functional characteristic of analog rice made from taro kimpul flour

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FUNCTIONAL CHARACTERISTIC OF ANALOG RICE MADE FROM TARO KIMPUL FLOUR (*Xhantosoma sagitifolium*)

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Abstract: Analog rice is artificial rice made from carbohydrate sources to resemble rice. Taro kimpul is one of Indonesia's local foods rich in carbohydrates that have not been widely used and have functional properties to be used as a raw material for analog rice. In this study, the manufacture of analog rice also used functional ingredients (beets and dragon fruit peels) containing phytochemical beneficial compounds and binders (carboxymethyl cellulose/CMC and carrageenan). This research aimed to determine the functional characteristics of analog rice and was expected to produce analog rice with a low-calorie value. The research was conducted in two stages: analog rice was made with four formulations, and an analysis of the functional characteristics of analog rice was conducted. This research was done with descriptive analysis so that it could describe the effect of adding functional ingredients and binders to the characteristics of analog rice. Based on the decision-making method, the best treatment in this study was taro analog rice F1 with the use of 2% carrageenan and 32% beetroot. The functional characteristics of taro analog rice F1 are as follows: crude fiber 2.13%, calories 112.29 kcal/100g, total phenol 0.51 mg GAE/g, anthocyanin 56.77mg/100g, and antioxidant activity of 74.92%. The analog rice obtained had higher antioxidant activity, total phenol, anthocyanin, and lower calorific value compared to polished rice.
Keywords: Beet; CMC; carrageenan; dragon fruit peel; functional ingredients

Abstrak: Beras analog adalah beras tiruan yang dibuat dari sumber karbohidrat menyerupai beras. Talas kimpul merupakan salah satu pangan lokal Indonesia yang kaya akan karbohidrat yang belum banyak dimanfaatkan dan memiliki sifat fungsional yang berpotensi digunakan sebagai bahan baku beras analog. Dalam penelitian ini, pembuatan beras analog menggunakan bahan-bahan fungsional (bit dan kulit buah naga) yang mengandung senyawa fungsional dan bahan pengikat (CMC dan karagenan). Penelitian ini bertujuan untuk mengetahui karakteristik fungsional beras analog talas dan diharapkan dapat menghasilkan beras analog dengan nilai kalori yang rendah. Penelitian telah dilakukan dengan dua tahap: pembuatan beras analog empat formulasi; dan analisis karakteristik fungsional pada beras analog. Penelitian ini dianalisis secara deskriptif sehingga menjelaskan pengaruh penambahan bahan fungsional dan pengikat terhadap karakteristik beras analog. Berdasarkan metode pengambilan keputusan perlakuan terbaik dalam penelitian ini adalah beras analog talas F1 dengan penggunaan 2% karagenan dan bit 32% dengan karakteristik sebagai berikut: serat kasar 2,13%, kalori 112,29 kkal/100g, total fenol 0,51 mg GAE/g, antosianin 56,77mg/100g dan aktivitas antioksidan 74,92%. Beras analog yang dihasilkan memiliki aktivitas

antioksidan, total fenol, antosianin yang lebih tinggi dan nilai kalori yang lebih rendah dibandingkan dengan beras sosoh.

Kata kunci: Bit; CMC; karagenan; kulit buah naga; komponen fungsional

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Introduction

Analog rice is artificial rice made from carbohydrate sources with the addition of water to resemble rice (Budijanto, 2015). Analog rice is one of the diversified food products. Analog rice which has a shape resembling rice grains can influence consumers like eating rice from paddy. Analog rice can also be designed to have functional properties by using various raw materials to be beneficial for health. Several previous studies related to analog rice which has functional properties, namely analog rice with a low glycemic index (Kurniawati, et al., 2016; Noviasari, et al., 2017); analog rice with antioxidant content (Khilmi, et al, 2020; Saati et al, 2020); and anti-cholesterol analog rice (Wahjuningsih & Susanti, 2018). Taro is one of Indonesia's local plants which is dispersed in almost regions of Indonesia, including Aceh. Taro kimpul is one of the varieties of taro that have been reported with low sugar and fat content. So people with heart disease, diabetes, and osteoporosis can suitable to consume it (Minantyo, 2017). Taro is a source of carbohydrates with a carbohydrate content of 85% and contains oligosaccharides which are a good source of prebiotics for the human body (Wahdaningsih, et al., 2017). According to Sukasih & Setyadjit, (2017), taro has low calories of 358 kcal/100gram compared to rice with 401 kcal/100gram calories. Based on the description above, taro kimpul can be produced into analog rice with functional properties. In addition to using carbohydrates as raw materials, functional ingredients and binders can be added to analog rice in the manufacturing process.

