Addition of Taro, Breadfruit, Seaweeds and Soymilk Waste Powders into Cassava Starch and Corn Powder-based Rice Analogues

Basuki Wirjosentono*, Tamrin, Amir Hamzah Siregar, Diana Adnanda Nasution, Isna Shara Siregar, Siti Sarah Fazira, Hanifah Siregar and Nurainun Mardhiah
Department of Chemistry, Faculty of Mathematics and Natural Sciences, Universitas Sumatera Utara, Medan 20155, Sumatera Utara, Indonesia

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Abstract: Rice analogue based on cassava starch is gaining attention in Indonesia due to its 23.7 million ton annual production of cassava has not been utilised optimally as alternative foods, and its relying on conventional rice as staple food by its increasing population. In this work an extrusion technique has been carried out to produce rice analogues using cassava starch (CS) and corn powder (CP) as basic raw materials and addition of natural fibres (NFs), i.e. taro powder (TP), breadfruit powder (BFP), seaweeds powder (SWP) and soymilk solid powder (SMP). It was found that optimum composition possesses physical properties and disolution time comparable to those of conventional rice was obtained when used weight ratio of CS/CP/NFs: 70/30/15. Morphological characterisation of the rice analogues showed fine distribution of natural fibres in the rice matrices, whereas addition of the natural fibres increased decomposition temperatures but did not affect melting temperature of the gelatinous phase significantly. It was also found that reduce carbohydrate and increase fibre and protein as well as other nutrition contents in the rice analogue have been revealed, therefore the rice analogues are suitable as alternative for diabetic and diet foods.

1 INTRODUCTION

Due to increasing population in Indonesia, in which in 2018 is reaching to 258.7 million, demand for rice as staple food is also increased. In addition, its 23.7-million-ton annual production of cassava has not been utilised optimally as alternative foods. Rice analogue (RA) is a food product based on carbohydrate from other resources such as: cassava, corn, taro and various plant tubers, which can be used as alternative for conventional rice. However, consumption and preference for the RA in Indonesia is still low due to the people's appetite and habit, although the nutrition content is comparable to that of conventional rice. To improve taste of the RA, researchers have developed RA based on cassava and corn powders and addition of rice bran (Budijanto and Yuliana, 2015; Khaniya et al., 2016). Other researchers reported preparation of rice analogue based on cassava and sago powders and studied preparation of RA based on sweet res potato and addition of cassava and carrot powders to improve its vitamin and nutrition contents (Anggraini et al., 2016). It has been reported that to formulate high protein RA, cassava and corn starches as raw materials have added with soybean powder (Khairunnisa et al., 2017). Rice analogue based on cassava starch (CS) and corn powder (CP) has been developed by Technopark in Lampung Tengah Indonesia, using blending process at water gelatinization temperature.

Furthermore, processing of polymeric melts and gels can be carried out using internal mixer and the processing can be designed in laboratory scale (Ismail et al., 2002). Compounding of polyolefin with palm oil fibre has also been carried out in reflux reactor using xylene solution (Wirjosentono et al., 2004). Processing of starch-based rice analogue blends has been reported using extrusion technique in gels phase in the presence of water at gelation point (Mishra et al., 2012). In this work rice analogue has been prepared using cassava starch (CS) and corn powder (CP) as basic raw materials and addition of other natural fibres (ONFs), i.e. taro powder (TP), breadfruit powder (BFP), seaweeds powder (SWP) and soymilk solid waste powder (SMP). Addition of other natural fibres is expected to increase fibre but lower carbohydrate contents as well as improve nutrition of the RA, which is important for diet and diabetic menu.

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2 MATERIALS AND METHOD

2.1 Materials

Raw materials in this work: cassava starch (CS), corn powder (CP), taro powder (TP), breadfruit powder (BFP), seaweeds powder (SWP) were purchase from traditional market in Medan. Soymilk solid waste powder (SMP) was collected from home industry producing soymilk in Medan. All the raw materials were then dried and grinded and filtered to produce 100 mesh particle size powders. Glycerol, vegetable oils, GSM and other chemicals were ex. Merck and used directly without purification.

