins. After cooking, the rice is frozen in a freezer at -4° C for 24 hrs, followed by thawing using the water immersion method at room temperature for 2 hrs. Finally, the rice is dried in a cabinet dryer at 60°C for three different drying time variations: 5 hrs, 6 hrs and 7 hrs.

2.3 Physical analysis

2.3.1 Rehydration time

The test refers to the theory by Yu *et al*. (2011). Incorporation of the sample into several hot glasses of waters with a ratio of 1:4. Then the time is calculated

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when the rice grains are completely hydrated (there is no white spot in the middle of the rice grains).

2.3.2 Bulk density

The test refers to the theory by Prasert and Suwannaporn (2009). Weigh and record the empty measuring cup and followed by weighing the sample on the measuring cup to the mark. The bulk density is based on the ratio between the weight of 50 mL of the sample (Bs) and the volume of the measuring cup of 50 mL (Bb).

$$D_k = \frac{B_s}{B_b} \times 100\%$$

2.3.3 Expansion volume

The test refers to the theory by Butt *et al*. (2008). The expansion volume of instant rice was determined by measuring the difference between the height of instant rice before rehydration (Ko) and the final height of instant rice after rehydration (Kt).

$$V_p = \frac{K_t}{K_0} \times 100\%$$

2.4 Proximate analysis

The chemical nutrients were analyzed by proximate testing referring to AOAC (2005), including moisture content (by thermogravimetry), ash content (the oven method); protein content (Kjeldahl method); and fat content (Soxhlet method).

2.5 Sensory evaluation

The method used is a quantitative affective test type acceptance test involving 35 untrained panelists. The assessment attributes consist of color, aroma, taste, texture, and overall. The sample assessment was in the form of a preference level from a value range of 1 to 7, were (1) disliked extremely, (2) disliked, (3) dislike slightly, (4) neutral, (5) like slightly, (6) liked, (7) liked very much (Widowati *et al.*, 2020).

2.6 Statistical analysis

The data obtained were analyzed using the two ways analysis of variance (ANOVA) method to determine whether there was an effect on each treatment. If the data shows a significant difference, then the DMRT (duncan multiple range test) tests is carried out with a significance level of p = 0.05.

3. Results and discussion

3.1 Physical characteristics

The rehydration time of instant yellow rice substituted with porang flour, which ranges from 198-283 seconds, is equivalent to 3-5 mins, as shown in Figure 1a. The sample with the fastest rehydration time produced 3% instant yellow rice in 7 hrs, while the longest rehydration time for instant yellow rice samples was 4% in 5 hrs. All rehydration time results were as expected, which was less than 5 mins (Hubeis, 1984). The results of statistical analysis showed that the substitution of porang flour and drying time had a very significant effect on the rehydration time of instant yellow rice, and there was also an interaction. The higher the concentration of porang flour, the longer the resulting rehydration time. While the opinion of Faridah and Widjanarko (2014), is that the more concentration of

