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The Effect of Rice Cooking Techniques on the Sensory Evaluation Test and Fluffiness Levels of Analog Rice Made from Sorghum, Mocaf, Glucomannan, and Moringa Flour

Pengaruh Teknik Penanakan Beras terhadap Evaluasi Sensori dan Tingkat Kepulenan Nasi dari Beras Analog Berbahan Baku Tepung Sorgum, Mocaf, Glukomanan, dan Kelor

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ABSTRACT

Background: Rice cooking is the process of rice making with several cooking stages and types such as using rice cookers and steamers. This analog rice innovation aims to increase the nutritional value, food diversification, and functional foods.
Objectives: To determine the effect of rice cooking techniques on sensory tests (color, texture, aroma, and overall appearance) and fluffiness levels between analog rice and C4 rice.
Methods: This experimental research used a Completely Randomized Design (CRD) on analog rice resulting from the best treatment (P2) with an additional composition of 2 gram of Moringa flour. The cooking techniques used rice cookers and steamers for cooking both analog rice and C4 rice. A total of 25 semi-trained panelists were selected to identify sensory evaluation and the fluffiness levels of the product. The statistical analysis used the Mann-Whitney test with the help of SPSS version 23.0.
Results: Cooking techniques using a rice cooker and a steamer influenced the sensory evaluation tests (color (p=0.004), texture (p=0.002), and overall appearance (p=0.006)) and fluffiness levels (p=0.004) for analog rice. However, cooking techniques did not influence the sensory evaluation test for taste (p=0.396) and aroma (p=0.058). The sensory tests such as color (p=0.607), texture (p=0.578), overall appearance (p=0.701), taste (p=0.482) and aroma (p=0.216) and the level of fluffiness in C4 rice (p=0.891) did not show differences.
Conclusions: The steaming cooking technique influences the preference and fluffiness levels of analog rice. Cooking analog rice with the steaming technique is highly recommended in order to increase consumer preference.

INTRODUCTION

Diabetes Mellitus (DM) is a chronic disease characterized by elevated blood sugar levels or hyperglycemia caused by damage to the pancreas, resulting in insulin hormone resistance and disturbances in carbohydrate, fat, and protein metabolism[1]. Diet for Diabetes Mellitus patients include type, amount, and schedule[2]. DM patients are advised to consume foods with a low glycemic index. The glycemic index value indicates the glycemic potential of carbohydrates. The higher the glycemic index, the greater the risk of increasing blood sugar levels[3].

Analog rice is a product made from raw materials other than rice and is shaped to resemble rice. The results of analog rice products tend to be better when compared to rice. Analog rice made from local non-rice flour provides a solution to increase food availability and diversification[4]. The use of analog rice as a source of local carbohydrates has higher nutritional value than rice and can also be used as a substitute for rice for DM patients[5].

Sorghum is a potential commodity of food energy sources that can be developed in Indonesia[6]. Sorghum has a higher content of protein and a lower content of fat is higher and has a lower fat[7]. The glycemic index content in sorghum seeds is relatively low, namely 46.88[8]. Mocaf flour is a flour product made from cassava

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and processed based on the principle of modified fermentation by lactic acid bacteria (LAB)[9]. Mocaf has a high-calorie content where 100 grams of mocaf contains 363 Kcal with a glycemic index of 59. Besides being gluten-free, mocaf also has high functional food value such as increasing digestibility and improving aroma, as well as high levels of Hydrogen Cyanide (HCN), fiber, and scopoletin[10]. The Moringa plant (Moringa oleifera) has been scientifically proven to be a green vegetable with higher potential and nutritional value than other plants. It contains minerals, amino acids, protein, ß-carotene, vitamin C, and vitamin E which can function as antioxidants. Every part of the Moringa plant can be used and one of the most common is its leaves[11]. Glucomannan is a type of dietary fiber that slows gastric emptying time, inhibits the absorption of glucose and fat, and prolongs the feeling of fullness[12]. Glucomannan can be utilized as a thickening agent or to improve the texture of foods such as in the production of noodles, cakes, bread, jellies, ice cream, jams, and juices[13]. Glucomannan contained in *Porang* can be a nutraceutical product, namely foods that have good effects on health such as prevention and treatment of disease for the management of Type 2 Diabetes Mellitus (T2DM)[14]. Preliminary research by Seftina (2022) focuses on proximate analysis (water content, ash content, protein, fat, and carbohydrates) and antioxidant activity in analog rice made from sorghum, mocaf, moringa, and glucomannan flour. The results showed that the addition of more moringa flour to the food can increase the percentage of antioxidant activity[15].