2.2 Preparation of Rice Analogue

Rice analogues were prepared based on cassava starch (CS) and corn powder (CP) at various compositions according to Mishra et al. (2012). The dry mixing (total weight 100g) of each sample was then extruded in an extruder, at rotation speed 40 rpm, and temperature 90ºC (Kharunnisa et al., 2017). The extruded samples were then cut to produce rice particles, dried in vacuum at constant temperature 80oC, and the disolution time were measured in boiling water, and compared to that of conventional rice as control. Extrusion procedure were repeated using optimum composition of CS/CP with addition of various loading (5, 10, 15, and 20 g) of TP, BFP, SWP, and SMP powders respectively.

2.3 Physical and Chemical Analysis of the Rice Analogue (RA) samples

Procedures of physical and chemical analysis of the RA samples were carried out based on the previous works (Tharise et al., 2014).

2.4 Dissolution Time

Put 5 grains of RA in a test tube and add boilled water to half full. Continue boiling on a Bunsen burner slowly with manual shaking. Dissolution time is time start from addition of boilled water untill the RA grains start to dissolve.

2.5 Water Content

RA sample was placed in a dried aand clean aluminium disc and dried in vacuum at 110ºC for 1 hour, cooled in desicator and weigh to contant weight.

2.6 Ash Content

5 g sample was placed in clean porcelein disc and weigh. Sample was preheated in furnace at 140ºC then decomposed at 800ºC for 15 minutes. Instantly cooled the disc in desicator to 25ºC then weight.

2.7 Protein Content

Total protein content of the samples were measured using modified Kjeldahl method. 0.5 g of sample was digested in 5 ml of concentrated sulfuric acid and Kjeldahl catalyst. Nitrogen in sample was converted to ammonium sulfat which reacted with Brucine reagent to produce coloured compound with absorption at 470 nm. Protein content was calculated based on 6.25 times on nitrogen content in sample.

2.8 Fat Content

5 g sample was wrap in known weigh filter paper and place in a Soxhlet apparatus. Reflux the sample for 5 hours in n-hexane, evaporate the solvent at 105oC cooled and weigh.

2.9 Fiber Content

Put 2 g sample in an Erlemeyer flask 600 ml, add 200 ml concentrated sulfuric acid and boiled for 30 minutes. Cooled the mixture diluted with distillef water and filter the residue in known weigh filter paper. Wash the residue with water to free acid and with 15 ml ethanol 95%. Dried the residue in oven at 110ºC for 2 hours and weigh to constant weight.

2.10 Carbohydrate Content

Carbohydrate content was calculated from the rest of: water, ash, protein, fat, and fibre contents in the sample.

2.11 Colour

Colour of the RA was measured using Cromameter CR 300 Minolta and calibration of white colour.

3 RESULTS AND DISCUSSION

3.1 Making of Charcoal

Rice analogue (RA) samples prepared according to Mishra. A., et.al., 2012, are shown in Table 1. Their dissolution times (DT) were measured and compared to that of conventional rice (CR). It was found that optimum composition with dissolution time close to that of CR (DT: 17 minutes) was that with ratio of cassava starch (CS) over corn powder (CP): 70: 30 (g/g), (DT: 15 minutes). The optimum composition was then used to prepare further RA samples with addition of varied loading of taro powder (TP), 5, 10, 15, and 20 g. It was shown that addition of TP increased DT of the RA samples (16 – 23 minutes), and therefore it was taken that the optimum composition with addition of TP with weight ratio: CS : CP : TP = 70 g : 30 g : 15 g (DT: 18 minutes). Further samples were prepared with addition of breadfruit powder (BFP), seaweeds powder (SWP), and soymilk solid waste powder (SMP) 15 g, respectively. Their colour become light brown due to addition of corn powder and further brown with addition of TP, BFP, SWP, and SMP powders.

