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The Effect of Cooking Techniques on the Texture and Color of Analog Rice Made from Sorghum, Mocaf, Glucommanan, and Moringa Flour

Pengaruh Teknik Penanakan terhadap Sifat Fisik (Tekstur dan Warna) Nasi dari Beras Analog Berbahan Baku Tepung Sorgum, Mocaf, Glukomanan, dan Kelor

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ABSTRACT

Background: Rice cooking techniques determine the physical properties acceptance. A healthy diabetic diet such as the consumption of analog rice with the benefits of functional food can help control blood sugar. Thus, the physical properties of analog rice are important.
Objectives: To determine the effect of cooking techniques on the physical properties (texture and color) of analog rice made from sorghum, Modified Cassava Flour (Mocaf), glucomannan, and moringa flour.
Methods: This experimental study used a completely randomized design (CRD). It used two rice cooking treatments (steamer and rice cooker) on analog rice and C4 rice with two repetitions of both treatment and analysis. This research was conducted during October-November 2022. The physical properties of rice, namely texture and color were tested using a texture analyzer and chroma meter. Data were analyzed statistically using the Mann-Whitney test with the help of SPSS version 23.0.
Results: The cooking technique did not affect the rice texture in terms of hardness bite 1, springiness, and chewiness of both analog rice and C4 rice (p-value>0.05). However, the cooking technique affected the color of analog rice (p-value<0.05), but it did not apply to C4 rice (p-value>0.05).
Conclusions: Both steaming and rice cooker techniques do not affect the physical texture of analog rice and C4 rice. However, the cooking techniques significantly influence the color of analog rice. The addition of moringa leaves to analog rice shows a significant difference in the color of both analog rice and C4 rice.

INTRODUCTION

Diabetes Mellitus (DM), both type 1 and type 2, is a type of degenerative disease with a high prevalence in Indonesia[1]. The 2018 Basic Health Research reported the prevalence of DM reaching 8.5%. This result is higher compared to the same research conducted in 2013, namely 6.9%[2]. DM is a non-communicable disease (NCD) that can attack almost all parts of the human body and cause complications. DM is characterized by elevated levels of blood glucose, namely random blood sugar levels equal to or more than 200 mg/dL and fasting blood sugar levels equal to or more than 126 mg/dl[3]. Diet is important for DM patients where they need to consume foods with a low glycemic index which can reduce blood glucose levels[3]. The glycemic index value of foods can be influenced by processing methods, such as heating (steaming, boiling, frying) and grinding to reduce particle size[4]. The increase in blood glucose levels is influenced by the amount of glucose produced from starch absorbed and digested by the body. Carbohydrates with slow digestibility are good for DM patients[5]. Analog rice is a functional food with a low glycemic index so it can be used as an alternative source of carbohydrates for DM patients. Analog rice is a processed product made from non-rice ingredients and has a shape similar to rice. Analog rice can be formulated to obtain the desired physical form and nutritional content by using some food ingredients[6–9].

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The main component of rice is starch granules consisting of amylose and amylopectin which can affect the quality of rice. Amylose in granules forms a crystalline structure, while branched amylopectin forms an amorphous (porous) structure. Amylose content, type of starch, water-to-rice ratio, and cooking techniques can influence the texture of rice[10]. The most commonly used cooking technique in Indonesia is *peliwetan* using a rice cooker or traditional steamer.

Texture can influence the taste of an ingredient, both in fresh and processed foods. The taste of a processed food can be influenced by its texture and consistency[11]. Generally, the tool used to analyze texture profiles is the texture analyzer. Color is a perception as a result of sensing light after interacting with an object. In terms of foods, color is important in food acceptance[12]. Color testing of a material can be done using a chromameter[13,14].

Wahyuningsih (2022) has analyzed food fiber and conducted organoleptic tests of analog rice made from sorghum, Modified Cassava Flour (Mocaf), glucomannan, and moringa flour. The result showed that panelists preferred analog rice P2 (2%)[15,16]. However, the study did not discuss the effects of cooking techniques on the physical properties of rice using laboratory equipment. Therefore, this present study aims to identify the effect of cooking techniques on the physical properties (texture and color) of analog rice made from sorghum, mocaf, glucomannan, and moringa flour. This study is expected to obtain a low glycemic index content so that it can be used as an alternative functional food for DM patients.

METHODS

This research used a quasi-experimental method with a Completely Randomized Design (CRD). This study consisted of two treatments, namely cooking rice using a steamer and rice cooker, and two samples, namely C4 rice and analog rice made from sorghum, mocaf, glucomannan, and moringa flour, with two repetitions of both treatment and analysis. The treatment design can be seen in Table 1. This research was carried out in October – November 2022 at the Laboratory of the Faculty of Agricultural Technology, Gajah Mada University. Preparation of analog rice samples was carried out at the Laboratory of the Faculty of Food Technology, University of Mataram. The independent variable was cooking techniques using conventional cooking and a rice cooker. The dependent variable was the physical properties (texture and color) of the analog rice. The process of making analog rice had been explained in previous research publications using an analog rice sample of P2 (2%) and the best treatment based on the sensory test was obtained from the addition of Moringa flour[17].