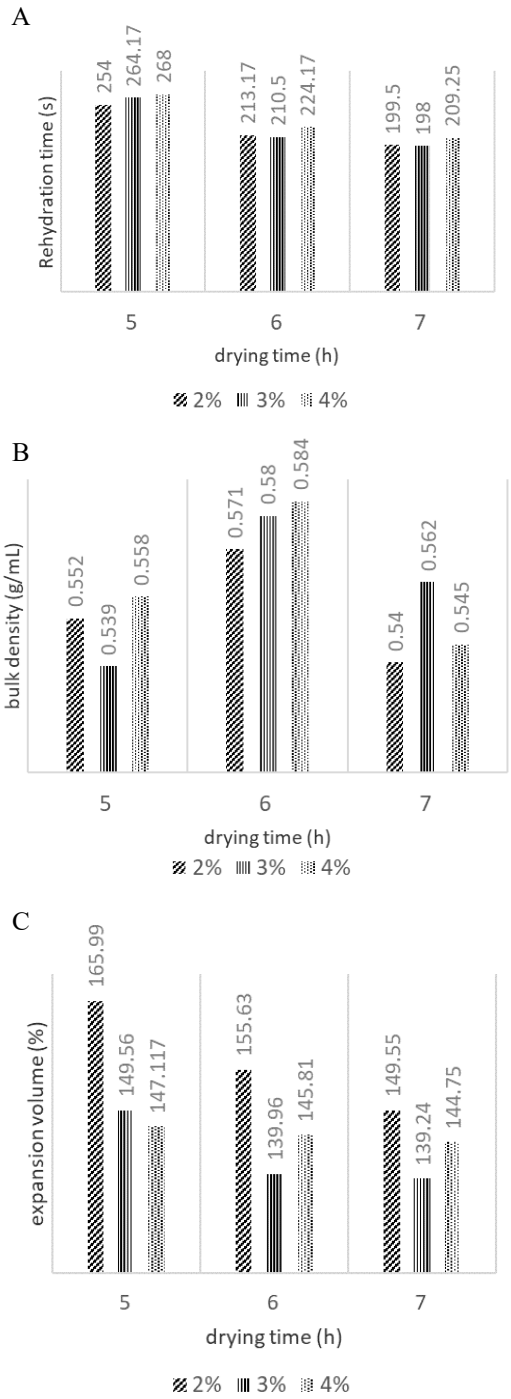

Figure 1. Physical characteristics of instant yellow rice substitution porang flour: (A) rehydration time, (B) bulk density, (C) expansion volume (%).

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porang flour, the lower the cooking time associated with gelatinization events. This is because the temperature and duration of gelatinization depend on the water content and the amount of purified konjac glucomannan (Patria *et al*., 2020). The longer the drying time, the faster the rehydration time needed. Due to the longer drying time, the water content decreases due to water transfer in the material which then affects the porosity and rehydration time (Rusdin *et al*., 2020).

The bulk density samples from all treatments ranged from 0.5393 to 0.5842 g/mL as shown in Figure 1b. The lowest value is instant yellow rice at 3% in 5 hrs, while the highest is 4% in 6 hrs. The results of the statistical analysis did not show a very significant difference in the bulk density, and there was an interaction. It is suspected that the bulk density is influenced by the addition of sodium citrate in the immersion process. The sodium citrate will decompose the protein in the rice during soaking, thus making the rice have a microsponge structure (Widowati *et al.*, 2010).

The sample expansion volume ranged from 134.89 to 165.99% as shown in Figure 1c. The smallest value was produced with 3% substituted instant yellow rice for 7 hrs, while the highest value is 2% for 5 hrs. The results of statistical analysis showed that porang flour substitution and drying time had a very significant effect on the expansion volume value of instant yellow rice development, but there was no interaction. The more concentration of porang flour, the value of the expansion volume decreases. Because the substitution of porang flour contains starch that can undergo gelatinization. Expansion volume is closely related to the process of gelatinization of starch in the product (Azizah *et al*., 2014). The longer the drying time, the lower the resulting expansion volume. Meanwhile, Widowati *et al*. (2010) stated that the lower the water content, the higher the instant rice's ability to absorb water, and the higher the expansion volume of instant rice when rehydrated. The decrease in the expansion volume produced is caused by the inaccurate level of dryness of instant yellow rice products.

3.2 Chemical compounds

The chemical characterization of instant yellow rice is shown in Table 1. The moisture content of instant yellow rice substituted with porang flour is relatively low, ranging from 6.28-9.67%. The highest value of the sample is 4% for 5 hrs, while the lowest water content is 3% for 7 hrs. Statistical analysis showed that the substitution of porang flour and drying time had a very significant effect on the water content of the product, and there was no interaction. The higher the concentration of porang flour, the higher the water content produced. It is suspected that the addition of porang flour to the yellow rice formulation binds water to a greater extent because of the glucomannan content in it (Yuwono *et al*., 2013). The water content decreases with drying time because the longer a material is in direct contact with heat, the more water displacement events occur which also affect the lower water content (Erni *et al.*, 2018).

