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Analysis of Phytic Acid and Tannin Content of Local Food-Based Analogue Rice as an Alternative Functional Food

Analisis Kandungan Asam Fitat dan Tanin Nasi dari Beras Analog Berbasis Pangan Lokal sebagai Alternatif Pangan Fungsional

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ABSTRACT

Background: Analog rice is an alternative food diversification that has rice-like characteristics. Various food ingredients can be utilized to produce analog rice as functional and healthy foods.
Objectives: This study aims to identify the effect of cooking techniques on the phytic acid and tannin content of analogous rice (made from sorghum, mocaf, glucomannan, and moringa flour) and C4 rice.
Methods: This experimental research used RAL for two treatments, namely cooking rice with a steamer and a rice cooker. This research was conducted in October-November 2022 at the Chem-mix Pratama Laboratory. The sample used analog rice and C4 rice for phytic acid and tannin content analysis using the Infrared Spectrophotometry and UV-S Spectrophotometry methods.
Results: The highest phytic acid content of analog rice cooked using a rice cooker and a steamer was 6.64 mg and 4.75 mg respectively. The highest average tannin content of analog rice cooked using a rice cooker and a steamer was 18.35 mg and 19.55 mg respectively. The highest phytic acid content of C4 rice cooked using a rice cooker and a steamer was 7.43 mg and 9.01 mg respectively. The tannin content of C4 rice cooked using e rice cooker and a steamer was 4.45 mg and 9.11 mg respectively.
Conclusions: The phytic acid content of analog rice is lower than in C4 rice. The tannin content of analog rice is higher than C4 rice. Tannin content reduction in analog rice needs to be studied further.

INTRODUCTION

Rice has become the main source of carbohydrates for some communities in Indonesia. The glycemic index value of white rice is relatively high, namely 82. Consuming foods with a high glycemic index for a long time can cause various diabetes complications and insulin resistance. Thus, foods with a low glycemic index can be used as alternative functional foods and support food diversification programs such as producing analog rice[1]. Analog rice can be produced from various ingredients molded to resemble rice grains with modified nutritional content. Analog rice is a food diversification product and can be consumed similarly to staple foods such as rice. Utilization of local ingredients as a source of carbohydrates to produce analog rice which is as nutritious as or even more nutritious than white rice[2]. Analog rice can be produced using extrusion technology by mixing food ingredients such as sorghum and mocaf (modified cassava flour) to make analog rice and molding it to resemble rice grains[3,4].

Sorghum contains antioxidants, especially those derived from tannins[5]. Tannins are polyphenolic compounds that can have both positive and negative effects. Tannins can affect the color, taste, and nutritional value of seeds and their products. Tannins are also antioxidants that bind free radicals enabling the body to prevent cell damage and the development of diseases[6]. Phytic acid is an antioxidant and anti-nutrient binding to proteins and minerals and forming bonds that reduce the solubility of the bound compounds. This condition reduces the absorption of minerals and proteins in the body resulting in a decrease in the nutritional value of food[7]. Glucomannan is a mannan-type polysaccharide found in conifers and tubers. Konjac glucomannan,

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derived from the plant Amorphophallus Konjac, is a water-soluble, high molecular weight, non-ionic glucomannan. Indonesia has some botanical sources of glucomannan such as *Morphophillus Ancophyllus Prain/Amorphophorus Mülleri Blume)*[8,9]. *Moringa Oeifera Lamk* belongs to the Moringaceae family which is a medicinal plant containing vitamins. Moringa contains 7 times more vitamin C than oranges, 10 times more vitamin A than carrots, 17 times more calcium than milk, 9 times more protein than yogurt, 15 times more potassium than bananas, and 25 times more iron. much more than spinach[10]. Mocaf is cassava flour *(Manihot Esculenta Krantz)*, a source of carbohydrates that is widely cultivated in Indonesia. Improvement of cassava flour using the fermentation method produces mocaf flour. The controlled fermentation process in mocaf flour production uses Lactic Acid Bacteria (LAB) seeds. Species studied covered *Lactobacillus plantarum* and *Lactobacillus Casei*[3,11].