Table 1. Treatment group

Type of rice	Cooking technique	Treatment	
		1	2
A	R	AR_1	AR_2
	K	AK_1	AK_2
C	R	CR_1	CR_2
	K	CK_1	CK_2

Notes: A = Analog rice; C = C4 rice; R = Rice cooker; K = Traditional steamer

The cooking process used two different tools, namely a rice cooker and a steamer. The cooking process was carried out based on the results of the researchers' pre-experiments. The first stage was soaking the analog rice in water for 10 minutes with a ratio of 1:2, and then drained. The analog rice was cooked using a steamer for ±13 minutes. Meanwhile, for cooking the analog rice using a rice cooker, the rice was immediately cooked with a water ratio of 1:2 for ±10 minutes without soaking. The C4 rice was washed 3 times and then cooked using two different cooking techniques, namely steaming and rice cooker. In the first technique, the rice was washed and soaked in water first, then half-cooked in 1:2 water for ±10 minutes. Then, it was steamed for ±15 minutes. Meanwhile, for cooking the rice using a rice cooker, it used 1:2 water and it was cooked for ±20 minutes. Cooked rice was stored in a container covered with aluminum foil. Then the samples were taken to the laboratory with an estimated travel time of 30 minutes[18].

The physical properties analysis process was carried out in the Gajah Mada University laboratory and carried out by laboratory staff. The physical properties analysis used a CT-3 texture analyzer with the working principle of applying a compressive force to the sample, and then producing a texture profile in the form of a graph that connects force with distance[19]. Analysis of color properties was carried out using a CR-400 chromameter which can describe colors through color notation. Color notation is an objective way to determine or describe a type of color. The most commonly used color notation system is the Hunter notation system which consists of three parameters for describing colors, namely L, a, and b[20].

The data obtained from laboratory tests were processed and presented systematically based on the existing theory. The physical properties of texture and color data were tested for data normality first. If the data are normally distributed, then the test can use the Independent Samples T-test. This test aims to see the difference in the averages of two unpaired samples. Data processing used SPSS version 23.0 and Microsoft Excel. This research received ethical approval from the Alma Ata University Ethics Commission (No: KE/AA/XI/10966/EC/2022).

RESULTS AND DISCUSSIONS

The visual appearance of analog rice and C4 rice from a rice cooker and steamer can be seen in Figure 1. In terms of texture, analog rice from a rice cooker had a fluffier texture, while steamed analog rice had a springy texture. C4 rice from a rice cooker had the same texture as steamed C4 rice, namely fluffier. Both the analog rice

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from a rice cooker and steamer had a green color. However, analog rice from a rice cooker has a bright green color, while analog rice from a steamer has a dark green color. C4 rice from a rice cooker and C4 rice from a steamer had a white color. The picture of the analog rice and C4 rice is presented in Figure 1.

(a) Analog rice from a rice cooker (b) Analog rice from a steamer (c) C4 rice from a rice cooker (d) C4 rice from a steamer

Figure 1. Analog rice and C4 rice

Texture

The results of tests on the physical texture of analog rice and C4 rice using a rice cooker and steamer are presented in Table 2. The test used the Independent Samples T-test and obtained a P-value of 0.111 for the hardness bite indicator indicating that there is no difference in hardness bite 1 between analog rice from the rice cooker and steamer. The results of statistical tests on the springiness indicator obtained a P-value of 0.059 meaning that there is no difference in springiness between analog rice from the rice cooker and steamer. The chewiness indicator obtained a P-value of 0.557 meaning that there is no difference in chewiness between analog rice from the rice cooker and steamer. Thus, there is no influence of cooking technique on hardness bite 1, springiness, and chewiness in analog rice from the rice cooker and steamer. Table 2. Test Results for Physical Texture Properties of Rice from Analog Rice and C4 Rice Using Rice Cooker and Steaming Techniques.