Wahyuningsih (2023) revealed that the substitution of Moringa leaf flour influences the color, aroma, taste, texture, insoluble dietary fiber, soluble dietary fiber, and total dietary fiber of analog rice ($p<0.05$). The organoleptic test showed that the panelists preferred analogous rice in P2 with the addition of 2% moringa flour. The results of the dietary fiber analysis were insoluble dietary fiber 11.16 - 13.65%, soluble dietary fiber 0.60 - 0.99%, and total dietary fiber 11.80 - 14.62%[16]. Cooking rice is the process of processing rice using some cooking stages using various cooking equipment. Cooking rice can also be done using cooking utensils such as pans and steamers which are cooked by steaming. A rice cooker is one of the modern rice cooking equipment that is widely used[17]. Studies concerning the effects of analog rice cooking techniques on the level of preference are still limited. Therefore, this present study aims to find out the effect of rice cooking techniques on the level of preference (texture, taste, color, aroma, and overall appearance) and the fluffiness level of rice from analog rice made from sorghum and mocaf which are substituted with moringa and glucomannan which are expected to have a low glycemic index and rich in antioxidants as an alternative functional food for food diversification.

METHODS

This experimental research used a Completely Randomized Design (CRD) with two treatments and three repetitions. It aims to identify the effect of cooking techniques on the level of preference for analog rice. The control treatment was C4 rice. This trial activity was carried out in November-December 2022 at the Food Processing Laboratory at Alma Ata University, Yogyakarta. This research obtained an approval from the Ethics Committee of Alma Ata University. Panelists who take part in the sensory evaluation test process filled out informed consent first before data collection (No: KE/AA/XII/10968/EC/2022).

Table 1. Treatment groups

Type of rice	Cooking technique	Repetition		
		1	2	3
A	R	AR_1	AR_2	AR_3
	K	AK_1	AK_2	AK_3
C	R	CR_1	CR_2	CR_3
	K	CK_1	CK_2	CK_3

Notes: A= Analog rice; C= C4 rice; R= Rice cooker; K= Steamer.

This research involved 25 panelists. The sample in this study was analog rice made from sorghum and mocaf which were substituted with moringa and glucomannan. The panelists were students from the Nutrition Program of Alma Ata University, Yogyakarta. Before the sensory evaluation test, the panelists received training to understand certain sensory properties. They had attended advanced culinary nutrition courses to study sensory testing material. The criteria of the panelist covered 1) being physically and mentally healthy and having no allergies; 2) not in conditions of sick, empty stomach, or hungry; and 3) volunteering as a panelist. The independent variable was analog rice cooking techniques (steamer and rice cooker), while the dependent variable was the sensory evaluation or level of product preference/acceptance based on the indicators of texture, aroma, taste, color, overall appearance, and fluffiness levels of analog rice.

Hedonic test analysis was carried out for the sensory evaluation of analog rice and C4 rice. The sample was tested randomly with a certain code and each panelist was given one sample at a time. Panelists filled in the results in the provided sheet. The results covered the categories of color, taste, aroma, texture, overall appearance, and fluffiness levels expressed in the form of a 5-point scale, where 1 = strongly disagree; scale 2 = disagree; scale 3 = neutral; scale 4 = agree; and scale 5 = strongly agree. This study used a 5-point scale as it is a relatively simple scale but has quite good sensitivity in terms of assessment[18]. The preference level was tested by preparing the sample, namely analog and C4 rice cooked using a rice cooker and a steamer. Each treatment used 15 grams of rice stored in a coded small plastic cup. The samples were placed on the table along with a glass of mineral water, a pen, a form, and a questionnaire. The panelists first filled in their identity and willingness to

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become a panelist on the form and questionnaire. Then the panelists assessed their preference for texture, aroma, taste, color, overall appearance, and fluffiness level by observing, looking at, and tasting the samples by giving scores on the questionnaire sheet. After that, panelists were advised to drink water to neutralize again before tasting and observing the next sample.

