Effects of Konjac (*Amorphophallus muelleri Blume*) Flour Addition and Drying Time on the Crude Fiber and Texture Level of Instant Yellow Rice

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ABSTRACT

Instant yellow rice is a traditional breakfast dish prepared using special technology for quick and practical cooking and a longer shelf life. Since rice has low crude fiber content as the main ingredient, substitution with local sources, such as konjac flour, can be made. Konjac flour is the powdered root of konjac plant, and it contains high crude fiber. Therefore, this study aimed to examine the texture and crude fiber properties of instant yellow rice with the addition of konjac flour. Furthermore, a completely randomized design (CRD) was used with two factors, namely variations in konjac flour concentration (2%, 3%, and 4%) and variations in drying time (5 hours, 6 hours, and 7 hours). Each sample was analyzed for the physical (hardness, stickiness and chewiness texture) and chemical characteristics (crude fiber content). The results showed that the konjac flour concentration had a significant ($p<0.05$) effect, while the drying time had no significant ($p<0.05$) effect on the physical and chemical characteristics of instant yellow rice. Therefore, 5 hours of drying might be enough for the rice processing. The addition of 2% konjac flour on instant yellow rice dried for 5 hours showed 2.48 ± 0.50^{a} N of hardness texture, 5.53 ± 0.07^{c} N stickiness texture, 4.59 ± 0.02^{a} N chewiness texture, and 5.20% of crude fiber. Addition of 3% konjac flour on instant yellow rice dried for 5 hours showed 5.74 ± 0.08^{b} N of hardness texture, 4.73 ± 0.17^{b} N stickiness texture, 4.37 ± 0.05^{a} N chewiness texture, and 5.20% of crude fiber. The addition of 4% konjac flour on instant yellow rice dried for 5 hours showed $6.41\pm0,02^{c}$ N of hardness texture, 4.06 ± 0.70^{b} N stickiness texture, 3.33 ± 1.52^{a} N chewiness texture, and 5.35% crude fiber. This showed the best treatment was the use of instant yellow rice with 4% konjac flour addition at 5 hours drying time.

Keywords: Crude fiber; drying time; instant yellow rice; konjac flour; texture

INTRODUCTION

Rice is considered a main staple food globally as it plays an economically important role in the world, with Indonesia having the highest level of consumption. According to data, national rice consumption reached 123.89/kg/capita/year in 2020 (BPS, 2021). This high level of consumption has led to increased rice imports due to the large population, recording 356,286 tons cumulatively in 2020 (BPS, 2021). Therefore, a program promoting the diversification of products from local food sources is required to address the threat of a global

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food crisis and effectively contribute to sustainable food security (Suryana, 2014). In addition to the inadequacy of local food sources, rice increases the risk of diabetes (Bhavadharini et al., 2020). This is evident from the increase in the number of diabetics in Indonesia, accounting for 10.7 million and 19.47 million in 2019 and 2021, respectively (IDF, 2019). According to predictions, the number of diabetics in Indonesia is expected to increase to 23.33 million by 2030 (IDF, 2021). Hence, innovative food diversification is required to provide a rice substitute that does not cause diabetes.

Konjac flour is a powder derived from konjac tubers with a high glucomannan content with a neutral taste, up to 65%, compared to other types cultivated in Indonesia, facilitating the combination with other ingredients (Anggraeni et al., 2014). Glucomannan is a water-soluble, strong hydrocolloid, and low-calorie food fiber used in the food and non-food industries, such as cosmetics and health product industries (Saputro et al., 2014). Studies have been conducted to determine the functional value of glucomannan in konjac flour for health. This substance has anti-hypercholesterolemia properties (Dai et al., 2016), normalizes blood triglyceride levels (Agustin, 2019), controls blood sugar levels (Mashudi et al., 2022), improves digestive performance (Chiu & Stewart, 2012), reduces postprandial glycemia, and reduces cardiovascular risk (Ho et al., 2017). Fresh konjac tubers contain 3.58% glucomannan, 7.56% starch, 0.92% protein, and 0.19% oxalic acid (Sari & Suhartati, 2015). Moreover, konjac flour is rich in minerals essential for metabolism, such as potassium, magnesium, and phosphorus, as well as trace elements, including selenium, zinc, and copper (Purwanto, 2014). Its crude fiber content is 5.9% (Hasni et al., 2022), while white rice only has 0.57% (Hernawan & Meylani, 2016). Therefore, konjac flour has a great potential to be developed as a functional food with various health benefits. It has been used as an emulsifier and stabilizer in food, drinks, and cosmetic products due to its gelling properties (Behera & Ray, 2017). It has also been developed in several analog rice studies (Yuwono et al., 2013), where the quantity of flour used increases with water content, rehydration power, and level of hardness of instant rice. Ali et al. reported that instant rice had a low crude fiber content, up to 0.22%; hence, konjac flour could be used to improve nutritional value, specifically crude fiber (Ali et al., 2012). However, the flour has an unattractive dull yellow or brownish-yellow color on the processed rice (Purwanto, 2014).

