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Physical and Nutritional Properties of Analog Rice Based on Modified Cassava Flour and Modified Suweg Flour

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ABSTRACT: Analog rice can be developed from modified cassava flour (MOCAF) and modified Suweg *(Amorphophallus campanulatus)* flour (MSF). This research aims to study the physical and nutritional characteristics of analog rice made from a combination of MOCAF and MSF. Analog rice was formulated from both flour with MOCAF: MSF ratios (w/w), among others (100:0), (90:10), (80:20), (70:30), (60:40), and (50:50). The dough was printed in an extruder and dried so that it becomes analog rice. The results showed that changes in the MOCAF: MSF ratio cause significant changes to the physical characteristics and nutrients of analog rice. Interestingly, the increasing amount of MSF in the formulation causes the weight of one hundred grains, bulk density, protein, water, ash, and crude fiber in analog rice to rise. However, water absorption, color brightness, fat, and carbohydrates in analog rice was fell 54%, 17%, 23%, 4%, respectively. Therefore, analog rice produced from MOCAF and MSF can be a source of food to maintain the nation's food security.

Keywords: *Artificial rice; Manihot esculenta; Elephant foot yam; Amorphophallus campanulatus; Extruder*

INTRODUCTION

Technological developments have encouraged researchers to create analog rice. Analog rice is developed from raw materials for carbohydrate sources to be printed into a shape similar to rice grains (Budijanto & Yuliyanti, 2012; Mishra et al., 2012). Previous studies have successfully developed analog rice made from raw materials such as MOCAF and tofu waste flour (Yuwono & Zulfiah, 2015), sorghum and spices (Rasyid et al., 2016), white corn (Noviasari et al., 2013), and rice flour rupture (Yogeshwari et al., 2019).

Carbohydrate sources that can be used as analog rice can be derived from tubers. Some types of tubers that have the potential to be developed include cassava and suweg. Cassava production in Indonesia reaches 24 million tons per year (BPS, 2016). Cassava has been developed into MOCAF which can be used in various food product applications (Rosmeri & Monica, 2013; Subagio, 2008). MOCAF has a starch and amylopectin content of 78.45% and 67.33%, respectively (Hidayat et al., 2009). MOCAF application in food products will produce products with softer and crumb textures (Rahmadian, 2018) that will becomes an obstacle when developed into analog rice.

One effort to overcome this problem is by mixing it with Suweg (*Amorphophallus campanulatus*) flour. The addition of Suweg flour in the formulation of cookies proved to be able to improve the texture to be more robust (Darmawan, 2011). Suweg flour has a starch content of around 88.7% (Hasbullah & Umiyati, 2017c). In addition, it has a high content of food fiber (Faridah, 2005). Suweg flour also contains glucomannan. The interaction between glucomannan and starch causes the texture of the cookies to be stronger (Yuwono et al., 2013), and this properties is expected to be built in the matrix of analog rice. Zhang et al. (2020) reported that konjac glucomannan interacted with wheat starch and contributed to a more compact starch structure.

Nevertheless, Suweg flour still has weaknesses that are a brownish color and a very strong characteristic aroma (Hasbullah & Umiyati, 2017a; Nurdyansyah et al., 2016; Hasbullah & Umiyati, 2017b). Efforts have been made to overcome them modifications in the process. Modified suweg flour (MSF) has a brighter color and a very low aroma of suweg compared unmodified suweg flour (Syah et al., 2020). Regarding previous study, to produce analog rice from MSF is needed combining with MOCAF. MOCAF will become the main materials that provide amylose and amylopectin sources and also has a cheaper price, while MSF has glucomannan that can improve the properties of analog rice. Thus, combining MOCAF and MSF in making analog rice will provide a better extent of the characteristics and nutritional value of analog rice.

MATERIALS AND METHODS

Material and Tools

The main ingredients used to make analog rice consisted of cassava obtained from Grobogan, Central Java, suweg tubers from Ungaran, Central Java, BimoCF starters (Balai PATP, Indonesian Agency for Agricultural Research and Development), and CMC (PT. Chemifin Jaya Utama). The chemical used H_2SO_4 (Merck), NaOH (Merck), TiO_2 (Merck), $Na_2S_2O_3$ (Merck), H_3BO_3 (Merck), aquadest, K_2SO_4 (Merck), alcohol, hexane (Merck), Kjeldahl tablets (Merck), and Mr-BCG indicator was the chemical analysis standard (p.a.).