The ash content of instant yellow rice substituted with porang flour ranged from 2.692-2.912%. The highest value was obtained from instant yellow rice at 4% for 7 hrs, while the lowest is 2% for 5 hrs. The results of statistical analysis showed that the substitution of porang flour had a very significant effect on the ash content, while the drying time did not have a very significant effect and there were interactions. The higher the concentration of porang flour used, the ash content will increase. This is because the mineral content of porang flour is quite high such as potassium, magnesium, phosphorus, zinc, selenium, and copper (Pasaribu, 2019).

The fat content of instant yellow rice substituted with porang flour ranged from 1.42-3.06%. The highest value was obtained from instant yellow rice substituted with 4% porang flour with a drying temperature of 60°C

Table 1. Chemical characteristics of instant yellow rice substitution porang flour.

Substitution of Porang Flour (%)	Drying Time (hrs)	Parameter				
		Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Carbohydrate (%)
2	5	8.36±0.59^{e}	2.69±0.021^{b}	6.76±0.16^{abcd}	2.29±0.04^{e}	78.66±2.22^{a}
	6	7.13±0.00^{cd}	2.69±0.15^{b}	6.50±0.02^{abc}	1.59±0.01^{c}	81.95±0.28^{cd}
	7	6.54±0.09^{ab}	2.77±0.15^{bc}	5.73±0.67^{a}	1.42±0.10^{b}	82.81±1.77^{d}
3	5	8.67±0.25^{e}	2.84±0.01^{c}	7.75±0.22^{de}	1.84±0.07^{d}	78.89±0.3^{b}
	6	7.13±0.28^{cd}	2.85±0.07^{c}	7.34±0.21^{cde}	1.81±0.05^{d}	80.88±0.1^{bcd}
	7	6.28±0.91^{a}	2.87±0.05^{c}	7.07±0.32^{bcde}	1.46±0.02^{b}	81.93±0.67^{cd}
4	5	9.67±0.16^{f}	2.86±0.00^{c}	8.13±0.80^{e}	3.06±0.00^{g}	76.07±0.86^{a}
	6	7.25±0.38^{d}	2.86±0.00^{c}	7.80±0.30^{de}	2.29±0.03^{e}	80.32±0.81^{bcd}
	7	6.85±0.03^{bcd}	2.91±0.05^{c}	7.18±1.30^{cde}	2.43±0.011^{f}	79.73±3.13^{bc}

Values are presented as mean±SD. Values with different superscripts within the same column are statistically significantly different based on the 5% Duncan follow-up test.

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for 5 hrs, while it was produced from instant yellow rice substituted with 2% porang flour by drying at 60℃ for 7 hrs. The results of statistical analysis showed that the substitution of porang flour and drying time had a very significant effect on fat content, but there was no interaction. The fat content resulting from the treatment of variations in the concentration of porang flour showed an up-and-down pattern. The decrease in fat content is thought to be because the fat content in porang flour is very low, namely 0% (Zalewski and Hanis, 2015). Meanwhile, the increase in fat content is suspected that porang flour has properties as a natural emulsifier which then a saponification reaction occurs so that the fat content is not all dissolved in fat solvents such as ethanol, petroleum ether, and alcohol (Cato *et al.*, 2011). The longer the drying time, the more fat in instant yellow rice will come out and evaporate so that the fat content, especially free fatty acids, decreases (Jaroenkit *et al*., 2013).

Protein content ranged from 6.090-8.131% with the highest value being instant yellow rice at 4% in 5 hrs, while the lowest is 2% in 7 hrs. Statistical analysis showed that the substitution of porang flour and drying time had a very significant effect on protein content and there were interactions. The higher the substitution of porang flour used, the higher the protein content produced. This is presumably due to the use of porang flour with a protein content of 7.07% including hydrocolloids which play a role in protein levels (Lala *et al*., 2013). Protein content decreased, as the drying time was carried out. Due to protein denaturation events that occur with the increased drying time of foodstuffs.

The carbohydrate content of instant yellow rice ranged from 78.662 to 82.813%, with the highest value of instant yellow rice at 2% in 7 hrs and the lowest in 4% in 5 hrs. Statistical analysis showed that the substitution of porang flour and drying time had a very significant effect on carbohydrate content, and there were interactions. A higher concentration of porang flour can increase the carbohydrate content because porang flour is composed of carbohydrates by 77.68% (Nurjanah, 2010). And the longer the drying time is applied, the higher the carbohydrate content. Due to the increase in the heat received, evaporation of material water occurs, protein denaturation, and evaporation of fat into free fatty acids that it affects the presence of carbohydrates (Riansyah *et al.*, 2013).

