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A study of sago starch and red bean flour-based analog rice development as functional food

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Abstract

Sago can be used as a non-rice carbohydrate source in the analog rice manufacture. Red bean flour is used as a protein source, and its high content of amylose can shape the nature of grains like rice in addition to its high dietary fiber and low glycemic index. The objective of this study was to determine the characteristics of the physical and chemical properties of raw materials of sago starch and red bean flour for analog rice. It was done in three steps: preparation, formulation, and testing. The preparation was to examine the physical and chemical characteristics of each of raw materials;the formulation was to make analog rice, and the testing was to test the sensory characteristics of analog rice.

The result of composite flour gelatinization profile showed that pasting temperatures ranged from 74.73°C to 75.68°C, the peak time was from 6.13 minutes to 6.57 minutes; sago starch and red bean flour respectively contained moistures of 11.99% and 10.99%, ashes of 1.19 and 3.38%, fats of 0.71% and 3.35%, proteins of 0.9% and 24.98%, carbohydrates of 86.11% and 57.12%, starches of 84.67% and 44.26%, amyloses of 43.69% and 27.35%, dietary fibers of 2.54% and 14.32%, and resistant starches 18.31% and 10.51%.The addition of red bean flour up to 10% (BS100, BSKM5 and BSKM10) produced analog rice acceptable to panelists.

Keywords: analog rice, sago starch, red bean flour, extrusion

INTRODUCTION

Analog rice is rice made from non-rice flour such as sago starch, modified cassava flour, arrowroot, corn, sorghum, and various types of other tubers (Samad, 2003). Analog rice can be made in accordance with the desired functional characteristics of the used raw materials. Local food material of non-rice carbohydrate source which is potential for making analog rice is sago starch.The availability of sago starch in Indonesia, especially in Eastern part of Indonesia is very potential to be developed. With its high content of amylose, namely: 28.84% (Jading et al., 2011), Sago will produce good analog rice texture and can improve its functional characteristics. The texture of the produced analog rice will determine its acceptability for consumers. In this case, it is strongly influenced by the amylose content of the used raw materials. However, sago starch as a substitute to rice has a disadvantage, namely: its low protein content. Therefore, other protein sources are required, and of them is red bean flour. Analog rice is processed by using extrusion technology. This technology facilitates the making of analog rice, and it can produce rice products similar to rice grains (Mishra et al., 2012). Extrusion process is a manufacturing process that combines humidity, high pressure, thermal,

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short time mechanical friction, and granulating as a result of extrusion through mold (Riaz, 2000).The result of extrusion is thendried until its water content is below 15% in order to increase its storability. The objectives of sago starch and red bean composite flour formula-based analog rice product development are expected to produce analog rice with better physicochemical characteristics and acceptability for consumers, to improve its functional characteristics and to increase the utilization of local resources toward national food security and authority. This study aimed at assessing the sago starch and red bean flour-based analog rice development, which is viewed from the physicochemical properties of raw materials, and a sensory test of produced analog rice.

MATERIALS AND METHODS

Materials and Tools

The main materials for this study were sago starch (*Metroxylon spp*.), varieties of Meranti and varieties of Local red beans (*Phaseolus vulgaris*). The sago starch was obtained from Selat Panjang, Riau, while the red bean was obtained from farmers in Parakan Sub-district, Temanggung regency. Chemical materials for analysis with pro analysis quality (Sigma, or E-Merck) were bought in Santosa chemical store, Semarang. The main tool used in this research was the Rapid Visco Analyzer (RVA), a unit of chemical analysis such as soxhlet tube, mikrokjeldahl units, spectrophotometers, and centrifuge.

Preparation Step

The first step was making the composite flour formula with the ratio of the sago starch and the red bean flour of BS100 (100%: 0%), BSKM5 (95%: 5%), BSKM10 (90%: 10%), BSKM15 (85%: 15%), BSKM20 (80%: 20%) and BSKM25 (75%: 25%). The composite flour was analyzed RVA to see gelatinization profile used as a reference for the following process.
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Step of Analog Rice Manufacture

The next stage was manufacturing the analog rice of 6 formulas of composite flour that had been made. Before manufacturing the analog rice, emulsion consisting of GMS, distilled water, coconut oil, and carrageenan was made first. Furthermore, the emulsion was mixed with composite flour, exposed to homogenization for 5 minutes, and then steamed for 15 minutes. The steamed materials were directly put into the extruder, exposed to homogenization for 2 minutes, and then molded into analog rice (the molding process was repeated for 2 times). After the granules were formed, then they were dried in a cabinet dryer at a temperature of 50^0C for 12 hours.