The tools used include analog rice extruder (Screw extruder BPPT), cabinet dryer (Hot air cabinet CV. Wangdi Wusono), glassware, oven (UF 30, Memmert), furnace Thermo Scientific FD 1540M (Thermolyne), Soxhlet (Pyrex), Kjeldahl complete system basic Behr (Behrotest), Chroma Meter (FRU, Japan).

Experiment Design and Data Analysis

This study was used a Completely Randomized Design with MOCAF: modified suweg flour (MSF) ratios (w/w) including (100:0), (90:10), (80:20), (70:30), (60:40), and (50:50). Each treatment was repeated three times. The data were analyzed by ANOVA continued posthoc using Duncan in the SPSS 2.1 program. Significant differences were stated at $p<0.05$. Data were presented with standard deviations.

Modified Cassava Flour (MOCAF) Preparation

MOCAF flour preparation refers to Sulistyo & Nakahara (2014). Cassava was selected from the harvest age of ±20 months. Cassava peeled manually and sliced with a thickness of ±3 mm using slicer machine (PRJ 200V, Maksindo). Fermentation was carried out on 100 kg of cassava slices in 2 liters of BimoCF solution (1 g/L) for 24 hours, room temperature, open container. Then rinse with water until clean and drain in spinner machine (SPIN-5 Agrowindo) for 1 hour. After that it was dried in the sun for ±17 hours to dry. Dry chips were ground using a dry mill machine (HMR-50-SS, Agrowindo) and sieved 100 mesh.

Modified Suweg Flour (MSF) Preparation

MSF preparation refers to Muhammad et al. (2021) and Syah et al. (2020). Suweg harvested from age of ±2 years. Suweg tubers were washed and peeled. Then slice 3 mm and soaked in sodium metabisulfite solution (4%/L) for 3 hours. Then washed and drained for one hour. Fermentation was carried out with BimoCF solution (1 g/L) for 18 hours, room temperature, open container. Wet chips were drained for 30 minutes, pressed, and dried in a drying cabinet at ±50 °C for 22 hours. Dry chips were milled (Disk Mill AGC 21, Maksindo) and sieved 60 mesh.

Analog Rice Preparation

Analog rice was prepared by referring to Yuwono & Zulfiah (2015). Composite flour from MOCAF and MSF according to the treatment as much as 500 g was homogenized with 15 g CMC, and 150 ml water. The dough was steamed at 100 °C for 20 minutes. Then printed in an extruder (Screw extruder BPPT) at 70 ºC. Drying in the sun with temperatures ranging from 37-45 °C for 18 hours.

Samples Analysis

The physical analysis consists of yield (Widara, 2012), bulk density (Syah et al., 2022), the weight of 100 grains (Widara, 2012), water absorption (Dewi, 2008), and color (L*, a*, b*) (DeMan, 1999). The yield was measured by comparing the weight of analog rice compared to the raw material. Bulk density was measured by comparing the weight of analog rice at a given volume. The color was measured with a Chroma Meter (FRU, Japan) to get the values of lightness (L*), redness-greenness (a*), and yellowness-blueness (b*).

Analysis of nutritional value consisted of moisture content, ash content, fat content, protein content, carbohydrate content, and crude fiber content (AOAC, 2005). Moisture and ash content using thermogravimetric. Fat content was analyzed with Soxhlet Extractor. Protein content using micro Kjeldahl. Carbohydrate levels were measured differently. Crude fiber content was measured by the acid-base washing method.