This research used samples of C4 rice and analog rice. Analog rice was made from sorghum and mocaf substituted with moringa and glucomannan. The cooking techniques used a rice cooker and a steamer. The analog rice was first soaked in water for 10 minutes with a ratio of 1:2. After soaking, the sample was drained and then cooked for ± 13 minutes using a steamer. Meanwhile, the analog rice was not soaked but was immediately cooked with a ratio of 1:1 and cooked for ± 10 minutes using a rice cooker. For C4 rice, was washed 3 times and then soaked in water first then steamed half-cooked in a ratio of 1:2 for ± 10 minutes then steamed again for ± 15 minutes[17]. For the cooking technique using a rice cooker, C4 rice was washed 3 times and cooked using a rice cooker in a ratio of 1:2 for ± 20 minutes. The analog rice was produced at the University of Mataram, and the researchers ordered the analog rice using the analog rice formulation in previous research and the analog rice sample used was the P2 analog rice (2% addition of Moringa flour) as the sample with the best treatment results based on the previous sensory test[19]. The nutrition content and complete formulation for making P2 analog rice are presented in Tables 2 and 3.

Table 2. Nutrition content of analog rice

Nutrient	Value
Protein (%)	9.18
Fat (%)	1.14
Carbohydrate (%)	81.23
Water content (%)	8.16
Ash content (%)	0.28

Table 3. Analog rice formulation

Treatment code	Sorghum flour (gram)	Mocaf (gram)	Moringa flour (gram)	Glucomannan (gram)
P2 (2%)	88	10	2	0,1

Table 4. General characteristic of the panelist

Characteristics of Panelist	Type of characteristics	Number of panelists	Percentage
Sex	Female	25	100%
Age	20 years	5	20%
	21 years	7	28%
	22 years	4	16%
	23 years	9	36%
Semester	Semester 6	12	48%
	Semester 4 (Level transfer)	13	52%

The data obtained from the preference-level testing were processed and presented systematically. The analysis was carried out to compare with relevant theories. Data processing used SPSS and Microsoft Excel programs. The effect of rice cooking techniques on sensory evaluation (texture, taste, color, aroma, and overall appearance) and the fluffiness level were tested using the Mann-Whitney test with a confidence interval (CI) of 95% and $\alpha < 0.05$.

RESULTS AND DISCUSSIONS

The appearance of analog rice and C4 rice cooked using a rice cooker and a steamer is presented in Figure 1. The results show significant differences in the color of the rice. Analog rice made from composite flour added with Moringa flour has a dominant green color compared to C4 rice which appears to have a white color.

Based on the Table 5, the comparison of preference levels for analog rice cooked using a rice cooker and a steamer shows an influence on the level of color preference ($p=0.004$), texture ($p=0.002$), overall appearance ($p=0.006$) and fluffiness ($p=0.004$). However, the cooking techniques do not influence the taste ($p=0.396$) and aroma ($p=0.058$) of analog rice. Analog rice cooked using a steamer is preferable to analog rice cooked using a rice cooker in terms of color, texture, overall appearance, and fluffiness ($p<0.05$). Based on the results of comparing the preference level for C4 rice cooked using a rice cooker and steamer, there is no influence on the level of color preference ($p=0.607$), taste ($p=0.482$), texture ($p=0.578$), aroma ($p=0.216$), overall appearance ($p=0.701$), and fluffiness ($p=0.891$). Cooking techniques do not have a significant influence in all categories of color, taste, texture, aroma, overall appearance, and fluffiness ($p>0.05$) of C4 rice. Panelists who tested the level of preference for the cooking technique using a rice cooker and a steamer gave a score of 4 (Agree) or 5 (strongly agree).

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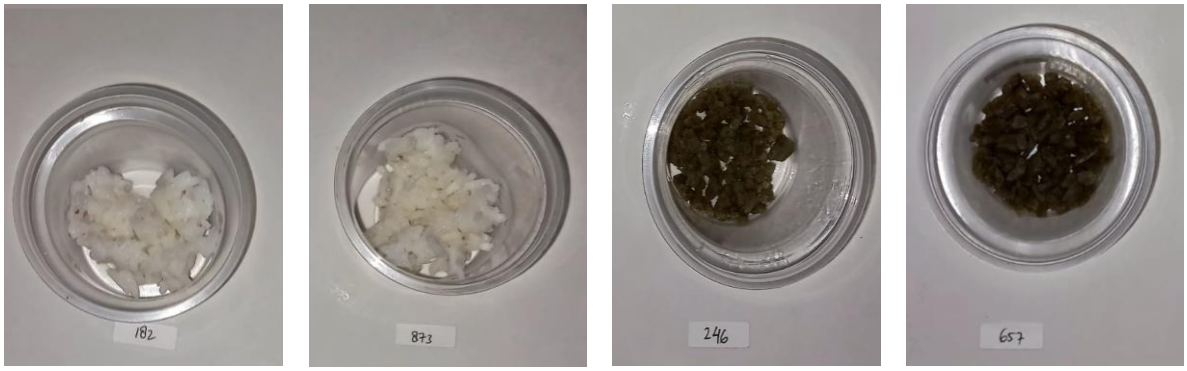