Table 2. Results of physical texture properties of analog rice and C4 rice from a rice cooker and steamer

Treatment	Hardness Bite 1		Springiness		Chewiness	
	Mean ± SD	p-value	Mean ± SD	p-value	Mean ± SD	p-value
AR	116.20 ± 28.927	0.111	0.68 ± 0.010	0.059	29.07 ± 5.933	0.557
AK	59.80 ± 2.467		0.75 ± 0.024		25.78 ± 3.035	
CR	18.37 ± 2.128	0.096	0.61 ± 0.007	0.294	3.45 ± 0.569	0.085
CK	28.06 ± 4.055		0.62 ± 0.007		5.44 ± 0.672	

Notes: AR: Analog rice from a rice cooker, AK: Analog rice from a steamer, CR: C4 rice from a rice cooker, AK: C4 rice from a steamer

The statistical test results on the control sample of C4 rice on all indicators of hardness bite 1, springiness, and chewiness obtained a p-value >0.05. This means that there is no difference in hardness bite 1, springiness, and chewiness between C4 rice from a rice cooker and steamer. Therefore, cooking techniques do not influence hardness bite 1, springiness, and chewiness in C4 rice from a rice cooker and steamer. The comparison between analog rice and C4 rice from a rice cooker and steamer obtained the same results, namely cooking techniques do not influence the texture of analog rice and C4 rice.

Hardness bite 1

Hardness is the pressure force needed to break down a food product. Hardness is indicated by the maximum force on the first compression in units of kilogram-force (KGF)[21]. In this study, the results of statistical tests on the indicator of hardness bite 1 obtained a p-value of 0.111 for analog rice and 0.096 for C4 rice. This means that there is no difference between analog rice and C4 rice from a rice cooker and steamer. Therefore, cooking techniques do not influence the hardness of the first bite of rice from analog rice and C4 rice.

Theoretically, the hardness value of the product is influenced by the water content of the food. The higher the hardness value of a product, the higher the water content[22]. Djidin (2023) revealed that the water content of analog rice from a rice cooker and steamer had no difference[23]. Thus, it can be said that the cooking technique does not influence the water content of analog rice as well as the hardness level.

Springiness

Springiness is a parameter to see the ability of a food product to return to its initial position. The results of statistical analysis tests on springiness indicators obtained a p-value of 0.059 for analog rice and 0.294 for

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C4 rice. This means that there is no difference between analog rice and C4 rice from a rice cooker and steamer. Thus, cooking techniques do not influence the springiness of analog rice and C4 rice.

The springiness value is influenced by the amylose and amylopectin content. The higher the amylose content and amylopectin solubility level, the lower the springiness or elasticity properties[24]. The heating process can result in structural changes in amylose and amylopectin. The longer the heating time, the more amylose levels will increase[25]. In this study, the heating time using a rice cooker and steamer did not differ significantly, which made it possible not to cause changes in the structure of amylose and amylopectin in analog rice.

Chewiness

Chewiness is a value obtained from the product of the hardness, cohesiveness, and springiness values in the texture profile analysis (TPA) test. Chewiness is the chewing power or energy required to chew solid food until it can be swallowed[26]. The results of the statistical test for the chewiness indicator obtained 0.557 for analog rice and 0.085 for C4 rice. This means that there is no difference between analog rice and C4 rice from a rice cooker and steamer. Thus, cooking techniques do not influence the chewiness of analog rice and C4 rice.

The chewiness value has a direct relationship with the hardness level of a product as the chewiness value is the result of the multiplication of the hardness, cohesiveness, and springiness values. The higher the hardness value, the higher the chewiness value produced[27]. The results of the statistical tests showed that the hardness bite 1 and springiness values for cooking with a rice cooker and steamer are not significantly different.

Color

The L value is an indicator stating the brightness level with a value of L = 0 meaning black and L = 100 meaning white. The L values in the AR and AK treatment were 34.23 and 22.42 respectively, which means that analog rice had a darker color, close to black. The L values in the CR and CK treatments were 64.26 and 65.09 respectively. This means that C4 rice had a brighter color closer to white. The value a is an indicator of the degree of redness with a positive value (+) meaning red and a negative value (-) meaning green. The a value in the AR, AK, CR, and CK treatment results are negative, namely -1.71, -0.15, -4.10, and -4.17 respectively. This shows that analog rice and C4 rice tend to be green. The b value is an indicator of the degree of blueness with a positive value (+) meaning yellow and a negative value (-) meaning blue. The b value for the AR, AK, CR and CK treatment results was positive, namely 14.73, 12.26, 6.76, and 7.12 respectively. This indicates that analog and C4 rice tend to be yellow.

The L (Lightness) value is a parameter that shows the level of brightness with a value of 0 meaning black and 100 meaning white. The results of statistical tests using the Independent Samples T-test on analog rice obtained a P-value of 0.012, which means that there is a difference between analog rice from a rice cooker and steamer. Thus, cooking techniques influence the level of the black-white color of analog rice. Based on the results of the study, the L indicator shows that the brightness level of analog rice from a rice cooker is higher than analog rice from a steamer.

The a value is an indicator showing a mixture of red to green with an a+ value from 0 to +100 meaning red and an a- from 0 to -80 meaning green. The results of the statistical test for indicator a on analog rice samples obtained a P-value of 0.038. This means that there is a difference between analog rice from a rice cooker and a steamer. Thus, cooking techniques influence the level of red-green color in analog rice. In indicator a, all results obtained from the treatment were negative, which means that all samples showed a green color.

