Physicochemical Characteristics and Dietary Fiber of Analog Rice from Seaweed (*Sargassum* sp.) and Beneng Taro Combination

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Submitted: 05.07.2023; Revised: 20.11.2023; Accepted: 30.11.2023

ABSTRACT

Development of analog rice from *Sargassum* sp. and beneng taro combination is expected to be an alternative food to increase the amount of dietary fiber intake for the community. The aim of this research is to determine the best characteristics of analog rice from *Sargassum* sp. and beneng taro as a high fiber food. The concentration of added *Sargassum* sp. seaweed in this study were 0%, 5%, 10%, and 15%. The results showed that a concentration of 15% was the best treatment with a white degree value 1.23%; water absorption capacity 61% and swelling power 59.3%. The chemical characteristics of the best analog rice are 10.14% moisture content; ash content 4.14%; fat content 0.60%; protein content 5.69%; and carbohydrates content 79.44%. The dietary fiber of analog rice is 23.74%.

**Keywords:** analog rice, dietary fiber, physicochemical, *Sargassum* sp., taro beneng

INTRODUCTION

Fruit and vegetables are sources of fiber which the body really needs. It is known that the percentage of the Indonesian population that does not consume enough fruit and vegetables has reached 95.4% (Kemenkes 2019). The recommendation for good fiber intake according to WHO is 25-30 grams per day, while the average consumption of dietary fiber for the Indonesian population is 10.5 grams per day (Rahmah et al. 2017). Lack of fiber consumption can increase the risk of death from non-communicable diseases such as colon cancer, diabetes, hypertension, stroke, heart disease and obesity (Anggraini 2018).

One effort that can be made to overcome the above problems is to increase consumption of foods high in dietary fiber. These food ingredients can be found in seaweed *Sargassum* sp. Based on research by Matanjun *et al.* (2009) the amount of dietary fiber contained in 100 grams of dry *Sargassum* sp. is 39.67%. People don't like to consume seaweed directly as a vegetable because it smells fishy and tastes unpleasant. Therefore, it needs to be formulated into processed products so that the level of acceptance increases and at the same time we get the benefits we want.

Analog rice is a processed product that can be made using non-rice ingredients and has a shape like rice (Mishra *et al.* 2012). Analog rice has advantages over rice because its nutritional composition can be designed so that it has better functional properties.
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(Noviasari et al. 2017). The main ingredients in making analog rice usually come from local ingredients high in carbohydrates, such as sorghum (Anggraeni et al. 2016), corn (Noviasari et al. 2015), taro (Kumolontang and Edam 2020), cassava and sweet potato (Saragih et al. 2020). One of Banten's local foods that has the potential to be used in making analog rice is tao beneng (Xanthosoma undipes K.Kock). Taro beneng has a carbohydrate content of 79.80-84.10% (Putri et al. 2021).

The development of analog rice as a functional food is still ongoing, apart from reducing dependence on rice through food diversification, the functional properties of analog rice are very beneficial for health. Several studies have examined the addition of various ingredients to improve the functional properties of analog rice. Fauziyah et al. (2017) examined the addition of bean flour to increase fiber content and antioxidant activity in rice analog from sorghum. Anggraeni et al. (2016) examined the addition of fish bone meal and seaweed to gembili tubers to increase the fiber and calcium levels of analog rice. This research aims to evaluate of characteristics in making analog rice from a combination of seaweed (Sargassum sp.) and beneng taro as a high fiber food.

MATERIALS AND METHODS

Tools and Materials

The main ingredients used in this research were beneng tao flour from Pandeglang Regency, Banten and seaweed (Sargassum sp.) from the waters of Anyer Beach, Banten. Other materials used are carboxymethyl cellulose (CMC), (Ca(OH)2) 1% and water. The tools used in this research were baking pans, basins, winnowing pans, 80 mesh strainers, stoves, plastic packaging, pans, noodle makers (ATLAS), ovens (Memmert), analytical scales (Boeco BBI-32), choppers and glassware.

Making Seaweed (Sargassum sp.) Flour

Making seaweed flour refers to Hudaya (2008). Procedure for making seaweed (Sargassum sp.) flour begin by soaking the seaweed for 24 hours in fresh water to remove dirt and mineral salts. The seaweed that has been soaked is then washed under running water, then soaked in 1% lime water (Ca(OH)2) for 1 hour. Next, the samples were washed again until clean and soaked in fresh water for 24 hours, then rinsed until clean and reduced in size. The samples were dried using oven at 60°C for 15 hours. The dried seaweed is ground into flour then sieved and then stored in plastic packaging.