Functional raw materials with phytochemical properties that can be used are beetroots and dragon fruit peels. Beet contains several active compounds such as carotenoids, glycine betaine, saponins, betacyanin, betanin, polyphenols, and flavonoids (Singh and Hathan, 2013). Beets also contain a total anthocyanin of 23- 77 mg/100 g (Guine et al., 2018). Dragon fruit peel is a waste that has not been widely used. According to Niah (2016), the antioxidant activity in 1 gram of red dragon fruit peel is 20.867%, and IC_{50} is 3.14 grams/100 ml. Dragon fruit skin also contains anthocyanin color pigments of 12.4 mg/100 g (Phanthuwongpakdee, et al., 2020). According to Panjaitan (2019), the donut with an addition of 32% of beet was the best treatment and favored by panelists, and Oktiarni, et al., (2012) also reported that the addition of dragon fruit peel by 38% to the wet was the best treatment and the most preferred wet noodles by the panelists.

Binders/thickeners are hydrocolloids generally used as additives to improve the quality of food products (Herawati, 2018). The binder/thickener that can be used to manufacture analog rice is CMC and carrageenan. CMC can help to get the right thickness because of its ability to bind water (Putra, et al., 2015). Carrageenan can interact with macromolecules so that it can form a gel and make the elasticity of the product increase (Widyaningtyas & Susanto, 2015). Based on Noviasari (2022), the addition of CMC (4%) and carrageenan (2%) is the best concentration in the manufacture of taro analog rice. This study aimed to determine the functional characteristics of taro analog rice with functional ingredients and binders. In addition, it is expected to produce analog rice with a low calorific value.

Methods

Materials

This study makes analog rice consisting of four formulations using two factors: functional ingredients and binders. The primary raw materials are taro kimpul flour from the "Sarisa" brand Yogyakarta and sago starch from the "Javara" brand. Fixed components consist of water (50%) and Glyceryl Monostearate/GMS (2%). The functional ingredients used are 32% beetroot and 38% dragon fruit skin which is subtracted from the water. The binder CMC 4% and carrageenan 2% are from the primary raw materials. The formulation of analog rice is presented in Table 1.

Table 1. The formulation of phytochemical ingredients and binders in analog rice based on kimpul taro flour

Formulation Analog Rice	Material			
	Beet (%)	Dragon fruit peels (%)	Carrageenan (%)	CMC (%)
F1	32	-	2	-
F2	-	38	2	-
F3	32	-	-	4
F4	-	38	-	4

Research Stages

Functional Ingredients Extract (Noviasari et al., 2021)

Dragon fruit peel and beetroot were washed and then added with 1:1 water then blended for 5 minutes. A filter cloth was used to obtain a thick extract filter after they were blended for 5 minutes.

Production of Taro Analog Rice (Noviasari et al., 2022)

GMS and binders (CMC or carrageenan) were dissolved in hot water. Before the functional materials were added (32% beetroot or 38% dragon fruit skin) taro Kimpul flour was mixed with sago starch in a ratio (70:30). Next, water 50%, GMS 2%, and binders (CMC 4% or carrageenan 2%) according to the concentration of this research were mixed into the dough until smooth. By using a noodle grinding machine from Atlas brand with size number 2, the dough is formed into noodles and cut manually to rice-like with a size of 0.5 cm. Then analog rice was steamed for 10 minutes at a temperature of 80°C and then dried for 6 hours using an oven at a temperature of 60°C.

Observed Parameters

Parameters observed in analog rice were crude fiber (BSN, 1992), total phenolic content (Zainida, et al., 2017), Anthocyanins (Lee, et al., 2005), Antioxidant activity using the DPPH method (Kubo, et al., 2002), and calories (Arbi, et al., 2018).

Statistical Analysis

The data that has been collected will be presented as a table and analyzed descriptively. The best treatment is determined by using a decision-making method, namely the Bayes method (Sukarno, 2020).

Results

The analog rice in this study had a higher crude fiber, total phenolic content, anthocyanin, and antioxidant activity than polished rice (Table 2). The addition of beetroot extract and dragon fruit peel which contains crude fiber, high anthocyanins, and total phenols causes an increase in the analog rice produced. This causes the antioxidant activity of analog rice to be higher than the antioxidant activity of polished rice produced.