Analysis method

The raw materials of sago starch and red bean flour were respectively exposed to gelatinization analysis profile by using the Rapid Visco Analyzer (RVA), proximate analysis (AOAC, 2006), carbohydrate content (by different), dietary fibers by enzymatic method (Asp, 1983), and amylose by UV-Vis spectrophotometer method (Williams et al., 1970), and resistant starch content (Goni et al., 1996 with modification). The produced analog rice was tested in term of its sensory characteristics by using the multiple comparison test (Rahayu, 2001).

Experimental Design

The experimental design used in this study was the completely randomized design of one factor, that is, composite flour comparison (sago starch and red bean flour) with 6 treatment stages. The study was repeated for 4 times. The acquired data were tabulated by using MS. Excel 2013. To determine the effect of variable on the measured parameters, a statistical analysis was conducted by using the Statistical Analysis System (SAS) version 9.2. Through one way ANOVA test and if there was a significant difference between the levels, then it was continued with Duncan Multiple Range Test Test (DMRT) at 5% level.

RESULTS AND DISCUSSION

Characteristics of Basic Materials

The basic ingredients used in the analog rice manufacture are sago starch and red bean flour. The chemical characteristics of sago and red bean flour can be seen in Table 1. The physical characteristics of composite flour as the basic material of analog rice manufacture can be seen in the gelatinization profile (Table 2). The produced analog rice is exposed to sensory test using the multiple comparison test, with cooked rice as a comparison (Table 3)

Table 1. Chemical Composition of Sago Starch and Red Bean Flour (wb).

Composition	Sago Starch	Red Bean Flour
Water content (%)	11.09	10.99
Ash (%)	1.19	3.38
Protein (%)	0.90	24.98
Fat (%)	0.71	3.35
Carbohydrate (%)	86.11	57.12
Amylose (%)	43.69	27.35
Amylopectin (%)	56.31	72.65
Starch (%)	84.67	44.26
Soluble fiber (%)	0.93	5.50
Insoluble fiber (%)	1.61	8.82
Dietary fiber (%)	2.54	14.32
Resistant starch (%)	18.31	10.51

Table 2. Physical Characteristics of Basic Materials and Composite Flour.

Formula	Peak Visc *cP*	Holding Visc *cP*	Breakdown Vis *cP*	Final Visc *cP*	Setback Visc *Cp*	Peak Time *Minute*	Pasting Temp *°C*
BS100	4457,5^{f}	1527^{e}	2930,5^{f}	2641^{e}	1114^{d}	6,13^{a}	74,725^{a}
BSKM5	4184,5^{e}	1525^{d}	2659,5^{e}	2603,5^{d}	1078,5^{c}	6,13^{a}	74,7^{a}
BSKM 10	3920,5^{d}	1467^{c}	2453,5^{d}	2540^{c}	1073^{b}	6,27^{b}	74,85^{ab}
BSKM 15	3526,5^{c}	1400^{b}	2126,5^{c}	2479^{b}	1079^{ab}	6,4^{c}	75,3^{bc}
BSKM 20	3231,5^{b}	1330,5^{a}	1901^{b}	2343^{a}	1012,5^{ab}	6,44^{c}	75,525^{c}
BSKM 25	2849^{a}	1259,5^{a}	1589,5^{a}	2197,5^{a}	938^{a}	6,565^{d}	75,675^{c}

Table 3. Result of Analog Rice Plural Comparative Test.

Organoleptic Test	Texture	Taste	Aroma
BS100	0.00^{b}	0.60^{c}	0.13^{bc}
BSKM5	0.07^{b}	0.27^{c}	0.20^{c}
BSKM10	0.13^{b}	-0.27^{b}	0.20^{c}
BSKM15	-0.73^{a}	-0.73^{ab}	0.40^{ab}
BSKM20	-0.67^{a}	-1.00^{a}	-0.87^{a}
BSKM25	-0.93^{a}	-1.20^{a}	-0.87^{a}

Chemical Characteristics of Basic Materials

Chemical characteristic that contributes to the formation of the analog rice texture is amylose content, where the amylose content of the sago starch in this research was higher than those of the research by Zi-Ni (2015) (25.77%), by Uthumporn et al. (2014) (30%), and Hazila et al. (2010) (27%). At the same concentration, sago has a higher viscosity than the other cereal starches. The nature of the sago gel is stronger, its adhesiveness was low, but its cohesiveness is high. The differences of amylose content are caused by the different place and varieties. Haska and Ohta (1992) found that the sago is resistant to the α-amylose enzyme

compared to the cereal starch. Thus, in general the sago is resistant to microbes and digestive enzymes (Karim et al., 2008). Amylose component relates to the water absorption and perfection of the product gelatinization process, where the higher amylose content will increase the water absorption and it will be more difficult for gelatinization.

