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The Effect of Pregelatinization with Heat and Moisture Treatment on Physicochemical and Pasting Characteristics of Red Glutinous Rice Flour

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KEYWORDS

red glutinous rice; physicochemical properties; pasting properties; pregelatinization

Abstract Red glutinous rice is native from Pacitan and is still limited to local region consumption. The color of the rice flour showed that it has bioactive content, which is the potential to wider the use. The effect of pregelatinization using heat and moisture treatment by boiling on physicochemical (starch, amylose, anthocyanin, gel consistency, Lab color, SEM figure) and pasting properties of red glutinous rice flour was determined. The time and temperature of pregelatinization were 5, 10, and 15 minutes and 50°C, 60°C, and 60°C. The experiment was done with a completely randomized design with three replications. Starch content range to 62-77%, amylose content 3.29-5.75%, anthocyanin 2.64-6.71 mg/100g, Moisture 6.16-7.45, L 72.5-73.95, redness 5.11-6.00, yellowness 8.87-9.62, and gel consistency 9.7-12 cm. the increase of time and temperature of pregelatinization lead to decrease of amylose, starch, and anthocyanin content, and viscosity. After pregelatinization, the setback viscosity was lower it means that the rate of retrogradation is lower than native starch. SEM figure also showed that pregelatinization using heat and moisture treatment did not destroy the starch granules.

Introduction

Glutinous rice is one of the raw materials for Indonesia's food production, with 42,000 tons per year. Glutinous rice, widely known to the public, consists of two types: white sticky rice and black sticky rice. White sticky rice has a wider use than black sticky rice because of the stiffer nature and characteristics of black sticky rice. White sticky rice is commonly used as an ingredient for tetel, tape, wingko, rengginang, boiled, etc. The disadvantage of white sticky rice is that it has no pigment. Pigmented rice from several studies is an important source of antioxidants (Sompong *et al.*, 2011; Kong *et al.*, 2010; Ichikawa *et al.*, 2001; Murdifin et al., 2015; Nam *et al.,* 2006; Tananuwong and Tewaruth, 2010). Other pigmented sticky rice in Indonesia is red sticky rice. Red sticky rice is rarely used outside the community. The red sticky rice was only introduced by agricultural R & D in 2012, and its use is limited to the Pacitan area and its surroundings.

Natural starch generally has poor functional characteristics (Nakorn et al., 2009). Improvements in nature and function are usually carried out by modification. Modifications can be made by chemical modification with starch structures (Okunlola, 2015). Conversions can also be made to physical improvements such as pregelatinization with water and heat treatment so that starch has better staining properties (Lai *et al.*, 2001). Other pregelatinization can be done by hot air puffing, drum drier, and drum drier (Lai and Cheng, 2014; Valous *et al.*, 2002; Laovachirasuwan et al., 2010). Pregelatinization can improve the physicochemical characteristics and properties

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of starch (Gbenga *et al.,* 2014). Besides, pregelatinization can increase the swelling properties of starch to produce better excipients (Dengate, 1984; Okunlola, 2015). Glutinous rice starch has higher amylopectin compared to rice starch, so it has better melting characteristics and development (Park *et al*., 2007). Research on the pregelatinization of red sticky rice is expected to increase red glutinous starch in the community.

Materials and Methods

Materials

The materials used were red glutinous rice var Inpari 25 Opak Jaya from Pacitan Regency, which was planted in the dry season. Chemicals and reagents used for analysis was KOH 0,2 N solution, destilled water, KOH 1,7%, deionized water, ethanol, sodium hydroxide (NaOH) 1 N, acetic acid 1 N, H_2SO_4, PP indicator, NaOH, H_3BO_3 solution, standardized HCl 0,1 N, petroleum ether, H_2SO_4 0,325N, NaOH 1,25N, alkalized Na-carbonate 2%, calcium chloride buffer (0,03 mol/L, pH 1,0), sodium acetate buffer (0,4 mol/L, pH 4,5), ethanol 80%, ethanol 10%, petroleum ether, destilled water, HCl 25%, NaOH 45%, Nelson reagent, arsenomolibdat reagent, $CaCO_2$, Pb-acetic, Na-oxalic, and anthrone reagents.