Yellow rice is a food prepared by combining several herbs and spices, including turmeric, ginger, bay leaves, and coconut milk. The attractive color and distinctive aroma stimulate appetite, and the high carbohydrate content, as well as health benefits due to the presence of turmeric are major advantages (Aziza, 2016). Yellow rice is produced through several processes, ranging from the preparation of the ingredients to the final product, which is time-consuming. In addition, it has a short shelf-life due to the influence of coconut milk, which spoils easily. Coconut milk is an essential ingredient contributing to a savory taste and fragrant aroma due to its fatty and methyl ketone compounds (Rahayu, 2017). Food instantiation technology using the drying method is an efficient solution for producing food with a longer shelf-life without altering basic ingredients. The appropriate drying time needs to be determined to obtain good characteristics of instant yellow rice. According to Rewthong et al., the faster the drying of product, the better the quality and the higher the porosity of instant rice (Rewthong et al., 2011). This drying method can also be combined with a fortification process to improve the quality of instant food. Therefore, this study aimed to investigate the effect of konjac flour addition and drying time on the hardness, stickiness, chewiness texture and crude fiber content of instant yellow rice.

METHODS

Materials

The ingredients used in making instant konjac yellow rice included konjac flour from the "Hasil Bumiku" brand and Sintanur rice from Pasar Legi, Surakarta. Meanwhile, the spices used were coconut milk packaged under the brand "Sasa", turmeric, ginger, galangal, shallots, bay leaves, panda leaves, lemongrass, salt packaged under "Refina", and sugar packaged under "Rose Brand", obtained from Legi market, Surakarta.

The equipment used included analytical balances, digital balances, cutting boards, knives, spoons, plates, plastic bowls, pressure cookers, stoves, pans, spatulas, cabinet dryers, and freezers. Analysis tools were analytical balance, oven, porcelain cup, hot plate, vacuum pump, Buchner funnel, furnace, Erlenmeyer, desiccator, spatula, filter paper, and Texture Profile Analyzer.

Processing of Instant Konjac Yellow Rice

The process of producing instant yellow rice using konjac flour substitution included soaking Sintanur Wangi rice in a 5% sodium citrate solution for 2 hours. This was followed by washing and mixing with mashed yellow rice seasoning, namely shallots, turmeric, ginger, and galangal. Powdered coconut milk, bay leaves, pandan leaves, lemongrass, sugar, and salt were subsequently added, along with konjac flour at concentrations of 2%, 3%, 4%, and stirred for 5 minutes. The mixture was cooked in a pressure cooker for 4 minutes and frozen

at -4°C for 24 hours. Subsequently, the frozen mixture was dried using a cabinet dryer at a temperature of 60°C for three variations of drying time, namely 5, 6, and 7 hours.

Physical Analysis of Instant Konjac Yellow Rice

Texture Profile Analysis (TPA) method by Texture Analyzer TXT 32 was used to determine the physical properties of instant yellow rice, including hardness, stickiness, and chewiness. The instant rice sample was pressed twice with a 6 mm in diameter probe at a speed of 5 mm/s, and compressed to 30% of its initial height. The macro program of the TXT 32 texture analyzer software was used to obtain parameter values (Cato et al., 2015).