Amylopectin component greatly determines the swelling power and solubility of starch. The content of high amyloseis also potentially used as raw material for instant products like analog rice. Sago and red bean flour have high resistant starch content (18.31 and 10.51%), so that they can be used as functional food ingredient. Red bean flour was added to sago starch-based analog rice in order to increase the protein levels. The data in Table 1 show that the protein content of red bean flour is fairly high, that is, 24.98%. Red bean flour also contains high dietary fiber, that is 14.32%, consisting of the insoluble fiber 8.82% and soluble fiber 5.50%.

Amilographic Characteristics of Composite Flour

The result of RVA indicates that the starch gelatinization profile of mix flour is influenced by gelatinization profile of basic materials. Heating at the gelatinization process causes the swelling of starch granules in water which has irreversible characteristics, as a result, the viscosity increases. Gelatinization temperature is the temperature when the increase in viscosity due to swelling of the starch granules maximally begins to be detected (Richana and Sunarti, 2004). The temperature of material gelatinization can determine the best temperature used during the extrusion process. Prior to the extrusion process, partial gelatinization processon the materials is expected to happen. If the process temperature is much lower than gelatinization temperature, it will produce fragile analog rice and it cannot be cooked into rice. If the temperature is too high and the time takes more than the gelatinization time, it will cause perfectly gelatinized material so that when it gets into the extrusion tool it will be sticky and cannot form grains like rice. The gelatinization temperature of formula flour in Table 2 is around 74.73 to 75.66^{o}C, and there is not a significant difference between the formulas. Analog rice manufacture uses limited water that is 50% of the total flour dough. Therefore, the temperature for pre-gelatinization is higher than temperature for gelatinization. Moreover, the time of gelatinization is around 6.13 to 6.56 minutes. The gelatinization temperature is influenced by several factors such as size, amylose and amylopectin, the heating medium condition, as well as food ingredients like fat, dietary fiber, resistant starch and protein. The amylose content of sago starch is higher than that of the red bean flour. It is suspected as the cause of gelatinization temperature difference on both the materials.

Other parameters known on the gelatinization profile (Table 2) include peak viscosity (cP), viscosity of hot pasta (cP), viscosity of breakdown (cP), cold pasta viscosity (cP), viscosity of setback (cP) and time of gelatinization (minutes). Formula BS100 has a lower gelatinization temperature, peak viscosity, viscosity of breakdown (stability of starch pasta against the heating), and a higher setback viscosity. Peak viscosity describes the ability of starch to inflate freely before breakdown. The value of peak viscosity is influenced by the levels of amylose and amylopectin in the ingredients. Table 2 shows that the viscosity of breakdown BS100 is higher than those of other formulas. When cooling process takes place, it causes the re-association between the molecules of starch (setback). Thus, it forms gel and viscosity will increase to reach the final viscosity. Formula BS100 which only consists of sago starch shows that the highest viscosity of setback, where it shows that the retrogradation process becomes stronger, but it decreases with the addition of more red bean flour. Red bean flour has a higher protein content than sago starch. According to the research Richana and Sunarti (2004), the protein in food causes the increasing gelatinization temperature.

Sensory Analysis ofAnalog Rice

Analog rice sensory test is conducted by using plural comparison test against the parameters of aroma, taste and texture. This test is used to determine the selected formula to the products which have the level of acceptance to the cooked rice. Sensory test is conducted

on 20 semi-trained panelists. Sago analog rice (BS100), sago analog rice with the addition of 5% and 10%of red bean flour (BSKM5 and BSKM10) have value of texture, taste and aroma which exceeds the cook rice because value is greater than Value 0 (Table 3).Value of 0 shows the same value with rice, the positive value is better while a negative value is worse than rice. The result of Analog Rice from the above formulations can be seen in Figure 1.

Figure 1. Sago and red bean analog rice.

CONCLUSIONS

The following conclusions can be drawn from the study:

- Sago starch and red bean flour have the physical and chemical characteristics which are potential to be developed in the manufacture of analog rice. Formula of sago starch analog rice and red bean can produce analog rice with the good physical and chemical characteristics.
- Based on the plural comparison tests, analog rice with the formula sago starch and red bean flour can produce analog rice with the texture, taste and aroma similar to the rice in general. The addition of red bean flour up to 10% (BS100, BSKM5 and BSKM10) produces analog rice is acceptable to the panelists.

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