

Physicochemical Characteristics of Artificial Rice from Composite Flour: Modified Cassava Starch, *Canavalia ensiformis* and *Dioscorea esculenta*

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Abstract. Indonesia is the third largest country on the global paddy rice production and also considered as a rice importer. Even, Indonesia has the biggest per capita consumption of paddy rice (140 kg of paddy rice per person per year). Product diversification using local commodities. Artificial rice is potential to be developed as a new value product using different types of grains. It is one of appropriate solutions for reducing imported rice rate. Artificial rice was produced using high nutrition composite flours (modified cassava starch, corn, *Canavalian ensiformis*, and *Dioscorea esculenta*). This study consists of three main stages, preparation of composite flour, formulation, and artificial rice production using hot extruder capacity 10 kg/day. The objectives of this studies were to investigate some formulation in compare with commercial paddy rice. Artificial rice has been successfully conducted using prototype of hot extruder with the temperature 95°C. Physical analyses (color and water absorption) were carried out to artificial rice product and commercial paddy rice. Chemical analyses (nutrition and amylose content) of product will be also presented in this study. The best formulation of artificial rice was achieved in 80% modified cassava starch, 10% *Canavalian ensiformis*, and 10% *Dioscorea esculenta*, respectively.

1 Introduction

Artificial rice could be developed as a new value product using different types of grains with added nutrients and functionalities. The terms of artificial rice, enriched rice, or reformed rice were introduced by several authors [1-5]. The developed products could avoid deficiency in nutrients as compared to the natural rice without major changes in consumers' dietary habits. The main advantages could be the easy process of developing instant rice and the possibility of incorporating different nutrients with desired textural characteristics. In addition, it could be developed using wastes or byproducts with low cost and utilizing energy efficient process, such as extrusion [6].

Artificial rice can be obtained from carbohydrates sources, such as potatoes, tubers and cereals [7-9]. Modified cassava flour and *Dioscorea esculenta* have a high carbohydrate content of up to 90% thus could be alternative raw materials for artificial rice [10]. They are also easy to obtain, affordable price and have a capability to be used with another component for improving artificial rice physicochemical properties. Protein is a kind of nutrition which is very important for human growth. *Canavalia ensiformis* and corn can be developed into an preference food product because of its high protein content (23-27.6%) [11,12]. Yellow corn from corn indicates the existences of carotenoid 6.4-11.3 µg/g [11]. Utilizing composite flours from modified

cassava, corn, *Dioscorea esculenta*, and *Canavalia ensiformis* flour will meet the human nutrition needs (Figure 1).

In general, artificial rice production can be conducted using granulation method and extrusion method [8,9]. There are differences of gelatinization techniques and molding stages from these methods. Artificial rice has the shape of granules and oval using granulation and extrusion method, respectively [13]. A number of studies are reported on the development of artificial rice [1-4,6]. Based on the shortcomings from previous studies, this study focused on artificial rice production from composite flour from modified cassava starch, *Canavalia ensiformis* and *Dioscorea esculenta* using hot extrusion process. Innovation processes of artificial rice might be an appropriate alternative solution for Indonesia to produce high nutritional value and good physicochemical properties of imitative rice in compare with commercial paddy rice. The design and fabrication of hot extruder capacity 10 kg/day were conducted to produce artificial rice. Some formulations were investigated on proximate analysis, water absorption, amylose content, and color brightness properties in compare with commercial paddy rice (Rojolele).

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2 Material and Methods

2.1 Materials

The raw materials used in this study were composite flour from modified cassava starch, corn, *Canavalia ensiformis*, and *Dioscorea esculenta*. Skim milk, Gliserol Monostearat (GMS), salt, and oil were also involved in this study. Artificial rice was produced using hot extrusion as represented on Figure 2. The formulation of artificial rice was shown in Table 1.

2.2 Methods

The composite flours, skim milk, GMS, water, salt, and oil were mixed at 80-90°C for 20 minutes. This blend components were proceed on extruder to produce artificial rice. Products were immersed into boiled salt solution for 2 minutes, washed by water, and then dried at 60°C for 4 hours.

2.3 Analysis

Artificial rice products were analyzed for color brightness, water content, proximate properties (carbohydrate, protein, and fat content), water absorption, and amylose content. Color brightness and water content were analyzed using Minolta Chromameter CR-300 and oven. Protein, fat, and amylose content were tested using Kjedadhl, extraction, and iodo-iodi calorimetric method, respectively. Carbohydrate content followed by the difference method.