Pregelatinized Starch Preparation (Modification From Rini and Soichi, 2018)

80 mesh of red glutinous rice flour was heated in water in a ratio of 1:4 with different combinations of time (5, 7.5, and 10 mins) and temperature (50°C, 60°C, and 70°C). Then, the flour was decanted and dried in a cabinet drier for 6 hours, milled, and sieved 80 mesh.

Chemical analysis

After heat moisture treatment, the pregelatinized flour was analyzed in starch content (AOAC, 2005), amylose content (AOAC, 2005), water content (AOAC, 2005), and anthocyanin content (Yodmanee, 2011).

Physical analysis

For physical analysis include color lab (Yuwono and Susanto, 2009), Gel consistency (Masniawati, 2013), *Rapid Visco Analyzer* (RVA) (Frost *et al.,* 2009),

Data Analysis

The experiment was done in a completely randomized design with three replications. The response was analyzed by analyzing variance and DMRT if the temperature and heat treatment time significantly affected the dependent variable. Data was presented in mean ± standard deviation.

Result and Discussion

Red glutinous rice as the main ingredient for this research is native from Pacitan published in 2012 by the Indonesian Ministry of Agriculture number 2437/Kpts/SR.120/7/2012 with a variety of INPARI (Inbrida Padi Sawah Irigasi) 25 Opak Jaya (Table 1). Yulianingsih and Shoichi (2018) report that heat moisture treatment can produce pregelatinized flour as hydrocolloids. Pregelatinization is a physical modification to obtain a better rice flour characteristic, such as increased gelling characteristics and solubility (Alves *et al.,* 1999). Pregelatinization also improve to the gel strength and viscosity of starch (Li *et al.,* 2020). It also improved the quality of various products suct as noodles and pharmaceutical excipients (Kankate *et al.,* 2020 and Sofi *et al.,* 2020)

Chemical composition

The characteristics of red glutinous rice used in this study can be shown in Table 1. The difference between rice and glutinous rice is in the ratio of amylose and amylopectin of the starch. Raw red glutinous rice contains 5.69 % amylose and 70.43% starch. Table 2 shows that increase time and temperature of pregelatinization decreasing the starch and amylose content of red glutinous rice. This led to amylose leaching into the moisture; similar phenomena were also found maize starch

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modification in Awolu *et al.* (2020). Amylose leaching starts at the early stage of heating (Park and Kim, 2020). Heat and moisture treatment will contribute to a decrease in amylose content. Amylose plays a crucial part in the characteristics change in modified starch (Gerçekaslan, 2021).

Table 1. Red Glutinous Rice Characteristics

Characteristics	Red Glutinous Rice
amylose content (%)	5.69 ± 0.49
starch content (%)	70.43 ± 6.80
Anthocyanin (mg/100g)	10.18 ± 0.67
Moisture (%)	11.75 ± 0.80
gel consistency (Cm)	10.5 ± 0.50
color	L = 73.3 A = 6.3 B = 9.3

Raw red glutinous rice contains 10.18 mg/100g anthocyanin. The anthocyanin content of red glutinous rice is similar to blue/purple wheat flout, which consists of 5.3–17.4 mg/kg (Varga *et al*. 2013) and lower than purple maize kernels (54-105 mg/100g) (Salinas *et al.*, 2005). After various times and temperatures of pregelatinization, the anthocyanin content was declined (Table 2). The lowest content of anthocyanin was found in the 10 min and 70°C of pregelatinization. The degradation of anthocyanin content is strongly affected by heating duration and magnitude (Patras *et al.,* 2010).

