Macronutrient Profile of Analog Rice Based on Cornstarch, Modified Cassava Flour, and Suweg Flour

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Abstract. Analog rice is a food diversification product made from raw materials of various flours as an alternative to paddy rice which is produced from tubers and cereals which have a chemical content similar to rice. Cornstarch, modified cassava flour (Manihot esculenta), and suweg flour were chosen as the ingredients of analog rice due to the macronutrient content of carbohydrates, protein, fat which expect might improve the nutritional content of the analog rice. The aim of this study was to determine the macronutrient levels of analog rice of cornstarch, mocaf, and suweg flour. Research stages: the production of analog rice using formula cornflour:mocaf 1:1 and the addition of suweg flour of 0%, 5%, 10%, 15% and 20%. Then the ingridients was mixed with water and stirring. Preconditioning processed were done by steaming for 5 minutes at 90 ºC. Therefore the formula were shaping manually in order to produce rice grains. The analog rice were drying in a cabinet dryer for 5 hours at 60°C. The chemical analysis, among starch content, amylose content, amylopectin content, protein content and lipid content using AOAC 2003.06-2006. The results of the this study showed that the analog rice based on cornstarch, mocaf, and the addition of suweg flour had starch content range from 82.06 to 84.06%, amylose content ranged from 26.91 to 28.53, amylopectin content ranged from 54.37 to 56.12%, protein content ranged from 0. .46 to 1.25%, and lipid content ranged from 0.02 to 0.43%. The result concluding that the higher addition of suweg flour on rice analog might increase the starch, amylopectine, protein and fat content while decrease the amylose content. Therefore, cornstarch, modified cassava flour and suweg flour are potentially used as analog rice raw materials.
Keywords: rice ; analog; macronutrien ; carbohidrat ; protein ; lipid.

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1 Introduction

Food diversification using local raw materials are a way to develop food security. The dependence on one of the staple food ingredients can lead to the weaknesses of food security. The data of rice consumption as a staple food contributes energy per capita to more than 54% of the Indonesian consumption, and consumption other than rice only contributes around 5%. In general, the Indonesian society have a strong depend on rice consumption as a staple food. Creating rice-like products using ingredients from other carbohydrate sources will increase the local food consumption and support Indonesia's food security. It is hoped that staple foods can contribute nutrients not only carbohydrates but also sufficient protein and fat as macronutrients needed by the body in an effort to fulfill balanced nutrition.

Analog rice is a food diversification product made from various flour as an alternative of rice (Pudjihastuti, et al., 2019). The shape and texture of analog rice are similar to general rice but made by extrusion processes using some local food ingredients such as tubers and cereals (Winarti, et al., 2018). Analog rice is produced using some ingredients that contained chemical compositions similar to rice. The characteristics of analog rice has to be similar better than general rice, it depends on the materials used and the processing itself (Adelina, et al., 2019). Generally, paddy rice had 79% starch, 24.60% amylose, 49.10 amylopectin%, 0.19% protein and 0.7% fat (Sari et al., 2020)

Based on research by Paramita (2011), it was found that the average carbohydrate content of some flours from local tubers was >48%. In addition, cereals also contain lots of fiber, nutrients that the body needs, such as food, vitamins, minerals, and especially as a source of vegetable protein. Tubers are not included as food sources of protein because the protein content in them is relatively low. The nutritional content of analog rice with the use of local food as a source of carbohydrates is not much different or even exceeds the nutritional content of paddy rice. Cassava tubers have been widely used and modified, one of which is to make flour such as mocaf (modified cassava flour). Mocaf is flour modified by cassava cells which is processed through fermentation. Mocaf is what is used as the basic ingredient for making analog rice. Mocaf has a high amylose content, relatively low protein and does not contain gluten (Damayanti et al., 2014). The amylose content which is high enough in flour can make analog rice have a solid and strong structure so that starch molecules do not absorb water into it (Rosmeri and Bella, 2013). Cornstarch is a source of carbohydrates which is processed from corn kernels so that it contains starch from the endosperm of corn kernels. Starch consists of at least three main components, namely amylose, amylopectin and intermediate materials such as protein and fat. Maizena has a proportion of amylose and amylopectin around 25:75. According to SNI (1995) regarding cornstarch, the maximum fiber content in cornstarch is 1.5%. This corn starch has the ability to form a thick gel so that it can adjust the texture and properties of the gel. The process of forming the gel is through gelatinization, which is a process of change due to swelling of starch granules and cannot return to its original shape (Ola et al., 2017). In this case cornstarch plays a role in improving the texture of the analog rice that is made. In the manufacture of analog rice made from flour, it produces rice which tends to have a texture that is easily brittle as a result of the absence of a binding agent or material that strengthens the bond between flours so that it can produce analog rice characteristics that are close to paddy rice.