Table 1: Dissolution times (minutes) of various samples of RA compared to that of Conventional Rice as control.

Code	RA Sample (g)	Dissolution time (min)	Colour
CR1	Conventional rice	17	White
RA2	CS/CP 90/10	5	Light brown
RA3	CS/CP 80/20	10	Brownish
RA4	CS/CP 70/30	15	Brown
RA5	CS/CP 60/40	23	Dark brown
RA6	CS/CP/TP 70/30/5	16	Light brown
RA7	CS/CP/TP 70/30/10	16	Brownish
RA8	CS/CP/TP 70/30/15	18	Brown
RA9	CS/CP/TP 70/30/20	22	Dark brown
RA10	CS/CP/BFP 70/30/15	19	Brown
RA11	CS/CP/SWP 70/30/15	19	Brown
RA12	CS/CP/SMP 70/30/15	18	Brown

Nutrition contents (carbohydrate, total fat, protein, and fibre contents) of the RA samples were measured and shown in Table 2. Compared to those of conventional rice (CR), carbohydrate contents of rice analogues decreased from 78 % to 60 % and the fibre contents increase from 3 upto 18 %. These were due to lower carbohydrate and higher fibre contents of the raw materials (CS, CP, TP, BFP, SWP, and SMP). And the protein and total fat contents were also increase. It is hoped that the rice analogues (RA) are better for diet and antidiabetics menus.

Table 2: Nutrition content of various optimized rice analogue (RA) samples.

Code	Carbohydrate (%)	Fat (%)	Protein (%)	Fibre (%)
CR1	78	2	7	3
RA4	68	3	10	8
RA8	64	4	10	15
RA10	62	5	10	16
RA11	60	6	12	18
RA12	60	7	15	15

Morphological investigation of the rice analogue samples were carried out using electron microscopy (SEM) as shown in Figures 1a-1c. In Figure 1a, i.e. SEM micrograph of conventional rice showed smoother surface of the grain, whereas addition of natural fibre in the RA matrices showed rougher grain surface due to formation of fibre phase granules (Figures 1b and 1c, granule size 1-2 µm), i.e. that of RA samples containing 15% of taro and soymilk powders, respectively.

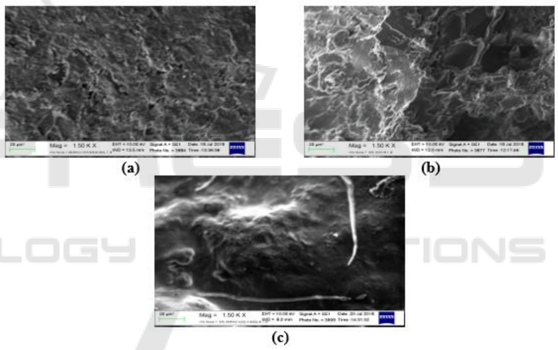

Figure 1: Grain surface SEM micrographs of: (a) conventional rice, (b) rice analogue containing taro powder 15% (CS/CP/TP: 70/30/15), and (c) that of containing soy milk powder 15% (CS/CP/SMP: 70/30/15), magnification 1500 times.

Results of thermographs of thermal analysis using DSC technique (heating range 25-600ºC) of conventional rice (Figure 2a) compare to that of rice analogue (Figure 2b) showed endothermic (due to water evaporation and melting) and exothermic processes (due to thermal oxidative decomposition). Characteristics of both endothermic and exothermic processes underwent in both samles were summarised in Table 3.

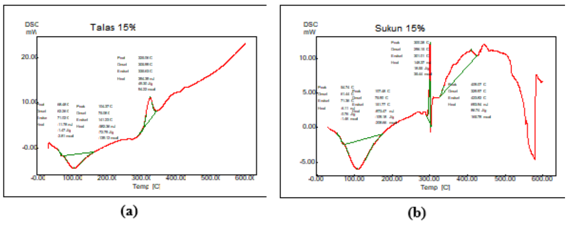

Figure 2: DSC thermograms of: (a) conventional rice, (b) rice analogue containing taro powder 15% (CS/CP/TP: 70/30/15).