3 Result And Discussion

3.1 Proximate analysis

Table 2 represented the proximate analysis of artificial rice in compare with commercial paddy rice “Rojolele”. Water content of artificial rice ranged from 10.23 to 13.44%, which approached the moisture content of rice “Rojolele”. They also have met the water content standard by SNI 01-6128-2008 (max 14% wt). Rice moisture content of less than 14% (wt) could prevent the growth of mold thus could extend its shelf life [10]. Protein analysis of various formulation of artificial rice ranged from 4.77% to 7.75% (wt). This protein content was slightly below “Rojolele”. In general, fat content of artificial rice were range between 0.7%-2.05% (wt) and lower than “Rojolele”. Some case, formula 4 and 10, have a greater fat content in compare with commercial paddy rice “Rojolele” (Figure 2). Carbohydrate status in various compositions was 65-80% (wt) and similar with the content of “Rojolele” (77.11% wt).

3.2 Amylose content

Amylose content is one of the key parameters to determine the physical properties of rice. The

unbranched polymer of amylose has the very strong bond and difficult to digest. Thus, they have a strongly correlation with low glycemic indexed. Accordance on amylose content, rice can be classified into five categories, waxy (1-2%), very low (2-12%), low (12-20%), intermediate (20-25%), and high amylose content (25-33%) [14].

Figure 3 showed the amylose content of artificial rice ranged from 13.88 to 17.56%. This artificial rice included in low amylose group (12-20%), thus it will become sticky and shiny when it cooked [14]. However, the amylose content should not influence the level of people preferences due to their different appetite.

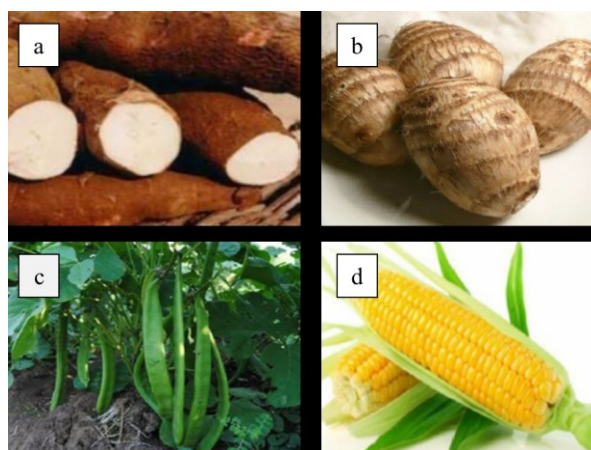


Fig. 1. Morphology of Cassava (a), *Dioscorea esculenta* (b), *Canavalia ensiformis* (c), and corn (d)

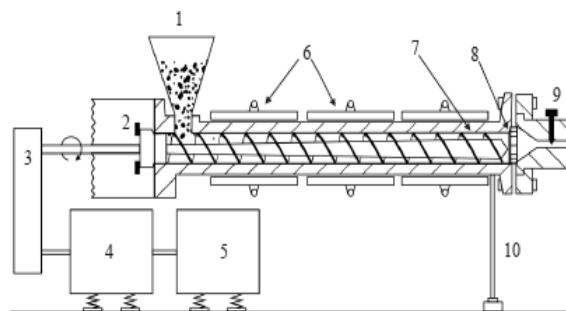


Fig. 2. Hot extrusion

3.3 Water absorption

Water absorption properties are one of the key parameters which influence the level of cooked rice. Table 4 represented the water content of artificial rice. Water absorption of artificial rice was 0.8 to 1.84 (Table 4). The average water absorption of rice in Indonesia was 2.5. Artificial rice had lower water absorption rate than ordinary rice, thus the fewer water will be needed to cook rice.