A local commodity that can be utilized for strengthens agent in analog rice production is suweg. The previous research by Santoso, et al (2020) determined that konjac flour (Amorphophallus oncophyllus) and coconut flour (Cocos nucifera L) to might function as

the main ingredients for analog rice. The high of glucomannan content in konjac tubers have potentially used as analog rice or shirataki. Glucomannan is a hemicellulose-type polysaccharide consisting of galactose, glucose, and mannose chains. Glucomannan has a fairly high level of water absorption so that it can be used as a binder, thickener and emulsifier (Sakaroni et al., 2019). The advantage of konjac tubers is its glucomannan content has benefit effect on human health. Glucomannan is a polysaccharide that water soluble, high in fiber and high molecular weight. The food high fiber content is good for consume by diabetics because it only causes an increases in blood lipid while decreases in blood sugar (Tester and Al-Ghazzewi, 2017).

The utilization of konjac tubers as an ingredient of analog rice has been widely developed. Therefore, this research was conducted to develop another local flour tubers that have a potential as an analog rice ingredients. Suweg bulbs are one of the local commodities that grow wild in Indonesia. However, suweg still is not widely known, thus its utilization and processing has not been optimal. Suweg tuber has a high content of glucomannan and other fiber content which has high potential as an ingredient in analog rice production. The ingredients of 100 g of suweg tuber are 1 g protein, 0.1 g fat, 15.7 g carbohydrates, 4.2 g iron, 62 mg calcium, 5 mg ascorbic acid and 0.07 mg thiamine. In addition, suweg has a starch content of 18.44% (Lianah et al., 2018).

Cornstarch, modified cassava flour (Manihot esculenta), and suweg flour were chosen as ingredients for making rice analogues to increase the content of fiber, carbohydrates and other nutrients. The formula also expected to improve the nutritional content of rice. However, information regarding the addition of suweg flour to analog rice is still limited. It is necessary to study the rice macroprotein analog based on cornstarch, modified cassava flour (Manihot esculenta), and suweg flour (Amorphopallus campanulatusI). The purpose of this study was to determine the macronutrient levels of rice analogous of cornstarch, modified cassava flour using several various addition of suweg flour.

2 Research methods

2.1 Materials

The ingredients used to make analog rice include commercial cornstarch ('Maizenaku', from Ega Food), commercial mocaf flour ('Mocafine' comes from the manufacturer Rumah Mocaf Banjanegara), suweg flour which has been purified for calcium oxalate content and obtained from the producer. in Sleman Regency, Yogyakarta, as well as commercial mineral water ('Le minerale', derived from PT. Tirta Fresindo Jaya).

The equipment used in this study were desiccator (NORMAX), electric stove (Hi-cook), cabinet drying (Steel co ED 200), oven (Memmert SN 55), analytical balance (Radwag), centrifuge (onemed), erlenmeyer (pyrex), filter paper (Whatman), measuring cup, tube (pyrex), water bath (memmert), soxhlet (pyrex), fat flask (pyrex), and condenser (pyrex).

2.2 Research stages

First step of making analog rice are weighed the ingredients (mocaf flour, cornstarch, suweg flour). The formula used for mocaf flour: cornstarch was 1:1 with various suweg flour of 0%, 5%, 10%, 15% and 20 % of the total dough. Then water was added to mix all the ingredients in the basin. Pregelatinitation-condition : the homogenous dough was steamed

for 5 minutes at 90 ± 5°C. After steaming, the dough was put into a manual shaper to produce the rice grains. The analog rice dough was put into a baking dish and dried in a cabinet dryer at 60°C for 5 hours. The dry analog rice was ready to be analyzed.