Phytic acid contains antioxidants and anti-nutritional compounds which have been proven as its disadvantages. Complex compounds such as insoluble proteins can bind to phytic acid. Thus, the formation of protein phytate compounds causes a decrease in protein availability for the body causing a reduction in the nutritional value of the food product. Tannin is a unique polyphenolic compound that can have both positive and negative effects on health. Tannins can affect the color, flavor, and nutritional quality of the products produced. Tannins also function as antioxidants which can bind free radicals enabling the body to avoid cell damage and prevent the emergence of various diseases. Free radicals contribute to damage to proteins, Deoxyribonucleic Acid (DNA) and fats in cells and tissues. Studies concerning the content of tannin and phytic acid as anti-nutritional substances in analog rice products made from sorghum flour, mocaf, moringa and glucomannan have never been done. Thus, this present study aims to analyze the phytic acid and tannin content in analog rice products and identify whether cooking techniques influence analog rice and C4 rice.

METHODS

This experimental research used RAL for two treatments, namely cooking rice with a steamer and a rice cooker. It used two samples, namely analog rice made from sorghum flour, mocaf, glucomannan, and moringa flour, and C4 rice with two repetitions of each (Table 1). This research was carried out in October-November 2022 at the Che-mix Pratama Laboratory to find out the phytic acid and tannin content. The production of analog rice was carried out in the Food Technology Laboratory of the Faculty of Agriculture, Mataram University. Meanwhile, the process of cooking analog rice and C4 rice was carried out in the Culinary Laboratory of Alma Ata University. The samples used analog rice made from sorghum flour, mocaf, glucomannan and moringa, and C4 rice. The development of this analog rice product is a modification based on previous research[12,13]. The independent variable in this research was cooking techniques using a steamer and a rice cooker, while the dependent variable was the analysis of phytic acid and tannin content.

Table 1. Research Treatment

Type of Rice	Cooking Techniques	Repetition		
		1	2	3
Analog Rice	R	AR_1	AR_2	AR_3
	K	AK_1	AK_2	AK_3
C4 Rice	R	CR_1	CR_2	CR_3
	K	CK_1	CK_2	CK_3

R: rice cooker, K: steamer, AR: analog rice cooked using a rice cooker, AK: analog rice cooked using a steamer, CR: C4 rice cooked using a rice cooker, CK: C4 rice cooked using a steamer

This research used some tools and materials such as scales, basins, mixers, extruder machines, steamers, and cabinet dryers as well as sorghum flour, mocaf flour, glucomannan flour, moringa flour, and water[14,15]. The preparation covered procuring samples in the form of analog rice and C4 rice. The analog rice formulation referred to the previous research with the best treatment of P2 (2%) with ingredients of 88 g sorghum flour, 10 g mocaf flour, 2 g moringa flour, and 0.1 g glucomannan flour[16]. The white rice used C4 rice. The production of analog rice was based on previous research[17].

First, the production of analog rice started with mixing all the flour according to the treatment and then stirring until smooth. The mixture of ingredients was added with 50% water and 2% oil from the weight of the flour after mixing sorghum, mocaf, moringa, and glucomannan flour then stirred to get a semi-wet dough using a mixer. Then, the dough was steamed so that the pre-gelatinization process occurred for 20 minutes at a temperature of 90-100°C. Then, it was ground using an analog rice printer to get cylindrical dough particles with a size of 3-5 mm with rice-like shapes. The dough was then dried using a drying oven at a temperature of 600°C for 5 hours. Dried analog rice was then sorted according to shape and size[18,19].

The analog rice cooking process referred to previous research guidelines[12,13,16]. The process began by soaking the rice in water for 10 minutes with a ratio of 1:2, then cooking using a steamer for ±13 minutes. Meanwhile, when using a rice cooker, the analog rice was immediately cooked in a water ratio of 1:2 for ±10 minutes. For C4 rice, the cooking process began with the rice three times and then cooked using two different cooking techniques. In the cooking technique using a steamer, the washed rice was browned with 1:2 water for ±10 minutes and then steamed for ±15 minutes, while cooking in a rice cooker was done with a ratio of 1:2 water for ±20 minutes. The cooked rice was stored in a container covered with aluminum foil. Then, the samples are taken to the laboratory with an estimated travel time of 30 minutes. This research used descriptive quantitative analysis to measure phytic acid and tannin levels using