RESULT AND DISCUSSION

Physical Characteristics of Analog Rice

Table 1. Physical Characteristic of Analog Rice

MOCAF:MSF	Yield (%)	Weight of 100 grain (g)	Bulk density (g/ml)	Water absorption (%)
100:0	68.46±2.73^{a}	1.39±0.08^{a}	0.61±0.01^{a}	170.97±2.22^{e}
90:10	69.60±3.09^{a}	2.00±0.03^{b}	0.62±0.01^{ab}	149.00±5.75^{d}
80:20	70.92±2.36^{a}	1.99±0.07^{b}	0.64±0.01^{ab}	129.61±5.44^{c}
70:30	71.21±1.11^{a}	2.15±0.06^{c}	0.63±0.02^{bc}	110.68±5.12^{b}
60:40	69.92±3.37^{a}	2.26±0.02^{c}	0.64±0.01^{bc}	104.52±2.78^{b}
50:50	66.75±1.75^{a}	2.46±0.06^{d}	0.66±0.01^{c}	79.38±4.02^{a}

The different letter notations in the same column show significant differences ($p<0.05$). MOCAF, Modified Cassava Flour; MSF, Modified Suweg Flour.

The difference in the ratio of MOCAF and MSF did not have a significant effect on yield (Table 1) because the total weight of flour used as raw material was the same. The yield of analog rice is quite low, range between 66.75 and 71.21%. The yield of analog rice was lower than the yield of analog rice mocaf and seaweed that is 99% (Agusman et al., 2014). The yield can be affected by the rice printing process. Some of the dough probably sticks inside of the extruder, so it does not come out into analog rice. However, it does not cause a significant difference in yield. This corresponds to the analog rice yields of corn and kidney beans made by Aini et al. (2019).

The weight of 100 analog rice grains showed a tendency to increase with the increasing number of MSF in the MOCAF & MSF ratio (Table 1). Statistical results show a significant increase in weight. This was possible because the MSF fiber content (2.46%) was higher than MOCAF (1.74%) (Syah et al., 2020; Hidayat et al., 2009). In addition, the particle size of flour might influence the weight of 100 analog rice grains. MSF was sieved at 60 mesh size so it has a larger particle size than MOCAF which sieved 100 mesh.

Bulk density analog rice showed a significant increase with increasing MSF in the MOCAF & MSF ratio (Table 1). This was possible due to the larger MSF particle size than MOCAF. In addition, MSF crude fiber (2.46%) and ash (3.03%) content were higher than MOCAF (1.37% and 1.37%, respectively) (Syah et al., 2020; Omowonuola et al., 2017). The bulk density of analog rice was greater than analog rice made from modified sago starch (0.49 g/ml) (Sede et al., 2015). However, this analog rice has a smaller bulk density than analog rice made from seaweed (1.51-1.61 g/ml) and IR 64 rice (0.79 g/ml) (Setiawati et al., 2014; Indrasari, 2008).

Analog rice water absorption has a significant decrease with the increasing number of MSF in the MOCAF & MSF ratio (Table 1) ($p< 0.05$). Water absorption was closely related to the amount of water needed for starch gelatinization, starch granule composition, and physical properties of starch after reacting with water (Yazid et al., 2018). Water absorpsion is influenced by the presence of hydrophilic constituents such as polysaccharides of the starch (Syah et al., 2022). Starch granules are consisted of amorphous and crystalline regions. The amorphous zone is formed by interaction between amylose and amylopectin branches that less ordered, while the crystalline region is attributed to the formation of double helices among amylopectin chains that is more compact. Native granules of the starch will swell due to the diffusion and absorption of water in the granule amorphous regions in an aqueous medium at low temperature (Donmez et al., 2021). In this recent study, the increase in starch content of analog rice may make it easier to absorb water because the amount of starch that is reactive to water was increasing (Harper, 2019), thus causing more water to be absorbed. MSF starch (77.64%) levels were lower than MOCAF (78.45–88.61%)(Putri et al., 2022; Supadmi et al., 2016; Syah et al., 2020; Wahjuningsih & Susanti et al., 2018). So, it was causing water absorption which decreases with increasing of MSF. Furthermore, Supadmi et al. (2016) reported that the amylose content of MOCAF reached 31.91% more than MSF that only 30.24%. It implies that the amorphous region of MOCAF that absorbs more water is higher than MSF. Although, the water absorption value of analog rice is still lower than IR 64 rice, reaching 295%(Basito, 2010).