(a) (b) (c) (d)

Figure 1. Analog rice and C4 rice
Notes: (a) C4 rice from a rice cooker, (b) C4 rice from a steamer, (c) analog rice from a rice cooker, (d) analog rice from a steamer

Table 5. Results of comparison of preference levels between analog rice cooked using a rice cooker and a steamer

Treatment	Color		Taste		Texture		Aroma		Overall Appearance		Fluffiness	
	Median (IQR)	p	Median (IQR)	p	Median (IQR)	p	Median (IQR)	p	Median (IQR)	p	Median (IQR)	p
AR	2 (2-3)	0.004	2 (2-2.5)	0.396	2 (2-2.1)	0.002	2 (1.5-2)	0.058	2 (2-3)	0.006	2 (2-3)	0.004
AK	4 (3-4)		2 (2-2.1)		3 (2-4)		2 (2-3.5		3 (2-4)		3 (2-4)	
CR	4 (4-5)	0.607	4 (4-5)	0.482	4 (4-5)	0.578	4 (4-5)	0.216	4 (4-5)	0.701	4 (3-5)	0.891
CK	4 (4-5)		4 (3-5)		4 (3.5-4)		4 (3-5)		4 (3-5)		4 (4-4.5)	

Notes**:** AR, analog rice from a rice cooker; AK, analog rice from a steamer; CR, C4 rice from a rice cooker; CK, C4 rice from a steamer**;** IQR, interquartile range.

Color

The cooking techniques using a steamer and a rice cooker for C4 rice are not much different in terms of color. There is a big difference between analog rice cooked using a rice cooker and a steamer. Panelists preferred similar rice in the AK treatment. The rice has a brighter green color in the AK treatment than in the AR treatment, namely a slightly faded green color. The green color of analog rice comes from Moringa leaf flour which is one of the raw materials for analog rice production. This green color is produced by chlorophyll compounds which are natural green leaf pigments found in leaves. This is consistent with research that participants' preference for colored Moringa leaf cake reaches 63.3%. Moringa leaf colored cakes often have a greenish color which is different from the color of cakes in general and is very attractive. Moringa leaves appear green as they contain chlorophyll compounds and this can affect the color of analog rice[20]. Other research reveals that the color of rice can be influenced by some factors including water absorption capacity. Besides, the chlorophyll content is influenced by the heating process so it is easily damaged. The protein in the chlorophyll-protein complex changes properties when heated, forming pheophytin which is a type of chlorophyll structure, and the color is no longer green due to the loss of magnesium metal and replaced with hydrogen ions[21].

Taste

Cooking analog rice and C4 rice using a rice cooker and steamer does not show a significant difference in taste preference. Panelists prefer the taste of C4 rice with CR or CK treatment because this treatment has the same taste as regular rice. In the AR and AK treatments, the taste of the analog rice is slightly bitter due to the addition of 2% moringa flour so the panelist does not like it. Moringa leaves have a unique taste due to the presence of tannins. If swallowed, tannins can produce a bitter taste and astringency because cross-links form between tannins and proteins or glycoproteins in the oral cavity, causing dryness, wrinkles, or astringency. Previous research concerning the panelists' level of preference for side dishes made from Moringa leaves, namely cakes, crackers, stir-fries, and *botok* shows that 40% of panelists have the lowest level of preference for side dishes made from Moringa leaves. Leaf products such as cakes, crackers, stir-fries, and *botok* can have different color percentages. The highest percentage of 70% can be found in Moringa leaf crackers. This can be because Moringa leaf supplements are a new product and people are not used to consuming them. The taste of Moringa leaves is less popular and tends to be unpleasant and bitter[22]. The finding of this present study is in line with other studies that the addition of Moringa flour lowers the panelists' scores. This is because Moringa contains tannins which cause a bitter taste[20]. The greater the addition of Moringa flour, the lower the assessment by the panelists as the more Moringa flour, the stronger the taste of Moringa leaves making it less attractive to consumers[23].