Table 2. The phytochemical content of taro analog rice

Analog Rice	Functional Analysis				
	Crude Fiber (%)	Calories (Kcal / 100g)	Total Phenols (mgGAE/g)	Anthocyanin (mg/100g)	Antioxidant Activity (%)
F1	2.13 ± 0,14	112,29 ± 1.89	0.51 ± 2.97	56.77 ± 2.04	74.92 ± 1.02
F2	3.88 ± 0,10	155.68 ± 5.22	0.47 ± 1.23	12.52 ± 6.07	88.23 ± 0.68
F3	1.58 ± 0.02	160.78 ± 4.43	0.45 ± 1.57	47.17 ± 2.01	79.03 ± 0.73
F4	2.58 ± 0.20	201.62 ± 2.2	0.33 ± 2.32	23.79 ± 6.61	83.89 ± 1.65
Polished Rice	2.00[a]	337[b]	0.04[b]	0.00002 ± 0.0[c]	41,28[d]

Mean values ± standard deviation (n=4). [a]Widyawati, et al., (2014) [b]Hasnelly, et al., (2020) [c]Ohtsubo, et al., (2005) [d]Alviyani, (2012)

The analog rice produced has a calorific value of medium category and is lower than polished rice so it is better consumed for consumers who want a calorie diet. Figure 1 shows the analog rice produced.



Figure 1. Analog rice F1, F2, F3, F4 (left to right)

Discussion

Crude Fiber

Crude fiber is a fiber that is not soluble in H_2SO_4 and NaOH (Tilawati, 2014), in this study the crude fiber of taro analog rice ranged from 1.58-3.08%, with an average of 2.54%. Table 1 shows that analog rice F2 has the highest crude fiber than other formulations and polished rice. This is caused by using dragon fruit peels with a higher crude fiber of 69,3% (Hernawati, et al., 2018). However, the crude fiber with the addition of dragon fruit peels (analog rice F2 and F4) is higher than beet. Carrageenan produced from *E. cottonii* contains a high crude fiber of 4.12 – 5.55% (Diharmi, et al., 2019). Therefore, analog rice added with carrageenan has a higher crude fiber content (analog rice F1 and F2). However, the crude fiber content in CMC has not been reported, but CMC can bind water, and fiber can disperse (Susilowati, 2010). The combination of dragon fruit peel and carrageenan causes analog rice F2 to have the highest crude fiber content than analog rice F1, F3, and F4. According to the American diet, human crude fiber intake per day ranges from 5-8 g/100g (Kusharto, 2007). The crude fiber content in this study almost met the daily intake of crude fiber needed by the human body. Foods with a high crude fiber content usually contain low calories, low sugar content, and low fat, which can help reduce obesity (Santosa, et al., 2012).

Calories

Calories analysis was carried out using a Bomb Calorimeter. According to Nutrition Labelling Singapore (2015), calorie-free food contains < 1 Kcal/100 g, low calorie contains < 40 Kcal/100 g, moderate calorie contains 100-300 Kcal/100 g and high-calorie contains > 300 Kcal/100 g. In this research, the calories of taro analog rice produced ranged between 112.29-201.62 Kcal/100 g with an average of 157.59 Kcal/100 g. In this research, the calorific value of taro analog rice is included in the food category with moderate calories. The calories of analog rice in this research are also lower than the calorific value of polished rice, which has a calorific value of 337 Kcal/100 g (Othsubo, et al., 2005) (Loebis, et al., 2017).

The use of binders and functional ingredients affects the calorie content produced. The calorific value of analog rice with the addition of CMC (analog rice F3 and F4) was higher than carrageenan (analog rice F1 and F2). This is because carrageenan can reduce the calorific value of food products. According to Kumar & Sharma (2004), the addition of 5% carrageenan as a substitute for fat in meat can decrease the calorie content of meat from 256.55 Kcal/100 g to 180.58 Kcal/100 g. Carrageenan contains crude fiber content to reduce the calories of analog rice produced. According to Srihari, et al., (2016), the higher fiber in foods can reduce the calorie content.

The calorific value of analog rice with the addition of dragon fruit peels (analog rice F4) is higher than analog rice with beets (analog rice F3). This is because beets contain a low calorific value. According to Gustiarani (2017), red beets have 43 Kcal/100 g; although the energy given per unit weight is down, beets can provide a filling taste because of the high fiber content (Srihari, et al., 2016). The calorific value of dragon fruit peel has not been reported, but according to Antarlina (2016), using 30% dragon fruit peel extract in wet noodles can reduce the calorific value of noodles with wheat flour and breadfruit flour from 150.61 Kcal/100 g to 138.92 Kcal/100 g.