Crude Fiber Analysis of Instant Konjac Yellow Rice

Gravimetric AACC method No. 32-10.01 (AACC, 2015) was used to determine crude fiber content. Firstly, 1 g of sample (A) was weighed and placed in an Erlenmeyer flask, dissolved in 100 mL of 0.325 N sulfuric acid, and refluxed for 30 minutes. Approximately 50 mL of 1.25 N sodium hydroxide was added and refluxed for another 30 minutes. The sample was filtered using Whatman filter paper, which had been pre-weighed (C). Subsequently, the residue on the filter paper was rinsed with 25 mL of distilled water, 20 mL of 95% ethanol, and 25 ml of K_2SO_4. It was subsequently dried in an oven at 105 °C for 2 hours, cooled in a desiccator for 15 minutes, and weighed (B). Crude fiber content was calculated using The Equation 1.

$$Crude\ fiber\ (\%) = \frac{B-C}{A}\ x\ 100\% \quad (1)$$

Statistical Analysis

Experimental design was conducted using a completely randomized design (CRD) with two factors, namely variations in the concentration of porang flour substitution and drying time. In addition, Two Ways Analysis of Variance (ANOVA) method was used to analyze data and determine the effect of each treatment. Differences were assessed using Duncan Multiple Range Test (DMRT) with a significance level of α = 0.05.

RESULTS AND DISCUSSION

Hardness

Table 1 shows that the hardness value of instant yellow rice ranged from 2.48±0,50 – 6,41±0,02 N. The highest hardness value was obtained from the sample with 2% konjac flour substitution after drying for 7 hours. Statistical analysis showed that the addition of konjac flour and drying time had various effects on texture. Hardness texture of the sample with 2% konjac flour using 5, 6, and 7 hours of drying time were 2.48±0.50^a, 2.57±0.10^a, 3.75±2.35^a, respectively, showing a significant effect. Texture with 3% konjac flour using 5 and 6 hours of drying time showed no significant effect, while 7 hours showed a significant effect. Hardness texture with 3% konjac flour dried for 5, 6, 7 hours were 5.74±0.08^b, 5.74±0.35^b, 6.38±0.35^c, respectively. Hardness texture with 4% konjac flour had no significant effect after 5, 6, and 7 hours of drying time. Texture of instant yellow rice with 4% konjac flour dried for 5, 6, 7 hours were 6.41±0.02^c, 6.21±0.02^c, 6.10±3.23^c respectively. The result was supported by previous investigation, showing that cooking methods on instant rice did not significantly affect hardness and stickiness of instant rice (Phukasmas & Songsermpong, 2019).

The varying additions of konjac flour to instant yellow rice showed a significant effect on hardness texture. The 2%, 3%, and 4% additions of konjac flour with 5 hours drying time showed 2.48±0.50^a, 5.74±0.08^b, and 6.41±0.02^c of texture hardness, respectively. The 2%, 3%, and 4% addition of konjac flour with 6 hours drying time showed 2.57±0.10^a, 5.74±0.35^b, 6.21±0.02^c of texture hardness, respectively. Furthermore, the 2%, 3% and 4% addition of konjac flour with 7 hours drying time showed 3.75±2.35^a, 6.38±0.35^c, 6.10±3.23^c of texture hardness, respectively. Yuwono et al stated that konjac flour contained glucomannan, a hydrocolloid contributing to harder texture (Yuwono

Table 1. Physical characteristics of instant yellow rice hardness

Drying time (hours)	Konjac flour (%)	Hardness (N)
5	2	2.48±0.50^a
	3	5.74±0.08^b
	4	6.41±0.02^c
6	2	2.57±0.10^a
	3	5.74±0.35^b
	4	6.21±0.02^c
7	2	3.75±2.35^a
	3	6.38±0.3^{5}c
	4	6.10±3.23^c

Notes: Different letters in the same row are significantly different (p>0.05)

et al., 2013). According to Schwartz et al, the presence of glucomannan affects gelatinization, leading to an increase in hardness. Studies have shown that high concentrations of konjac flour result in higher hardness texture values (Azizah, 2012). This corresponded with the current study, where higher konjac flour produced a higher value of texture hardness.