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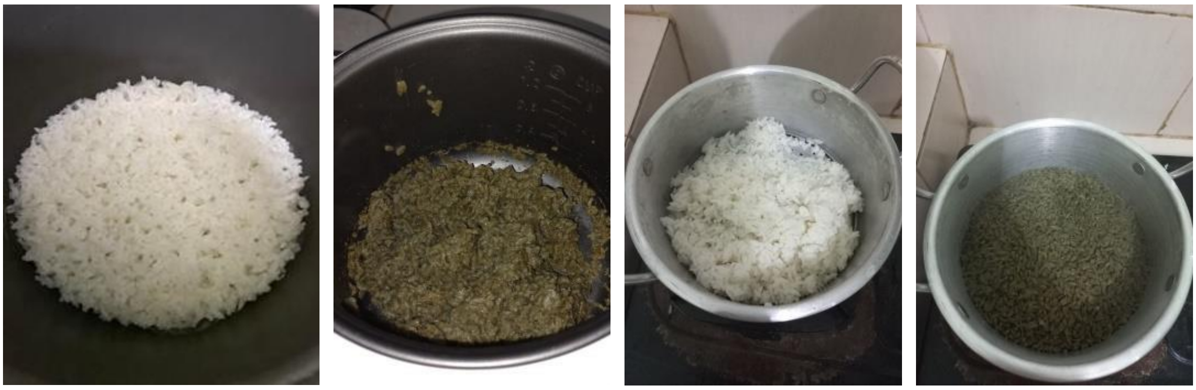
the UV-Vis spectrophotometric method[20]. This research was carried out in accordance with procedures and ethics based on the provisions in the research ethics review obtained from the Ethics Commission of Alma Ata University Yogyakarta (Number: KE/AA/XI/10965/EC/2022).

RESULTS AND DISCUSSIONS

The results of the research using samples of analog rice and C4 rice cooked using a rice cooker and a steamer with two repetitions showed that the highest phytic acid content is in C4 rice cooked using a steamer. The highest tannin content is in analog rice cooked using a rice cooker. Images of analog rice and C4 rice cooked using a rice cooker and a steamer are presented in Figure 1.



(a) C4 rice cooked using a rice cooker. (b) C4 rice cooked using a steamer. (c) Analog rice cooked using a rice cooker. (d) Analog rice cooked using a steamer.

Figure 1. C4 rice and Analog Rice

Phytic Acid Content of Analog Rice and C4 Rice

The phytic acid content of analog rice cooked using a steamer (AK) and a rice cooker (AR). Analog rice cooked using a rice cooker in replication 1 and replication 2 produced 6.7 mg/100 g and 6.5 mg/100 g respectively. Then, analog rice cooked using a steamer in replication 1 and replication 2 produced 3.9 mg/100 g and 3.8 mg/100 g respectively. Meanwhile, C4 rice cooked using a steamer in replication 1 and replication 2 produced 8.9 mg/100 g and 9.1 mg/100 g respectively. C4 rice cooked using a rice cooker in replication 1 and replication 2 produced 6.6 mg/100 g and 6.7 mg/100 g (Table 2) respectively.

Table 2. Phytic Acid Content of Analog Rice and C4 Rice

Treatment	Phytic Acid Content (mg/100 g)		
	Replication 1	**Replication 2**	**Replication 3**
Analog Rice			
AR1	6.71	6.57	6.64
AR2	5.94	6.08	6.01
AK1	3.99	3.85	3.92
AK2	4.62	4.89	4.75
C4 Rice			
CK 1	8.90	9.12	9.01
CK 2	8.23	8.46	8.34
CR 1	6.62	6.74	6.68
CR 2	7.36	7.51	7.43

AR: Analog rice cooked using a rice cooker, AK: analog rice cooked using a steamer, CR: C4 rice cooked using a rice cooker, CK: C4 rice cooked using a steamer

Phytic acid causes difficulties in absorbing natural iron and iron absorbed from foods derived from grains and nuts. Phytic acid is an anti-nutritional compound that, when ingested in large quantities, can inhibit the absorption of important minerals in the body, so the element can be excreted from the body through urine and feces[21,22]. The safe limit for consuming phytic acid in food is 250-800 mg/kg body weight/day[23]. The phytic acid test results of analog rice cooked using a rice cooker and C4 rice cooked using a steamer are 6.71 mg/100 g and 9.12 mg/100 g respectively. This is associated with the cooking method which influences the high and low content of phytic acid in analog rice and C4 rice. The phytic acid levels of analog rice tend to decrease from raw materials to soaking, steaming, and boiling. The results of this study are in line with previous studies that the decrease in phytic acid content is caused by the soaking process which is caused by diffusion and dissolution of phytic acid in analog rice. During soaking, the pH also decreases due to fermentation and acidification by lactic acid bacteria. The soaking process increases the

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phytase enzyme, which is an enzyme capable of hydrolyzing phytic acid into inositol and orthophosphate resulting in the reduction of phytic acid content[24,25].