Making Analog Rice

Making analog rice refers to the research of Agusman et al. (2014) with modifications to the formulation and molding tools used. Seaweed (Sargassum sp.) flour and beneng tao flour mixed in a bowl. Percentage of seaweed flour addition based on the weight of beneng tao flour, namely 0, 5, 10, and 15%. Next, carboxymethyl cellulose (CMC) is added and mixed with water, then stirred until it forms a semi-wet dough. The next stage is formed using a noodle maker, then cut into pieces (3-5 mm) and shaped like rice grains. The granules are then steamed for 6 minutes at a temperature of 90 – 100 °C until they gelatinize. The steamed granules were cooled at room temperature for 20 minutes, then dried in an oven at 40°C for 10 hours. The formulation for making analog rice is presented in Table 1.

Characterization of Analog Rice

Analog rice is characterized physically, including the white degree (Kaemba et al. 2019), water absorption capacity and swelling power (Yudanti et al. 2015). Chemical characterization uses water, protein, fat, ash and carbohydrate content
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**Data Analysis**
The data in this study were analyzed using the ANOVA test with a confidence level of 95%, if there was a significant difference ($P<0.05$), then continued with the Duncan test.

**RESULTS AND DISCUSSION**

**Physical Characteristics of Analog Rice**

The white degree of analog rice shown at figure 1. The addition of more seaweed flour had a significant effect ($P<0.05$) on reducing the whiteness value of analog rice (Table 2). The decrease in the white degree was caused by the influence of the brown color of the seaweed ($Sargassum$ sp.). This is in line with the statement by Karina and Desrizal (2021), that the addition of brown seaweed makes the color of the dodol darker. Apart from that, the dark color can also be influenced by the browning reaction (maillard) during heating processes such as steaming and drying. According to Damat et al. (2020) the heating process can cause maillard reactions between sugars from carbohydrates and amino acids.

The whiteness degree of analog rice added to seaweed flour ranged from 1.23 - 1.65% (Table 2). This value is lower when compared to analog rice from combination of seaweed ($E. cottonii$) and mocaf flour (17.70%) (Agusman et al. 2014), analog rice from combination of white corn and sago flour (66.81%) (Noviasari et al. 2013), analog rice from combination of cassava, coconut and sago (73.08%) (Kharisma et al. 2014), and rice from paddy (80.23%) (Noviasari et al. 2017). A low degree of whiteness can result in a decreased level of likeness (Karina and Desrizal 2021).

Water absorbtion capacity was carried out to determine the ability of analog rice to absorb water after the boiling process (Lindriati et al. 2014). Table 2 shows that the addition of seaweed did not have a significant effect ($P>0.05$) on the difference in the water absorbtion capacity. The average value of the water absorbtion capacity of analog rice added with seaweed flour ranges from 61 - 63%. The water absorption capacity of various rice analogues has been studied, the water absorbtion capacity of rice from paddy is 24.3% (Yulviatun et al. 2022), analog rice combination of a composite of cassava flour, corn flour and soybean flour is 60.52% (Pudjiastuti et al. 2021), analog rice from combination of mocaf, corn flour, and mung bean sprout flour 105.8-118% (Yulviatun et al. 2022). The higher the water absorption capacity, the higher the water needs for cooking. Water absorbtion capacity is influenced by the amylose content of the material, the higher the amylose content will have a positive correlation with water absorbtion capacity. Amylose in starch has the ability to form hydrogen bonds with water and consists of glucose units linked with α-1,4-glycosidic bonds (Srihari et al. 2016). Beneng taro has amylose and amylopectin contents of 19.27% and 37.02% respectively (Kusumasari et al. 2019). Swelling power shows the level of volume expansion of analog rice due to the cooking process (Yulviatun et al. 2022). Table 2 shows that the addition of seaweed did not have a significant effect ($P>0.05$) on the difference in the swelling power. The swelling power of analog rice added with seaweed flour ranged from 59.3 - 62.0%. The swelling power in this study was higher compared to analog rice combination of taro flour, maizena flour and sweet potatoes (8.8%) (Srihari et al. 2016), analog rice from a combination of mocaf flour, corn flour and green bean sprout flour (27.25 - 30.86%) and rice from paddy (50%) (Yulviatun et al. 2022). The research results of Andika et al. (2021) indicated that the greater the swelling power, the shorter the cooking time. Swelling power is influenced by the ratio of amylose...
and amyllopectin in the raw material. The higher the amyllose content, the more difficult to form a gel because the amorphous structure formed increases the gelatinization temperature, resulting in low swelling power (Srihari et al. 2016). The levels of amyllose and amyllopectin greatly influence the texture of analog rice, the higher the amyllose will produce chewy rice, while the higher the amyllopectin will produce fluffier and stickier rice (Adicandra and Estias 2016).