The color lightness (L*) of analog rice showed a significant decrease with increasing MSF (Table 2) ($p<0.05$). This was because MSF has a lower color lightness (L*) (76.87) than MOCAF (91.53) (Syah et al., 2020; Supadmi et al., 2016). The brown color on MSF was possible due to enzymatic browning where the oxidation of phenol compounds contained in the enzyme-catalyzed by phenolase(Richana & Sunarti, 2004). The analog rice color lightness of this study was higher than MOCAF analog rice substituted with tofu waste (59.75) and lower than rice (80.54) (Yuwono & Zulfiah, 2015; Noviasari et al., 2013).

The a* value of analog rice increased significantly with increasing MSF (Table 2) ($p<0.05$). This shows that the reddish color of analog rice was increasing with the increasing number of MSF in analog rice. This phenomenon was possibly related to the reddish color found in MSF which reaches 6.29(Syah et al., 2020). The a* value of analog rice in this study was still lower than analog rice made from soybean flour combined with oyek flour (9.35) and IR 64 rice (5.65) (Kanetro et al., 2017; Setiyaningsih, 2008).

The value of b* analog rice fluctuates and tends not to change significantly (Table 2) ($p<0.05$). This indicates that the yellow discoloration due to the addition of MSF did not have a major effect on analog rice. This insignificant change was thought to be related to the b* value of MSF 8.65(Syah et al., 2020). This analog rice has a b* value equivalent to analog rice made from MOCAF and tofu waste 10.68, but still lower than analog rice made from soy flour and oyek flour 18.10 (Yuwono & Zulfiah, 2015;Kanetro et al., 2017).

Tabel 2. Color Characteristic of Analog Rice

MOCAF:MSF	Lightness (L*)	a*	b*
100:0	65.75 ± 0.11^{d}	2.39 ± 0.05^{a}	11.22 ± 0.18^{b}
90:10	64.49 ± 0.48^{cd}	2.88 ± 0.04^{b}	10.19 ± 0.19^{a}
80:20	63.52 ± 0.20^{c}	3.74 ± 0.21^{c}	10.97 ± 0.52^{b}
70:30	57.85 ± 1.04^{b}	3.83 ± 0.02^{c}	12.94 ± 0.06^{c}
60:40	56.73 ± 0.70^{b}	4.43 ± 0.08^{d}	11.29 ± 0.05^{b}
50:50	54.56 ± 0.60^{a}	3.98 ± 0.07^{c}	11.12 ± 0.13^{b}

The different letter notations in the same column show significant differences ($p<0.05$). MOCAF, Modified Cassava Flour; MSF, Modified Suweg Flour.

Physical Characteristics of Analog Rice

Nutrient content in the analog rice was indicated by the presence of protein, fat, carbohydrates, ash, moisture, and crude fiber. In the recent study, the analog rice moisture content will increase significantly with the increasing proportion of MSF in the formulation (Table 3) ($p<0.05$). This result implies that the more MSF flour in the formulation of the analog rice, the better water holding capacity of the composite flours along drying process. It also describes that the composite flour of MOCAF and MSF can interact with each other to build a better dought matrix in the holding of water, even though no investigations about it, yet. This analog rice moisture content was the same as analog rice made from MOCAF and tofu waste (8%), but still lower than analog rice from MOCAF and cornflour (11%), and IR rice 64 (10.8%) (Yuwono & Zulfiah, 2015; Diniyah et al., 2016;Setiyaningsih, 2008).

Table 3. Nutrient Content of Analog Rice

MOCAF:MSF	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Carbohydrate (%)
100:0	8.00 ± 0.07^{a}	0.78 ± 0.09^{a}	8.83 ± 0.26^{c}	0.82 ± 0.03^{a}	79.98 ± 0.00^{d}
90:10	8.26 ± 0.08^{b}	1.08 ± 0.00^{b}	8.51 ± 0.19^{c}	1.40 ± 0.08^{b}	78.45 ± 0.16^{c}
80:20	8.26 ± 0.08^{b}	1.11 ± 0.01^{b}	8.31 ± 0.56^{c}	1.53 ± 0.04^{c}	78.59 ± 0.09^{c}
70:30	8.27 ± 0.02^{b}	1.11 ± 0.00^{b}	7.86 ± 0.34^{b}	2.24 ± 0.04^{d}	77.95 ± 0.09^{bc}
60:40	8.51 ± 0.00^{c}	1.22 ± 0.04^{c}	6.97 ± 0.15^{ab}	2.80 ± 0.08^{e}	77.75 ± 0.37^{b}
50:50	8.59 ± 0.01^{c}	1.33 ± 0.01^{d}	6.83 ± 0.50^{a}	3.56 ± 0.07^{f}	77.00 ± 0.45^{a}

The different letter notations in the same column show significant differences ($p<0.05$). MOCAF, Modified Cassava Flour; MSF, Modified Suweg Flour.