Stickiness

Stickiness of cooked rice is crucial for eating quality and consumer acceptance. The value can be obtained by leaching and molecular structural characteristics during cooking (Li et al., 2017). Texture of rice can be affected by various factors, such as amylose-amylopectin content and cooking method (Patindol et al., 2010). Table 2 shows that stickiness of instant yellow rice varied with the concentration of konjac flour added, ranging from 4.02 ± 1.78^{b} - 5.58 ± 0.70^{c} N. The lowest and highest values were obtained from the rice samples with 4% and 2% konjac flour, respectively. Statistical analysis showed that the addition of konjac flour had a significant effect on stickiness, while drying time had no effect. Stickiness value tended to decrease with an increase in konjac flour. It was also influenced by glucomannan, improving desirable textural properties and starchy product stability by interacting with starches from various botanic origins, including wheat, potato, tapioca, and rice (Lafarge et al., 2017). Glucomannan had the ability to adsorb water more effectively than other food fibers (Behera & Ray, 2016). Stickiness value was also influenced by amylose and amylopectin content in konjac flour. In other words, stickiness significantly decreased with increase in konjac flour, corresponding with the increase in total amylose and amylopectin. Konjac flour contained 18.2% amylose and 81.8 amylopectin (Tan et al., 2010). Amylose is a linear arrangement of α -1,4 glucose, while amylopectin is a water-insoluble branched structure containing linear (1.4 glucose) and branched (α -of 1.6 glucose) units (Behera & Ray, 2017). The levels of both contents play a crucial role during gelatinization and determine the characteristics of rice. Materials with low amylose and amylopectin produce sticky rice that does not expand, while those with high content yield a hard texture of rice (Winarti et al., 2018). The result corresponded with Wiset and Poomsa-ad., showing that stickiness value decreased with increase in the ratio of konjac flour. Furthermore, konjac flour was less sticky when compared with rice (Wiset & Poomsa-ad, 2022).

Chewiness

Table 3 shows that chewiness value of instant yellow rice with varying additions of konjac flour ranged from 2.62 ± 0.82^{a} - 4.59 ± 0.02^{b} N. The lowest and highest chewiness values were obtained from 4% and 2% konjac flour, respectively. Statistical analysis showed that the addition of konjac flour significantly affected chewiness value, while drying time did not have an effect. In other words, concentration of konjac flour increased with decrease in chewiness value. The values of 2%, 3% and 4% konjac flour dried for 5 hours were 4.59 ± 0.02^{b}, 4.37 ± 0.05^{b}, and 3.33 ± 1.52^{a}, respectively. The chewiness values with the addition of konjac flour dried for 6 hours were 4.40 ± 0.05^{b}, 3.77 ± 0.71^{ab}, and

Table 2. Stickiness of instant yellow rice

Drying time (hour)	Konjac flour (%)	Stickiness (N)
5	2	5.53 ± 0.07^{c}
	3	4.73 ± 0.17^{b}
	4	4.06 ± 0.70^{b}
6	2	5.58 ± 0.70^{c}
	3	4.58 ± 0.75^{b}
	4	4.02 ± 1.78^{b}
7	2	4.46 ± 0.13^{b}
	3	3.60 ± 2.46^{a}
	4	3.43 ± 1.31^{a}

Notes: Different letters in the same row are significantly different (p>0.05)

Table 3. Physical characteristics of instant yellow rice chewiness

Drying time (hour)	Konjac flour (%)	Chewiness (N)
5	2	4.59 ± 0.02^{b}
	3	4.37 ± 0.05^{b}
	4	3.33 ± 1.52^{a}
6	2	4.40 ± 0.05^{b}
	3	3.77 ± 0.71^{ab}
	4	3.31 ± 0.74^{a}
7	2	4.37 ± 0.05^{b}
	3	3.74 ± 0.15^{ab}
	4	2.62 ± 0.82^{a}

Notes: Different letters in the same row are significantly different (p>0.05)

3.31±0.74a, respectively. Furthermore, chewiness value with the addition of konjac flour dried for 7 hours were 4.37±0.05[b], 3.74±0.15[ab], and 2.62±0.82[a], respectively.

Konjac flour contains a hydrocolloid called glucomannan that forms a strong gel and resists melting when heated (Azizah, 2012). Glucomannan has several unique properties, such as the ability to form a thick solution in water, a large expanding force, and a gel form (Amyranti, 2020). Therefore, it tends to reduce texture of rice, specifically chewiness (Rejeki et al., 2021). Several other studies had contrasting results, with Kurniasari et al, stating that an increase in κ-carrageenan and konjac (1%–10%) in analog rice led to an increase in chewiness value (Kurniasari et al., 2020). High glucomannan content (64,98%) in konjac flour facilitated the shape of analog rice with good elasticity (Yuwono et al., 2013).