**Chemical Characteristics of Analog Rice**

The moisture content of analog rice is an important parameter to know because it affects to shelf life. According to Miftahudin et al. (2015), the lower the moisture content, the longer the shelf life of the product. Based on Table 3, the moisture content of analog rice added with seaweed flour ranges from 10.14 - 13.89%. The moisture content of analog rice in this study is similar to the moisture content of analog rice from corn flour (10.37%-13.76%) (Santoso et al. 2013), rice analog combination of banana flour and cassava flour (10.41%-13.08%) (Yudanti et al. 2015), and rice from paddy (9.86%) (Yulviatun et al. 2022). The moisture content of analog rice can be influenced by the length of the drying process, the longer the drying process will cause the moisture content to decrease (Santoso et al. 2013). The water content in this study is almost similar to rice from paddy, so it can be stored for a long time like rice from paddy.

Ash content is a rough description of the mineral content found in food (Spiraliga et al. 2017). The addition of more seaweed flour caused a significant increase (P<0.05) in the ash content of analog rice (Table 3). The ash content in analog rice with addition of seaweed (Sargassum sp.) flour ranges from 2.75 - 4.14% (Table 3). Ash content from various analog rice has been studied, ash content from analog rice of Eucheuma cottonii seaweed, mocaf and sago combination is 2.24 - 3.13% (Finirsa et al. 2022), analog rice from cassava, corn and black soybeans combination is 1.21% (Pudjihastuti et al. 2021), and analog rice from white corn is 0.38% (Noviasari et al. 2013). The ash content in this study also showed higher results compared to the ash content of rice from paddy which was only 0.92-1.28% (Yulviatun et al. 2022). This is due to the mineral content in Sargassum sp. quite high, reaching 33.74% dry weight (Siregar et al. 2018). Mineral content in Sargassum sp. are potassium (K), sodium (Na), magnesium (Mg), and iron (Fe) (Syad et al. 2013). Analog rice with 15% seaweed added does not meet healthy food standards based on SNI 01-7111.1-2005, because it has an ash content above 3.5% (BSN 2005).

Addition of seaweed (Sargassum sp.) flour had a significant effect (P<0.05) on increasing the fat content of analog rice (Table 3). The fat content of analog rice with the addition of seaweed flour has a value ranging from 0.36 - 0.72%. The results of the fat content in this study were still lower than the fat content in rice from paddy, which was 1.3% (Yulviatun et al. 2022). The low fat content in analog rice is caused by the low fat content in the raw materials for making analog rice. The fat content of the main raw material for making analog rice is 0.17% in taro beneng flour (Kusumasari et al. 2019) and 0.79% in Sargassum sp. seaweed (Gazali et al. 2018). Finirsa et al (2022) stated that analog rice which has a low fat content will not easily become rancid, so it will last longer when stored.

Table 3 shows that the addition of seaweed did not have a significant effect (P>0.05) on differences in protein levels. The protein content in analog rice ranges from 5.11 - 5.69%. The protein content of analog rice in this study showed higher results than analog rice combined with seaweed Eucheuma cottonii, mocaf and sago (0.60 - 0.73%) (Finirsa et al. 2022) and analog rice
from combination of taro flour, maizena flour and sweet potatoes (1.78%) (Srihari et al. 2016). The protein content of analog rice in this study were also close to the protein content of rice from paddy, which was 7.51% (Yulviatun et al. 2022). The high levels of analog rice protein in this study were influenced by the main raw materials, namely taro beneng and seaweed Sargassum sp. which has a protein content of 6.10% (Budiarto and Rahayuningsih 2017) and 8.42% (Siregar et al. 2018).