The results of the statistical test for indicator b obtained a P-value of 0.039 for analog rice. This means that there is a difference between analog rice from a rice cooker and a steamer. Therefore, cooking techniques influence the level of yellow-blue color of analog rice. The b value is a parameter that shows a mixture of blue to yellow with a +b value from 0 to +70 meaning yellow and a -b value from 0 to -70 meaning blue. Based on the research results, all samples obtained +b results, which means that the samples had a yellow color.

Table 3. Results of physical color property test of analog rice and C4 rice from a steamer and a rice cooker

Treatment	L		a		b	
	Mean ± SD	p-value	Mean ± SD	p-value	Mean ± SD	p-value
AR	34.23 ± 0.940	0.012	-1.71 ± 0.438	0.038	14.73 ± 0.000	0.039
AK	22.42 ± 1.576		-0.15 ± 0.035		12.26 ± 0.707	
CR	64.26 ± 0.491	0.189	-4.10 ± 1.099	0.956	6.76 ± 0.696	0.543
CK	65.09 ± 0.335		-4.17 ± 0.912		7.12 ± 0.742	

Notes: AR: Analog rice from a rice cooker, AK: Analog rice from a steamer, CR: C4 rice from a rice cooker, AK: C4 rice from a steamer, L: Lightness, a: Redness, b: Yellowness.

The results of the physical color properties of analog rice and C4 rice from a rice cooker and steamer are presented in Table 3. The test used an Independent Samples T-test and obtained a p-value of 0.012 for the L indicator in analog rice. This means that there is a difference in the L value between analog rice from a rice cooker and a steamer. Thus, cooking techniques influence the level of black-white color in analog rice. The

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results of the statistical test for the indicator a obtained a p-value of 0.038. This means that there is a difference between analog rice from a rice cooker and a steamer. Thus, cooking techniques influence the level of red-green color in analog rice. The results for indicator b obtained a p-value of 0.039. This means that there is a difference between analog rice from a rice cooker and a steamer. Therefore, cooking techniques influence the level of yellow-blue color in the analog rice. The color produced in analog rice comes from the material used, namely Moringa flour which is in line with Husnita (2017) that the use of Moringa leaves has a significant effect on the color °Hue of analog rice[28].

The results of the Independent Samples T-test obtained a p-value of 0.189 for the L indicator in C4 rice. This means that there is no difference between C4 rice from a rice cooker and a steamer. Thus, cooking techniques do not influence the level of black-white color in C4 rice. The results of the statistical test for the indicator a obtained a p-value of 0.956. This means that there is no difference between C4 rice from a rice cooker and a steamer. Thus, cooking techniques do not influence the level of red-green color in C4 rice. The results for indicator b obtained a p-value of 0.543, which means that there is no difference between analog rice from a rice cooker and a steamer. Thus, cooking techniques do not influence the level of yellow-blue color in the C4 rice.

In terms of appearance, the color of analog rice from rice is bright green, while analog rice from steamer has a dark green color. This is influenced by the L, a, and b values of analog from a rice cooker which show stronger green and yellow colors so the brightness level is also higher. Meanwhile, analog rice from a steamer has lower green and yellow colors so the brightness level is also lower. The addition of moringa flour in the rice-making process makes the rice green. Moringa leaves contain a natural green coloring substance called chlorophyll. Based on the results of statistical tests, cooking techniques influence the color level of analog rice. Theoretically, the chlorophyll content is easily damaged which is influenced by the heating process during material processing. The proteins in the chlorophyll-protein complex compound are denatured and form pheophytin during the heating process. Pheophytin is a form of chlorophyll structure that has changed color due to the loss of Mg metal and is replaced by hydrogen ions[29]. In this study, analog rice from a rice cooker has direct contact with the heat source, namely the rice cooker. Meanwhile, when steamed, analog rice gets its heat source only from water vapor. Thus, the chlorophyll in analog rice from a rice cooker is more easily damaged.

CONCLUSIONS

Cooking techniques both using a steamer and a rice cooker do not influence the texture of analog rice and C4 rice. However, they have a significant influence on the color properties of the rice. The addition of Moringa leaves to analog rice provides a striking difference in color between analog rice and C4 rice. Future studies concerning temperature measurements during the rice cooking process using a thermometer are needed. Besides, studies regarding amylose and amylopectin levels to determine the effect of cooking temperature and amylose and amylopectin levels on the physical properties of analog rice made from sorghum, mocaf, glucomannan, and moringa flour are also needed.

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CONFLICT OF INTEREST AND FUNDING DISCLOSURE

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AUTHOR CONTRIBUTIONS

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

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