2.3 Analysis

Analog rice was analyzed for the chemical macronutrients including starch, amylose, amylopectin, protein, and fat content. Starch content, amylose content, amylopectin content, protein content and fat content using AOAC 2003.06-2006. The research method used was one-factor Completely Randomized Design, which variations suweg flour addition of 5%, 10%, 15%, 20% on the analog rice of cornstarch and mocaf. Statistical analysis used one way Analysis of Variance (ANOVA) with a significance level of 5% using Software IBM SPSS 26 to determine the effect of the formulation on physical and chemical characteristics. If there is a significant difference, then the DMRT were tested.

3 Result and discussion

3.1 Starch, amylose and amylopectin levels

Rice analogue based on cornstarch, mocaf, addition of suweg flour has a significant effect on starch content. It is known that the starch content of cornstarch-based analog rice, mocaf with the addition of suweg flour has a value between 82.06 to 84.35. The addition of suweg flour increased the starch content of the analog rice. The result on Table 1, showed the analog rice had higher starch content which 80.95% - 84.35% compared to the white rice IR 64 which 73.70%. The higher starch content is influenced by the higher starch content of flours as the material of the analog rice. The flour involved are mocaf flour had 87% of starch (Winarti et al, 2018), cornstarch had 72.4% of starch (Hapsari, 2008), and suweg flour had 88.7 of starch (Hasbullah & Umiyati, 2017).

Table 1. Starch, amylose and amylopectin content of rice analog based on cornstarch flour, mocaf with various concentration of suweg flour

	Starch (%)	**Amylose (%)**	**Amylopectin (%)**	**References**
White rice IR 64	73,70	24.60	49.10	Loebis et al., 2017
Suweg flour 0%	80,95 ± 0,11^{e}	29,48 ± 0,3^{a}	51,46 ± 0,27^{d}	This study
Suweg flour 5%	84,35 ± 0,14^{a}	28,53 ± 0,03^{b}	55,83 ± 0,15^{a}	This study
Suweg flour 10%	82,06 ± 0,22^{d}	27,06 ± 0,19^{b}	54,99 ± 0,16^{b}	This study
Suweg flour 15%	82,57 ± 0,22^{c}	28,21 ± 0,13^{b}	54,37 ± 0,3^{c}	This study
Suweg flour 20%	83,03 ± 0,22^{b}	26,91 ± 0,15^{c}	56,12 ± 0,22^{a}	This study

*Data with mean ± SD; n = 3;

Starch is one type of carbohydrate macronutrient, a type of polysaccharide. Apart from being one of the macronutrient compounds of carbohydrates, starch has functional properties related to the texture of a food ingredient. The high content of starch would influence the water absorption of rice because of the presence of amylopectin molecules that are reactive to water molecules and results in more and more water being absorbed into the food (Kalungga, 2021). The ability of starch to bind water is influenced by free hydroxyl groups. The more hydroxyl groups, the more water bound to starch and increases the rehydration power of rice (Handayani et al, 2017). Starch consists of two components,

namely amylose and amylopectin. Amylose and amylopectin provide solubility properties and the degree of gelatinization of starch. The higher amylose content, the drier and less sticky the starch would be (Nisah, 2017).

The results showed that analog rice with the addition of suweg flour had a significant effect on amylose levels. The addition of suweg flour reduced the amylose content in analog rice based on cornstarch and mocaf. The amylose content of analog rice were ranged from 26.91% to 29.48%. Rice is divided into several types based on its amylose content which are high amylose levels (25%-33%), moderate amylose levels (20-25%), and low amylose levels (12-20%), very low amylose levels (2-12%) and glutinous rice (1-2%) (Denardin et al., 2012). The higher amylose content of rice would made the rice become harder. White rice IR 64 had amylose content of 24.60% which is moderate amylose levels. The high levels of amylose on rice analog might be influenced by the high levels of amylose content of mocaf flour which > 25% (Raharja et al., 2017). Therefore, this analog rice needed a further treatment to decrease the amylose content as in moderate levels. Otherwise, analog rice in this study had similar amylose content with taro analog rice which around 28.04% (Lestari et al., 2008).

The amylopectin of analog rice based on cornstarch and mocaf four had ranged from 51.46% to 56.12%. The results were determined that the higher suweg flour addition, the higher amylopectin content on analog rice. The highest analog rice amylopectin content was obtained by analog rice with 20% suweg flour. The higher amylopectin of analog rice might be influence by the high level of amylopectin on suweg which is 75.5% (Septiani et al., 2015). Amylopectin is a polysaccharide branch, so it breaks easily through the hydrolysis process thus made effect on the fluffier structure of rice (Shannon et al., 2009).