Table 2. Chemical Characteristics of Red Glutinous Rice Flour after Pregelatinization

Time (min)	Temperature °C	Starch (%)	Amylose (%)	Anthocyanin (mg/100g)	Moisture (%)
5	50	77.84 ± 3.03	5.75 ± 0.41	6.71 ± 1.10	6.74 ± 0.22
5	60	76.34 ± 1.08	4.98 ± 0.44	4.95 ± 0.32	7.45 ± 0.44
5	70	73.46 ± 3.99	4.60 ± 0.04	4.15 ± 1.17	7.16 ± 0.25
7,5	50	76.23 ± 2.95	5.66 ± 0.47	5.59 ± 0.08	6.96 ± 0.42
7,5	60	70.55 ± 2.32	4.95 ± 0.36	4.48 ± 0.75	6.61 ± 0.18
7,5	70	65.21 ± 3.45	3.86 ± 0.08	4.20 ± 0.75	6.16 ± 0.20
10	50	74.02 ± 3.56	5.41 ± 0.03	3.48 ± 0.46	7.41 ± 0.20
10	60	70.12 ± 5.18	4.60 ± 0.86	3.20 ± 0.55	7.39 ± 0.16
10	70	62.79 ± 2.08	3.29 ± 0.44	2.64 ± 0.60	7.36 ± 0.51

Decreasing anthocyanin levels due to pregelatinization can affect the color of red glutinous flour. Table 2 shows that the longer the healing process carried out can be expected to cause an increase in brown intensity so that the yellowish value is higher and the brightness level increases. This is probably due to the dissolution of anthocyanin pigments during the pregelatinization process (Mok and Hetthiarachchi, 1991). This is supported by a decrease in the redness value with increasing

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duration of pregelatinization. The table also shows that pre-gelatinization with the influence of temperature and time tends to increase gel consistency in the sample of red glutinous rice flour. The gel in rice flour is strongly influenced by the amylose content of Lu *et al.* (2017)

Table 3. Physical Characteristics of Red Glutinous Rice Flour after Pregelatinization

Time (min)	Temperature °C	Color			Gel consistency (Cm)
		(L*)	(a*)	(b*)	
5	50	72.50 ± 1.48	6.00 ± 1.08	9.62 ± 0.34	9.7 ± 0.25
5	60	72.77 ± 1.15	5.92 ± 0.85	9.42 ± 0.16	11.4 ± 0.53
5	70	72.58 ± 0.61	5.59 ± 0.50	9.60 ± 0.03	9.7 ± 0.42
7.5	50	73.36 ± 1.12	5.27 ± 0.48	9.37 ± 0.41	10.4 ± 0.36
7.5	60	72.87 ± 0.92	5.72 ± 0.91	9.26 ± 0.07	10.6 ± 0.35
7.5	70	73.30 ± 0.45	5.47 ± 0.40	9.34 ± 0.30	11.9 ± 0.79
10	50	73.76 ± 0.47	5.11 ± 0.41	8.87 ± 0.34	11.3 ± 0.76
10	60	73.92 ± 0.23	5.54 ± 0.51	9.02 ± 0.24	11.4 ± 0.50
10	70	73.02 ± 1.82	5.37 ± 0.61	8.99 ± 0.65	12.0 ± 0.55

The pasting properties of native and pregelatined red glutinous starch were analysed using Rapid Visco Analyzer (RVA) (Table 4). The result showed that pregelatinization increasing peak viscosity, setback viscosity, breakdown viscosity, and final viscosity. The setback viscosity of the native starch is higher than the pregelatinized starch. The lower value of setback viscosity showed that the pregelatinized red glutinous rice has a lower retrogradation rate. The peak viscosity and pasting temperature are almost similar. The cold peak viscosity of the pregelatinized starch is higher than the native starch. It is shown that the granules of the starch is still integrated. The SEM figure in fig 1 supports it. It is also indicated that thermal moisture treatment in 60°C for 10 min does not disrupt the starch structure. The increase of final viscosity in heat and moisture treatment pregelatinization also found in Gayary and Mahanta (2020). Most high protein commodities also experience an increase of setback viscosity after moisture treatment, but it is not found in red glutinous rice (Luga and Mironeasa, 2019).