Table 1. The formulation of artificial rice from composite flour: modified cassava, *Canavalia ensiformis*, Corn and *Dioscorea esculenta* flour

Formulae	Modified starch	<i>Canavalia ensiformis</i>	Corn flour	<i>Dioscorea esculenta</i>
1	60	30	10	-
2	60	30	-	10
3	60	20	10	10
4	60	10	20	10
5	60	10	10	20
6	60	30	10	-
7	60	30	-	10
8	60	20	10	10
9	60	10	20	10
10	60	10	10	20
11	60	30	10	-
12	60	30	-	10

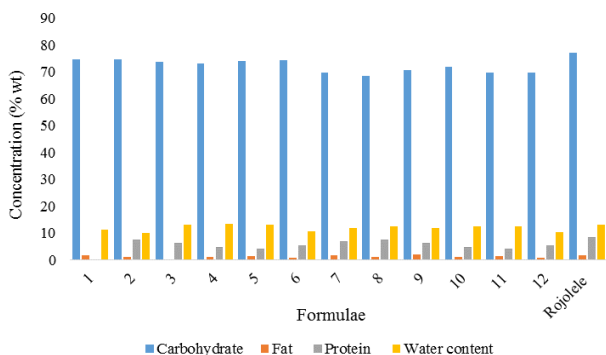


Fig. 2. Proximate analysis of artificial rice

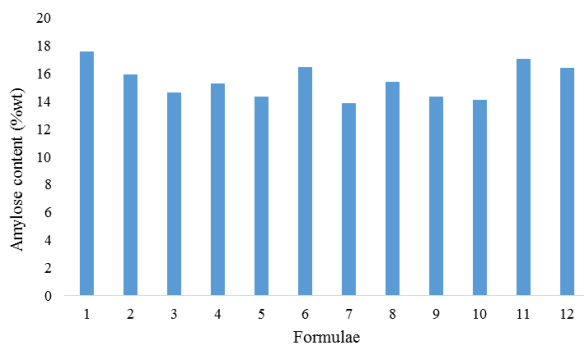


Fig. 3. Amylose content of artificial rice

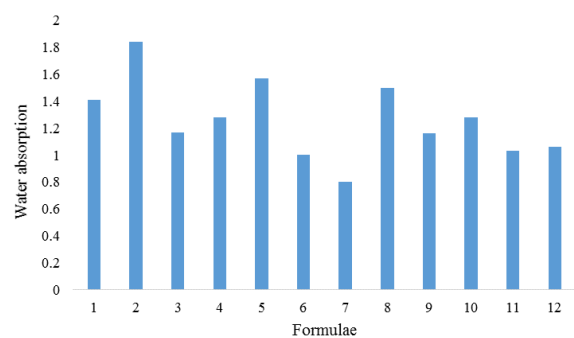


Fig. 4. Water absorption of artificial rice

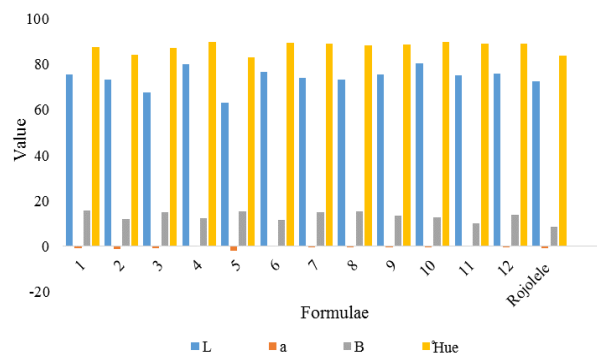


Fig. 4. Color analysis of artificial rice

3.4 Color analysis

Color measurement has three parameters to determine the quantity of color (L, a, and b). “L” is indicate lightness, “a” is the red or green coordinate, and “b” is the yellow or blue coordinate. Figure 4 and 5 showed the color analyzes and products of artificial rice. It indicates that all samples have a degree of yellow hue and the brightness range 63.29 to 80.45. When compared with Rojolele rice, rice analog portion has a degree of hue and brightness level that approximates the color of rice Rojolele. The brightness levels approaching rice is expected to increase consumer acceptance of analog rice.



Fig. 5. Artificial rice from modified cassava starch, *Canavalian ensiformis*, and *Dioscorea esculent*

4 Conclusion

The best formula of artificial rice contains 12.51% water, carbohydrates 71.94%, 4.86% protein and 1.1% fat. It also had 14.09% amylose content and belongs to low amylose groups. Starch modification process should be optimized to improve the amylose content therefore the rice becomes fluffier. Optimization of operating conditions is also needed at extrusion and cutting stage. A sharp knife is required so that the shape of the product will be more uniform. In fact, the artificial rice is expected to be alternative products non paddy rice which could reduce people's reliance on rice and might be used as a staple food in Indonesia

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