Table 3: Characteristics of thermal properties of conventional rice compared to those of rice analogue containing 15% of taro powder.

	Temperature of Thermogram (°C)			
	Start	Peak	End	Heat (J/g)
Conventional rice	75.08 305.99	104.37 325.06	141.23 335.63	-72.79 49.30
Rice analogue containing 15% TP	75.90 329.97	107.48 409.07	151.77 423.82	-109.18 86.74

In general, both thermograph of conventional rice and rice analogue showed endothermic peak 75.08–151°C (due to water evaporation and melting of gelatinous phase) and exothermic peak 296.15-423.82°C (due to thermal decomposition), respectively. When compared to those of conventional rice, endothermic peak of rice analogue showed slightly increase temperature (104.37-107.48°C), but with higher heat capacity (-72.79 to -109.18 J/g). In addition, exothermic peak of rice analogue also showed increase decomposition temperature (325.06-409.07°C), and the heat capacity also higher (49.30-86.74 J/g). These phenomena were related to the higher fibre content of rice analogue, which is upto 26.13%, since the fibre may absorb more water and require more heat to decompose.

4 CONCLUSIONS

It was found that optimum composition of rice analogue (RA) with dissolution time close to that of CR was that with ratio of cassava starch (CS) over corn powder (CP): 70/30. It was shown that addition of TP increased DT of the RA samples, and therefore it was taken that the optimum composition with addition of TP with weight ratio: CS: CP: TP = 70 /30/15. Morphology of the RA grains showed rougher surfaces due to the natural fibre contents, whereas thermal analysis using DSC technique indicated that increase fibre contents also increase the melting and decomposition temperatures of the RAs slightly. Compared to those of conventional rice (CR), carbohydrate contents of rice analogues decreased from 78% to 60% and the fibre contents increase from 3 up to 18%, and the protein and total fat contents were also increase, therefore that the rice analogues (RA) are better for diet and diabetics menues.

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REFERENCES

Anggraini, T., Putri, V. J., Neswati, N., Yuliani, Y., (2016), Characteristics of Red Sweet Potato (Ipomea batatas) Analog Rice (SPAR) From The addition of Cassava Flour (Manihot utillisima) and Carrot (Daucus carota), International Journal on Advanced Science and Engineering Information Technology, Vol. 6, N0.5, ISSN: 2088-5334.

Budijanto, S., and Yuliana, N. D., (2015), Development of Rice Analog as a Food Diversification Vehicle in Indonesia, Journal of Developments in Sustainable Agriculture, 10: 7-14.

Ismail, H., Edyham, M. R., Wirjosentono, B., (2002), Bamboo fibre filled natural rubber composites: The effects of filler loading and bonding agent, Polymer Testing, 21(2), pp. 139-144.

Khaniya, A. A. L. W., Budijanto, S., (2016), Development of rice bran based rice analog, The 23th Three-University International Joint Seminar and Symposium 2016, Bogor Agricultural University, Indonesia.

Khairunnisa, K., Budijanto, S., and Sitanggang, A.B., (2017), Formulation of high protein rice analog made of cassava, maize starch, and soybean, Proceedings of the 24th Tri-University International Joint Seminar and Symposium 2017, Mie University, Japan, October 23 – October 27, 2017, Paper number: TRIU17FD01.

Mishra, A., Mishra, H. N., Rao, P. S. (2012), Preparation of Rice Analogues Using Extrusion Technology, International Journal of Food Science and Technology.

Tharise, N., Julianti, E., and Nurminah, M., (2014), Evaluation of physico-chemical and functional properties of composite flour from cassava, rice, potato, soybean and xanthan gum as alternative of wheat flour, International Food Research Journal, 21(4): 1641-1649.

Wirjosentono, B., Guritno, P., Ismail, H., (2004), Oil palm empty fruit bunch filled polypropylene composites, International Journal of Polymeric Materials and Polymeric Biomaterials, 53(4), pp. 295-306.