Analog rice ash content increased significantly with an increasing number of MSF (Table 3) ($p<0.05$). This was possible because the ash content in MSF (3%) was higher than MOCAF 0.9-1.3% (Syah et al., 2020; Omowonuola et al., 2017; Kasaye et al., 2018). Ash content shows the number of minerals contained in the material(Bhat & Sridhar, 2008). Ash content in analog rice was higher than analog rice made from MOCAF and cornflour (0.69%), and higher than IR 64 rice (0.56%)(Diniyah et al., 2016;Setiyaningsih, 2008).

Analog rice fat content decreased significantly with the increasing number of MSF in the formulation (Table 3) ($p<0.05$). Although the fat content of MSF (0.44) was greater than MOCAF (0.31)(Syah et al., 2020; Hidayat et al., 2009). It might be related to increasing moisture content. This analog rice has higher fat content than analog rice made from MOCAF and tofu pulp (1.62%), and IR 64 rice (0.6%) (Yuwono & Zulfiah, 2015; Setiyaningsih, 2008).

Analog rice protein levels increased significantly with increasing MSF (Table 3) ($p<0.05$) . The higher protein content in MSF (4%) compared to MOCAF (0.7-2.9%) was thought to be the cause(Syah et al., 2020; Omowonuola et al., 2017; Kasaye et al., 2018). This analog rice has a higher protein content than analog rice made from MOCAF and seaweed (0.86-1.13%), but lower than IR 64 rice (10.9%) (Agusman et al., 2014; Setiyaningsih, 2008).

Analog rice carbohydrate levels decreased significantly with increasing MSF (Table 3) ($p<0.05$). This was due to rising protein levels and decreasing fat content. It was also related to carbohydrate levels of MSF (83.5%) lower than MOCAF (89.7%) (Syah et al., 2020; Omowonuola et al., 2017). This analog rice has higher carbohydrate content than analog rice made from peanut flour and ojek flour (78%) and IR rice 64 (78.1%)(Kanetro et al., 2017; Ohtsubo et al., 2005).

The level of crude fiber analog rice increased significantly with increasing MSF (Figure 1) (p<0.05). This was possible because the MSF crude fiber content (2.46%) was greater than MOCAF (1.7%)(Syah et al., 2020; Hidayat et al., 2009). This analog rice has lower crude fiber than analog rice made from MOCAF and tofu waste (6.64%), and IR 64 rice (4.6%) (Yuwono & Zulfiah, 2015).

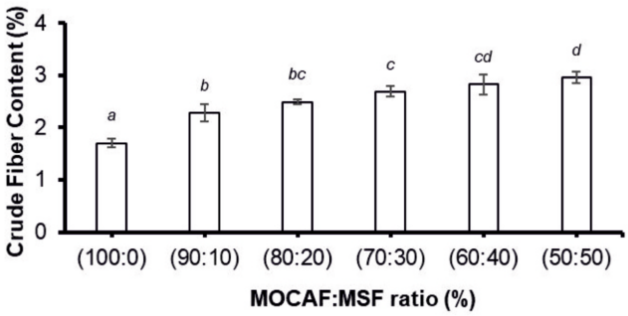

Figure 1. Crude Fiber Content of Analog Rice. Data is presented with a standard deviation line. The different letter notations in the same column show significant differences (P<0.05). MOCAF, Modified Cassava Flour; MSF, Modified Suweg

CONCLUSION

The increase in MSF in the MOCAF:MSF ratio in analog rice formulations had a significant impact on physical characteristics such as the weight of 100 grains, and the bulk density increased, but water absorption and color brightness decreased. Besides the analog rice nutrient content such as protein, moisture, ash, and crude fiber will increase along with the increase in MSF in the formulation, but the fat and carbohydrate content has decreased 23% and 4%, respectively.

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