Total Phenolic Content

The phenolic compound is one of the standard compounds in plants. Phenolic compounds have been exploited extensively because they have biological activities such as antimutagenicity, anticarcinogenic, antiaging, and antioxidants (Kosem, et al., 2007). The functional ingredients and binders used can influence the phenol content in analog rice. Analog rice with the addition of beets (analog rice F1) has a higher phenol content than analog rice with the addition of dragon fruit peels (analog rice F2). The phenol in beet is higher at 34.21-112.49 mg GAE/mL (Bazaria & Kumar, 2016) than in dragon fruit peel with phenol of 39.77-48.44 mg GAE/100 g (Wisesa & Widjanarko, 2014). The phenolic components found in dragon fruit peel consist of gallic acid, chlorogenic acid, caftaric acid, and ferulic acid (Suleria, et al., 2020). Phenolic compounds in beets consist of chlorogenic acid, gallic acid, and quercetin derivatives (Wruss, et al., 2015).

The binder also affects the total phenol of the rice analog produced. The phenol value of analog rice F3 is lower than analog rice F1. This is due to the difference in the binder used. Analog rice with the addition of carrageenan (analog rice F1 and F2) had a higher phenol value than analog rice with the addition of CMC (analog rice F3 and F4). CMC's amount of hydrogen compounds is more elevated than carrageenan (Distantina, et al., 2018). According to Morris, et al., (2012), the more hydrogen compounds in the phenolic chain will cause the phenolic compounds to become unstable and decrease. The total phenol from this study was higher than the total phenol from polished rice with a total phenol of

0.04 mg GAE/g sample and analog rice from several previous studies, namely analog rice from white corn, soybeans, and sago 0.25 mg GAE/g sample (Noviasari, et al., 2016); yellow corn, rice bran, and soybean 0.5 mg GAE/g sample (Kurniawati, et al., 2016); corn, sorghum, and sago palm 0.10 mg GAE/g sample (Budijanto, et al, 2018).

Anthocyanin

Anthocyanins have functioned as antioxidants or free radical scavengers, so they can play a role in preventing aging, cancer, and degenerative diseases, antimutagenic and anti-carcinogenic, and prevent liver function disorders, antihypertensives, and lower blood sugar levels (Rahayuningsih, et al., 2008). In this research, the anthocyanin of taro analog rice ranged from 12.52-56.77 mg/100g sample with an average of 35.06 mg/100 g. Analog rice with the addition of beet has higher anthocyanin levels than polished rice and analog rice with the addition of dragon fruit peel; this is because the anthocyanin in the beet is higher than the anthocyanin in the dragon fruit peel, and polished rice does not have pigment. According to Guine, et al., (2018), beet has anthocyanin content of 23-77 mg/100 g higher than the anthocyanin levels in dragon fruit peel. According to Phanthuwongpakdee, et al., (2020), the red dragon fruit peel has 12.4 mg/100 g of anthocyanin levels.

The anthocyanin content of analog rice with the addition of beets in this study was higher than analog rice based on 80% Baruk sago flour and 20% purple sweet potato flour, which was 35 mg/100gram (Kaemba, et al., 2017). The anthocyanin content of analog rice in this research was also higher than the anthocyanin content of brown rice. According to Sompong, et al., (2011), levels of anthocyanins in brown rice ranged from 0.33 to 1.39 mg/100 g.

Antioxidant Activity

One method that can be used to measure antioxidant activity is the 2,2-Diphenyl-1-picrylhydrazyl (DPPH) method. The radical scavenging activity was evidenced by a purple color change to yellow color when the DPPH solution was added to the extract (Dungir, et al., 2012). In this research, the antioxidant activity of taro analog rice ranged from 74.92 -88.23%, with an average of 81.51%. In Table 1, it can be seen that the lowest antioxidant activity was found in analog rice 1, and the highest antioxidant activity was found in analog rice 2. The antioxidant activity of analog rice with the addition of dragon fruit peels (analog rice 2 and 4) was higher than analog rice with beets (analog rice 1 and 3). This is because dragon fruit peel contains higher antioxidant activity, namely 78-80% (Nurliyana, et al., 2010), than beetroot antioxidant activity, 66-87% (Guine, et al., 2018).