Addition of seaweed flour had a significant effect ($P<0.05$) on differences in carbohydrate levels (Table 3). Carbohydrate content in analog rice with the addition of seaweed ranges from 77.63-79.43%. Carbohydrate content of analog rice has been studied, carbohydrate content of analog rice from combination of seaweed (Eucheuma cottonii) and mocaf flour is 69.99% (Agusman et al. 2014), analog rice from white corn (91.54%) (Noviasari et al. 2013), and analog rice from cassava, corn and black soybeans combination (73.3%) (Pudjihastuti et al. 2021). The carbohydrate content of analog rice in this study is similar to rice from paddy 80.14% (Rasyid et al. 2016). This shows that analog rice with the addition of 5-15% seaweed can be used as an alternative food source of carbohydrates that is equivalent to rice from paddy.

**Dietary Fiber**

Dietary fiber is part of the carbohydrates that can be consumed and it is found in many plant cell walls. This fiber cannot be hydrolyzed by human digestive enzymes because it is resistant to the digestive and absorption processes in the small intestine, and can undergo complete or partial fermentation in the large intestine (Sari et al. 2019; Sardi et al. 2021). Based on Figure 2, dietary fiber in analog rice with the addition of seaweed ranges from 18.22–23.74%. Addition of seaweed had a significant effect ($P<0.05$) on increasing the dietary fiber content of analog rice (Figure 2). The highest levels of dietary fiber are found with the addition of 15% seaweed flour. This result is higher than the dietary fiber in analog rice from Gracillaria sp. (9.44%) (Purwaningsih 2022), analog rice from white corn (5.35%) (Noviasari et al. 2013), analog rice from sorghum (5.50%) and rice from paddy (0.19%) (Noviasari et al. 2015).

The dietary fiber in analog rice can be classified as a high fiber food, because it has a fiber content more than 6% (BPOM 2016). Based on BPOM (2021), the serving size for instant rice is 50-60 grams, so by consuming 50 grams of analog rice can fulfills 30.37-39.57% of daily dietary fiber intake (30 grams per day for recommended dietary fiber intake). Dietary fiber has various benefits if consumed in sufficient quantities. Consumption of dietary fiber can prevent obesity, reduce blood sugar levels, prevent cancer, stimulate the growth of good bacteria in the intestine and reduce the risk of cardiovascular disease (He et al. 2022).

**CONCLUSION**

The analog rice in this study had a darker color compared to rice from paddy. The analog rice in this research can be used as an alternative source of carbohydrates to replace paddy rice. The best treatment in this study was the addition of 5% and 10% seaweed because the ash content complies with standards and has a high dietary fiber content.

**ACKNOWLEDGEMENT**

The authors express profound gratitude to the University of Sultan Ageng Tirtayasa grant number: 242/UN43/KPT.PT.01.02/2023, for funding this study.

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Table 1. Rice analog formulations

<table>
<thead>
<tr>
<th>Material</th>
<th>Addition of seaweed flour</th>
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<tr>
<td></td>
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<tr>
<td>Seaweed flour (g)</td>
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<tr>
<td>Beneng taro flour (g)</td>
<td>500</td>
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<tr>
<td>CMC (g)</td>
<td>5</td>
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<tr>
<td>Water (mL)</td>
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Table 2. Physical characteristics of analog rice

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<tr>
<td></td>
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<tr>
<td>White degree</td>
<td>4.42±0.14&lt;sup&gt;c&lt;/sup&gt;</td>
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<tr>
<td>Water absorption capacity</td>
<td>63±0.01&lt;sup&gt;a&lt;/sup&gt;</td>
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<tr>
<td>Swelling power</td>
<td>61.8±0.14&lt;sup&gt;a&lt;/sup&gt;</td>
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Note: Value with different notation in the same row has a significant differences (<i>P</i>&lt;0.05)

Table 3. Chemical characteristics of analog rice

<table>
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<td></td>
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<tr>
<td>Moisture content</td>
<td>11.56±0.32&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Ash</td>
<td>2.62±0.04&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>Fat</td>
<td>0.21±0.00&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>5.47±0.21&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>80.14±0.14&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Note: Value with different notation in the same row has a significant differences (<i>P</i>&lt;0.05)

Figure 1. Analog rice: (A) 0%, (B) 5%, (C) 10%, (D) 15%
Figure 2. Dietary fiber in analog rice