Table 4. *Rapid Visco Analyzer* of Red Glutinous Rice Flour

Test	HPV	CPV	Breakdown	Final Visc	Setback	Peak Visc	Pasting Temp
Pregelatinized (60°C, 10 mins)	3081.67± 187.96	1859.00 ±40.63	1222.67 ±148.67	3232.33± 87.83	150.67 ±107.51	6.89 ±0.04	73.63 ±0.55
Raw Flour	1867.00± 214.35	1325.00 ±63.10	542.00 ±167.90	2281.33± 140.66	414.33 ±73.70	6.82 ±0.10	72.33±0.58

HPV = High Peak Viscosity (95°C in cP)
CPV = Cold Peak Viscosity (50°C after 5 mins)
PT = Pasting Temperature (Initial gelatinization temperature °C)
PV = Peak Viscosity (cP)
SB = Setback Viscosity (cP)
BD = Breakdown Viscosity (cP)

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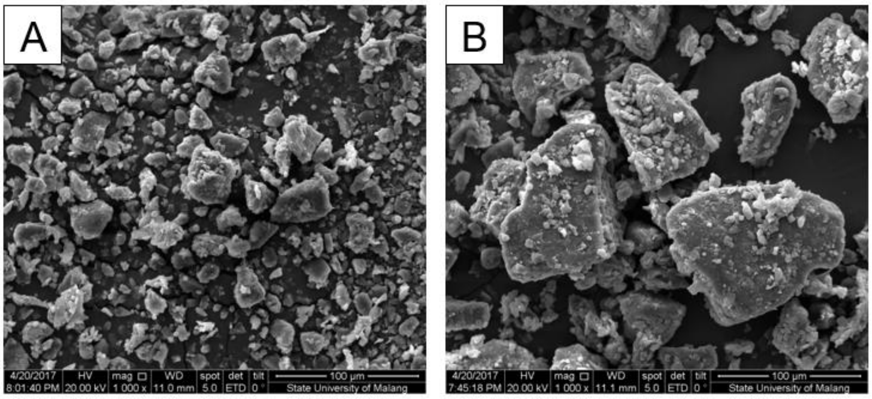

Figure 1A. Red glutinous rice starch granule before pregelatinization. 1B. Red glutinous rice starch granule after pregelatinization 10 min 60°C

The increase of the cold viscosity is likely related to the penetration of water to the starch's granule. The different pattern was found by Li *et al.* (2014) for buckwheat starch, Nakorn *et al.,* 2009 for rice starch, and Mazjoobi *et al*. (2015) for maize starch. The pregelatinization using drum drier had disrupted starch granules and have a lower cold peak viscosity in native starch. Cold peak viscosity is related to solubility in cold water and starch's dispersion capacity after cooking and cooling (Wani *et al.,* 2012).Native and pregelatinized starches were observed with Scanning Electron Microscope (SEM). The shape of the red glutinous rice starch was irregular polyhedral. Polyhedral types of granules were common in rice starch (Wani *et al.,* 2012). Shell type granules were also noticed by Zhang *et al.* (2005), Nimsung *et al.* (2007), and Kananurux (2009). The size of the granule after pregelatinization is bigger than the native. It may be related to the pregelatinization process. Muchlisyiyah (2017) was found that pregelatinized red glutinous rice has better water absorption and swelling properties than native starch. The picture also showed that pregelatinization in 60 C in 10 min does not cause the starch to lose its granular structure. The rough surface of the starch may due to the starch was not deproteinized before pregelatinization.

Conclusion and Suggestion

Pregelatinization using heat and moisture treatment had affected the physicochemical and pasting properties of red glutinous rice. Increasing time and temperature of pregelatinization had decreased the anthocyanin, amylose, and starch content of red glutinous flour. At the same time, increasing time and temperature had increased gel consistency. Pregelatinization had increased the viscosity of red glutinous rice flour but lowering the setback viscosity. SEM figure also showed that pregelatinization using heat and moisture by boiling does not rupture the starch's structure. Further analysis is needed to characterize red gluniouous red glutinuous rice's properties and its application into instant food products.

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