3.2 Protein and fat

The production analog rice is expected to overcome the needs of rice as staple food as well as carbohydrate source. Analog rice is expected to contribute macronutrients like those found in paddy rice. One of the macronutrients contained in rice is protein of 6.6 grams per 100 grams. In this analog rice study based on cornstarch, mocaf, and the addition of suweg flour, most of which are sources of carbohydrates. The result of protein and fat content of analog rice gets protein were shown in the Table 2.

Corn and cassava starches may be consumed by those with celiac disease because had no gluten (Sanchez et a., 2002)

Table 2. Protein and fat content of rice analogues based on cornstarch and mocaf with various concentration of suweg flour

	Protein (%)	**Fat (%)**	**References**
White rice IR 64	0,19	0,70	Sari et al., 2020
Suweg flour 0%	$0,46^{c} \pm 0,10$	$0,02 \pm 0,0^{b}$	This study
Suweg flour 5%	$0,61^{c} \pm 0,06$	$0,24^{ab} \pm 0,01$	This study
Suweg flour 10%	$0,89^{b} \pm 0,09$	$0,26^{ab} \pm 0,01$	This study
Suweg flour 15%	$1,08^{ab} \pm 0,06$	$0,27^{ab} \pm 0,01$	This study
Suweg flour 20%	$1,25^{ab} \pm 0,03$	$0,43^{a} \pm 0,14$	This study

*Data with mean ± SD; n = 3

In this study, the protein content of analog rice was higher from protein of rice which had 0.70%. According to Indonesian Food Composition Data (Ministry of Health, 2018) the protein content of mocaf flour is high as well as 1.2 grams per 100 grams. Aprilia N.P.R.D.,

et al, (2019) also stated that mocaf had high protein content which 1.38%. According to Indonesian Food Composition, Cornstarch flour had protein content of 0.3 grams per 100 grams (Vivi & Joni, 2015). The addition of suweg flour to also influence the incerasing og the protein content on the analog rice. The protein content of this analog rice were ranged from 0.46% - 1.25%. Otherwise, this protein content is still low than other analog rice protein. Enny Hawani et al., (2017) found that analog rice using rice flour and mocaf obtained 2.09% protein, 2.05% fat, and 46.47% carbohydrates. High protein levels were also found in the use of 15% cornstarch, 55% taro flour, and 30% sweet potato flour in analog rice studies which had 1.78 grams of protein (Srihari E, et al, 2016). In addition, protein content of analog rice in this study had similar to analogue rice from mocaf and seaweed which had produced 0.86% protein, and 0.15% fat (Agusman A, et al., 2014).

The fat content of the analog rice in this study was ranged from 0.02% to 0.43%. This fat content is lower than rice which had 0.7% (Table 2). Low-fat analog rice is good for a low-calorie diet, especially for people with obesity, heart disease, and diabetes mellitus because it doesn't produce excessive calories and has low glucose levels. Research on rice analogues of a combination of seaweed, mocaf and sago also produced low fat content, namely 0.22-0.77% (Finirsa M.A, et al., 2022). The fat content of analog rice in Diniyah's study, et al. (2016) which is 0.716-0.725%. The function of the presence of fat in analog rice is to improve the physical structure such as swelling power and facilitate the molding process of the dough (Setiawati, et al, 2014) Analog rice which has a low fat content is more advantageous during storage because oxidation does not occur easily thereby preventing rancidity during long-term storage long. In addition, the higher concentration of suweg flour in this study increased the protein and fat content of the analog rice. The analog rice with 20% suweg flour shown highest protein and fat content.

4 Conclusions

The macronutrient content of rice is analogous to cornstarch, mocaf with a 1:1 formula and the addition of suweg flour 0%, 5%, 10%, 15%, and 20% produces a starch content of 82.06-84.06%, amylose content of 26, 91-28.53%, amylopectin 54.37-56.12%, protein content 0.46-1.25%, and fat content 0.02-0.43%. Further research are needed to develop the better quality of rice analog based on cornstarch, mocaf flour with 20% of suweg flour to get a lower amylose content, higher protein content and higher fat content.

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