The binder used also contributes to the antioxidant activity of analog rice because it contains antioxidant compounds. Carrageenan is reported to have

antioxidant compounds, namely 60-80% (Yuan et al., 2006), and according to Fan, et al., (2014), CMC derivatives contain antioxidant compounds, namely 55%.

The antioxidant activity in this study was higher than in analog rice made from Baruk sago flour and purple sweet potato flour (Winarti, et al., 2018). Analog rice was made from Gadung flour, cornflour, and modified cassava flour in the research with values of 65% and 61.89%, respectively (Nisa, et al., 2020). This is may due to differences in the raw materials used.

Antioxidant Correlation

Determination of the contribution of bioactive components to an antioxidant activity can be used to determine the antioxidant mechanism of these components. This can be done by testing the correlation value between the bioactive components and the antioxidant activity of the sample. The correlation test used in this study is the Pearson correlation test.

Antioxidant Correlation with Total Phenol

The correlation value of antioxidant activity with total phenol in analog rice with the addition of beet showed a strong correlation with a positive value of 1.0 ($p<0.01$). This indicates that the total phenol added with beet extract significantly affects the antioxidant activity of the analog rice produced. The higher the total phenol in analog rice, the higher the antioxidant activity value of analog rice. The correlation value of antioxidant activity with total phenol in analog rice with the addition of dragon fruit peel showed a strong correlation with a negative value of -1.0 ($p<0.01$). This indicates that the correlation between total phenol and antioxidant activity shows the opposite value. According to Widyawati, et al., (2010), antioxidant activity is influenced by total phenols and flavonoid content. In beet, the most significant bioactive compound is total phenol, which is 245±1.732 mg/100 g, and flavonoid compound 0.88±0.010 mg/100 g (Chhikara, et al., 2019), while in dragon fruit peel, the most dominant bioactive compound is flavonoids with a value of 46.54 g QE/g and phenolic compounds of 0.4020 µg GAE/g (Wahdaningsih, et al., 2017). Based on this description, the antioxidant activity in dragon fruit peels is dominated by flavonoid compounds, and phenolic compounds dominate antioxidant activity in beets.

Antioxidant Correlation with Anthocyanins

The correlation value of antioxidant activity with anthocyanins in analog rice with the addition of beet and dragon fruit peels showed a strong correlation with a negative value of -1.0 ($p<0.01$). This value indicates that the correlation between anthocyanins and antioxidant activity offers the opposite value. It is suspected that beets and dragon fruit peels contain another pigment, namely betacyanin, which contributes as a free radical scavenger. According to Mutiara, et al., (2016), red beet extract contains betacyanin compounds which have the potential as a potent antioxidant with an IC_{50} value of 79.73, and according to

Romdonah & Kusumo (2017), dragon fruit peel also includes betacyanin of 36.67 mg/100g, which has the potential as an antioxidant.

Determination of the Best Formulation

In this research, Bayes Method (Sukarno, et al., 2020) was used to select the best formulation. The Bayes method can provide the best decision selection from the results of calculations involving several available criteria and alternatives (Barus and Gultom, 2018). The formula with the highest alternative value was chosen as the first rank. The decision matrix is shown in Table 3. The criteria used to consist of crude fiber, calories, total phenol, anthocyanin, and antioxidant activity; the importance values of the five criteria are given. The weight value is determined based on: 0.1 = not important; 0.2 = quite important; 0.3 = important; 0.4 = significantly significant; and 0.5 = very important. The best formulation was obtained by analog rice 1 (2% carrageenan and 32% beetroot).

Table 3. Matrix of Assessment Decisions by Bayes Method

Formulation	Crude Fiber	Calories	Total Phenol	Anthocyanin	Antioxidant Activity	Alternative Values	Ratings
F1	2	3	5	5	4	8.5	1
F2	3	3	4	1	5	7.5	2
F3	1	3	4	4	4	7.2	3
F4	2	2	3	2	5	6.5	4
Weight Value	0.5	0.5	0.4	0.4	0.5		

Conclusion

Utilization of taro Kimpul flour with the addition of functional ingredients (beets and dragon fruit peels) and use of binders (CMC and carrageenan) can produce analog rice that has functional? characteristics and all analog rice in this research have moderate calories. Analog rice F1 with 2% carrageenan and 32% beet is analog rice with the best features. The characteristics of analog rice F1 are as follows: crude fiber 2.13%, calories 112.29 kcal/100 g, total phenol 0.51 mg GAE/g, anthocyanin 56.77 mg/100 g, and antioxidant activity 74.92%.

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