Crude Fiber Content

Food fiber is a component of plant tissue resistant to hydrolysis by stomach and small intestine enzymes. Furthermore, fiber has several functions in the body, including slowing down digestion in the intestine, providing a feeling of fullness, and regulating blood glucose levels (Hernawan & Meylani, 2016). The crude fiber analysis of the instant yellow rice ranged from 4.8 to 7.6%. The highest value was produced by substituting 4% konjac flour with 7 hours of drying time, accounting for 7.66%. Conversely, the lowest value was obtained from 2% konjac flour with 5 hours of drying time, at 5.20%. Statistical analysis showed that both konjac flour substitution and drying time significantly affected crude fiber content, although there was no relationship between the two factors. In other words, the concentration of porang flour increased with crude fiber. Figure 1 shows the crude fiber value for each instant yellow rice sample. The increased crude fiber content could be attributed to the addition of konjac flour, which had a high fiber content of 9-11% (Widjanarko et al., 2015). According to Ali et al., yellow instant konjac rice had a higher content compared to instant rice, which contained 0.22% fiber (Ali et al., 2012). The fiber content of yellow instant rice was also higher than other analog rice varieties, such as analog rice with taro flour and coconut flour, containing 3.06% (Kumolontang & Edam, 2020), and analog rice with corn flour, containing 3.44% (Anindita et al., 2020). In addition, longer drying time resulted in higher fiber content because the gelatinization process that occurred during heating decreased water and increased crude fiber content (Sida et al., 2019).

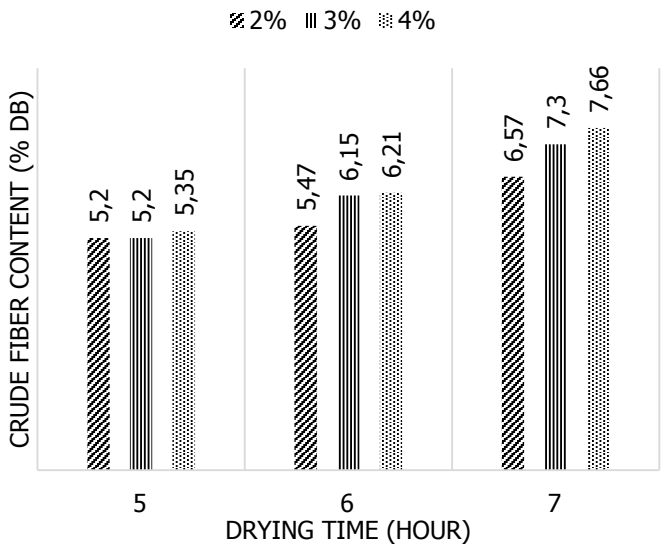

Figure 1. Crude fiber content of Instant Yellow Rice

CONCLUSION

In conclusion, konjac flour, known for high crude fiber, had been used for the fortification of analog rice product. Its addition had a significant effect on both physical characteristics, including hardness, stickiness, chewiness, and chemical characteristics, namely crude fiber. In comparison, drying times of 5, 6, and 7 hours had no significant effect on hardness, stickiness, chewiness, or crude fiber of instant yellow rice. Therefore, 5 hours drying time was considered sufficient for the processing of instant yellow rice. The addition of 2% konjac flour, dried for 5 hours in instant yellow rice, showed 2.48±0.50[a] N of hardness texture, 5.53±0.07[c] N stickiness texture, 4.59±0.02[a] N chewiness texture, and 5.20% of crude fiber. The addition of 3% konjac flour with 5 hours drying on instant yellow rice showed 5.74±0.08[b] N of hardness texture, 4.73±0.17[b] N stickiness texture, 4.37±0.05[a] N chewiness texture, and 5.20% of crude fiber. Lastly, the addition of 4% konjac flour on instant yellow rice dried for 5 hours at 60°C showed 6.41±0,02[c] N of hardness texture, 4.06±0.70[b] N stickiness texture, 3.33±1.52[a] N chewiness texture, and 5.35% of crude fiber.

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