3.3 Sensory characteristics

Organoleptic testing was conducted to evaluate the panelists' preference for instant yellow rice substituted with porang flour. The results include the assessment of sensory attributes which include color, aroma, taste, texture, and overall acceptance of instant yellow rice which is shown in Table 2. The results show that instant yellow rice substituted with porang flour was accepted by panelists between dislike and like with a score of 2.71 -5.63. The increase in substitution of porang flour gives yellow rice a darker yellow color, due to the nature of the color of porang flour, which is brownish (Purwanto, 2014), neutral aroma and taste, and can affect the level of hardness of instant rice which can affect the overall score of acceptance. The increase in drying time affects a stronger aroma because ingredients containing essential oils when dried longer than the distinctive aroma of the oil is not lost (Winangsih *et al.*, 2013). Ingredients containing essential oils are rich in volatile compounds, namely ginger by 14.06%-21.26% (Anam, 2010), turmeric by 2.5% (Yingngam and Brantner, 2018; Giofana and Andrianopsyah, 2019), lemongrass by 8-11% (Dacosta *et al.*, 2017), pandan leaves 1.6-1.8% (Adiyasa *et al.,* 2014), and bay leaves 0.16% (Istiqomah *et al*., 2020).

4. Conclusion

The increase in porang flour concentration has a

Table 2. Preferences levels of instant yellow rice substitution porang flour.

Substitution of Porang Flour (%)	Drying Time (hrs)	Parameter				
		Colour	Aroma	Taste	Texture	Overall
2	5	4.23±1.69^{b}	5.26±1.22^{c}	4.69±1.37^{ab}	3.60±1.42^{a}	4.49±1.31^{ab}
	6	4.97±1.32^{c}	4.46±1.5^{abc}	4.80±1.32^{b}	4.29±1.36^{abc}	4.66±1.08^{b}
	7	5.63±1.24^{c}	4.83±1.47^{bc}	4.51±1.36^{ab}	4.06±1.41^{abc}	4.63±1.09^{b}
3	5	2.80±1.35^{a}	3.77±1.65^{a}	4.09±1.36^{ab}	4.11±1.57^{abc}	3.80±1.32^{a}
	6	3.77±1.54^{b}	4.26±1.52^{ab}	3.97±1.52^{a}	4.29±1.43^{abc}	4.11±1.32^{ab}
	7	5.03±1.25^{c}	5.23±1.35^{c}	4.54±1.40^{ab}	3.51±1.42^{a}	4.34±1.41^{ab}
4	5	2.71±1.30^{a}	4.00±1.48^{ab}	4.40±1.50^{ab}	4.46±1.54^{bc}	4.17±1.29^{ab}
	6	3.66±1.45^{b}	4.83±1.38^{bc}	4.17±1.52^{ab}	3.86±1.31^{ab}	4.06±1.31^{ab}
	7	4.23±1.42^{b}	4.51±1.46^{abc}	4.20±1.51^{ab}	4.09±1.52^{abc}	4.20±1.39^{ab}

Values are presented as mean±SD. Values with different superscripts within the same column are statistically significantly different based on the 5% Duncan follow-up test.

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significant effect on several parameters, including rehydration time, moisture content, ash content, protein content, and carbohydrate content. It also leads to a reduction in fat content and an increase in expansion volume. However, it does not have a significant effect on bulk density or the preferences of the panelists. On the other hand, an increase in drying time significantly decreases rehydration time and expansion volume. It also affects nutrient content due to the evaporation of moisture, protein denaturation, coagulation, and the evaporation of fat into free fatty acids. This process leads to changes in water transfer, resulting in an increase in carbohydrates. Drying time, however, does not significantly impact bulk density, ash content, or the preferences of the panelists. In conclusion, the substitution of porang flour in instant yellow rice can provide an alternative for instant food with good nutritional qualities.

Conflict of interest

The authors declare no conflict of interest.

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