Texture

Cooking C4 rice using a rice cooker and a steamer does not show a significant difference in the level of

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texture preference. The analog rice cooked using a rice cooker and steamer has significant differences. Panelists preferred the analogous rice texture in the AK treatment as it has a slightly springy texture and is less sticky compared to the AR treatment with a fluffier and slightly sticky texture. Amylose is a parameter that determines the quality of doneness and taste. Rice with a low glycemic index has a consistency similar to steamed rice. Rice with high amylose becomes dry when cooked and produces a hard texture when cooled, while rice with low amylose has a soft texture[24]. This finding is in line with other research that a higher amylose content can make the texture of rice harder and softer. However, high levels of amylopectin can cause the texture of rice to become fluffier and stickier. Fat can also affect the texture of analog rice as fat or oil can weaken the dough where the hardness of extruded products can be lowered and increase the plastic properties of the product[25].

Aroma

Cooking techniques using a rice cooker for analog rice and C4 rice do not show a significant difference compared to using a steamer in terms of aroma preference. Panelists did not like the aroma of analog rice in the AK and AR treatments because they had an unpleasant aroma due to the addition of moringa flour to the analog rice. Moringa has a characteristic unpleasant aroma as it contains the lipoxidase enzyme which breaks down fat into compounds that cause an unpleasant smell. The addition of Moringa flour can affect the aroma of Moringa porridge due to its lipoxidase enzyme. Moringa leaves contain essential oils and lipoxidase enzymes which cause an unpleasant aroma[26]. The hedonic test and sensory evaluation of aroma showed that the use of fresh Moringa leaves was considered similar to the aroma of rice and was slightly preferred by panelists compared to the use of Moringa flour. This is in line with other research that panelists do not prefer a type of rice that uses Moringa flour compared to using fresh Moringa and low *sargassum sp.* This indicates that the use of raw Moringa leaves can result in a rice-like aroma with a slight moringa aroma[27].

Overall Appearance

The overall appearance is a combined assessment of the panelists' overall assessment results covering color, taste, texture, and aroma. The use of a rice cooker to cook C4 rice does not show a significant difference with a steamer on the overall level of preference. The use of a rice cooker to cook analog rice has significant differences compared to a steamer because, in the AR and AK treatments, the rice has a pleasant aroma and a slightly bitter taste. It is in line with previous research that the panelists have different preferences for each treatment. The panelists objectively assessed the sample. Overall appearance can also be defined as a combination of visible assessments such as color, aroma, and taste[28]. Based on four test parameters (color, aroma, taste, texture), the sensory test showed that on average, test participants have a better preference for crackers substituted with banana flour. Thus, the substitution of Moringa leaves for analog rice correlates with overall panelist acceptance[29].

Fluffiness

Cooking C4 rice using a rice cooker and a steamer does not show a significant difference in the level of fluffiness because the rice produced is equally fluffier. Cooking analog rice using a rice cooker and a steamer shows a significant difference. Panelists preferred the level of fluffiness of analogous rice from the AK treatment because the texture is slightly soft compared to the AR treatment which is fluffier and stickier. Fluffiness is an indicator for assessing the combination of stickiness and hardness or softness of the rice. The assessment of the fluffiness of rice is based on the stickiness and hardness of the texture of the rice by tasting and massaging with fingers. It is in line with other studies that higher levels of amylose can make the texture of rice harder and more tender. The higher the amylopectin level, the fluffier and stickier the rice[30]. Besides, in the cooking process, the ratio of water used affects the properties of the resulting material. Materials that absorb a lot of water cause an increase in the weight of the material as well as the length, width, and thickness of the material[30].

CONCLUSIONS

Cooking techniques influence the sensory tests (color, texture, aroma, overall appearance) and the fluffiness level between analog rice and C4 rice. The steam cooking technique influences the level of preference and the level of fluffiness of analog rice. Cooking analog rice using a steamer is highly recommended to increase consumer acceptance. Further studies concerning ways to remove the unpleasant aroma from analog rice made from sorghum and mocaf substituted with moringa and glucomannan are needed.

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CONFLICT OF INTEREST AND FUNDING DISCLOSURE

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AUTHOR CONTRIBUTIONS

NVS, ASA, SS, VA: conceived the experimental design of the study, methodology, supervision, writing–review, and editing; NVS, ASA: methodology, writing–original draft; RTSD, SR, FMK: data analysis, product development, and experimented.

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