Tannin Content of Analog Rice and C4 Rice

The tannin content in analog rice cooked with a rice cooker (AR) in replication and replication 2 produced 17.5 mg/100 g and 17.6 mg/100 g respectively. Then, analog rice cooked using a steamer (AK) in in replication 1 and replication 2 produced 19.6 mg/100 g and 19.5 mg/100 g respectively. Meanwhile, the tannin content in C4 rice cooked using a steamer (CK) in replication 1 and replication 2 produced 9.07 mg/100 g and 9.15 mg/100 g respectively. Then, C4 rice cooked using a rice cooker (CR) in replication 1 and replication 2 produced 4.2 mg/100 g and 4.3 mg/100 g respectively (Table 3).

Table 3. Tannin Content of Analog Rice and C4 Rice

Treatment	Tannin Content (mg/100 g)		
	Replication 1	**Replication 2**	**Replication 3**
Analog Rice			
AR1	17.57	17.63	17.6
AR2	18.42	18.29	18.35
AK1	19.60	19.54	19.55
AK2	19.41	19.47	19.44
C4 Rice			
CK 1	8.90	9.12	9.01
CK 2	8.23	8.46	8.34
CR 1	6.62	6.74	6.68
CR 2	7.36	7.51	7.43

AR: analog rice cooked using a rice cooker, AK: analog rice cooked using a steamer, CR: C4 rice cooked using a rice cooker, CK: C4 rice cooked using a steamer

Tannins are nutritional inhibitors affecting the digestibility of protein from sorghum so it needs to be reduced. The protein structure of tannins contains very large molecules, hydroxyl groups, and large hydrophobic rings[24]. Soaking process can reduce tannin content. The soaking process can reduce tannin content. The soaking process is characterized by the dissolution of components such as tannin, phytic acid, and other dissolved substances, changes in the color of the soaking water, and the formation of bubbles on the surface. Water enters sperm cells more easily called absorption. Tannins contain a lot of phenol with polar OH groups which bind with water resulting in changes in the structure of the tannin, causing the tannin to decompose and dissolve and be transported into the water[25].

The decrease in tannin during the cooking process is due to the nature of tannin which is labile to heating and dissolves easily in water resulting in leaching and degradation of tannin molecules and some tannin components which will dissolve into the media. This is in line with previous studies that the decrease in tannin levels occurs due to the processing process. High temperatures can damage tannin molecules and change the chemical properties of these molecules causing a reduction in reactivity and ability to form insoluble complexes with other molecules. High temperatures during the processing process can cause damage to the tannins due to a qualitative change in the molecular structure of the tannins[26].

The decrease in tannin content is caused by water-soluble tannins. The longer the fermentation takes, the longer the sorghum grains will be in contact with water resulting in the decrease in tannin content. The solubility of the tannin component in water can be seen from the brownish color of the soaking water[27]. The safe limit for consumption of tannin content in food is in line with the Acceptable Daily Intake (ADI) value for tannin, namely 560 mg/kg body weight/day[28,29]. This is in line with this research as the tannin content in steamed analog rice and C4 rice is 9.12 mg/100 g and 9.15 mg/100 g respectively. This means that the tannin content in analog rice and C4 rice is safe to consume because it is still below the safe limit for tannin consumption per day.

CONCLUSIONS

The phytic acid content of analog rice is lower than C4 rice. The tannin content of analog rice is higher than C4 rice. Studies concerning the modification of composite flour and other raw materials to reduce the phytic acid and tannin content of analog rice products need to be carried out to improve product quality.

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CONFLICT OF INTEREST AND FUNDING DISCLOSURE

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AUTHOR CONTRIBUTIONS

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

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