Nutritional Content, Food Contamination, Sensory Test on Analog Rice Based on Local Food, Arrowroot Starch (*Maranata arundinaceae Linn*), Corn Flour (*Zea mays*), Soybean Flour (*Glycine Max(L) Merril*)

Sri Supadmi(✉), Ina Kusrini, and Slamet Riyanto

Cibinong Science Center, National Research and Innovation Agency (BRIN), Jl. Raya Jakarta-Bogor, Pakansari, Kec Cibinong, Bogor 16915, West Java, Indonesia
sris018@brin.go.id

Abstract. Analog rice can be used as a substitute for rice to meet nutritional needs and as food diversification. This study was to determine the characteristics of local food-based analogs of Garut starch, Corn Flour, and Soybean Flour. The main composition of analog rice products consists of arrowroot starch (25%), corn flour (65%), soybean flour (10%), 2% glyceryl monostearate (GSM) additives, and water. The nutritional content of analog rice per 100 g: energy 432.8 Cal, fat 3.19 g, protein 9.54 g, carbohydrate 76.54 g, amylose 20.54 g, dietary fiber 5.53 g, sodium 27.52 mg, phosphor 225.34 mg, calcium 851.57 ppm, potassium 2068.48 ppm, zinc 3.86 ppm, iron 3.71 ppm, Vitamin B1 13.5 ppm, vitamin B2 0.01 ppm, vitamin B6 2.49 ppm, folic acid 55.37 ppm, vitamin B12 1.73 ppm, vitamin E 0.04 ppm, total phenol 27 .29 mgGAE, antioxidant 16.07%, water content 9.58 g, ash content 1.15 g. The test heavy metal contamination: arsenic (As), cadmium (Cd), mercury (Hg), tin (Sn), lead (Pb) and microbial test: total plate count (TPC), mold, Escherichia coli has shown values below the Indonesia National Standard (SNI) or safe for consumption. Contamination of organochlorine pesticide residues and organophosphorus showed negative results. Sensory test 56.7% of panelists stated that the texture was neutral, meaning that the analog rice texture was neither hard nor soft. Sensory test 70% of analog rice is light brown and 23.3% had a slightly yellow color. Parameters of taste like, slightly like and neutral were 46.6%% panelists, color like, slightly like and neutral 83.3%, smell like, slightly like, and neutral was 53.4%. Texture like, slightly like, and neutral is 76.6%. The advantages of this analog rice are that it is safe for consumption, has good energy, protein, and dietary fiber, and has low sodium content. Raw material and analog rice, contamination not found. Analog rice has the potential to help the health of the body.

Keywords: analog rice · functional food · local food · nutritional content

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1 Introduction

Arrowroot (*Maranta arundinaceae L.*) is a plant in the *Marantaceae* family with spindle-shaped, elongated, and segmented rhizomes. It can be consumed fresh or made into flour. Arrowroot starch rhizome (*Maranta arundinaceae L*) contains 12% dry arrowroot in the form of flour and 1.7% protein [1]. Corn is the most important cereal crop in the world after wheat followed by rice, belonging to the genus *Zea* of the family *Poaceae*, subfamily *Panicoideae*. Maize is known as corn. Corn has attracted the attention of research and adaptability that contribute to modern agriculture and food security as a major source of energy [2]. While soybean [*Glycine Max (L.) Merrill]* is an important crop that is cultivated and used to produce vegetable oil, as well as a food source. Currently, soybean plants are mostly cultivated and consumed around the world.

Not optimal nutrition is associated with poor health and an increase in the risk of diseases such as an increase in the prevalence of degenerative diseases, including diabetes mellitus (DM). The results of national health research reported that the prevalence of DM in Indonesia based on an examination of blood sugar levels in the population aged 15 years increased from 6.9 percent in 2013 to 8.5 percent in 2018 [3]. Food problems can be overcome by a diversification program that promotes local food ingredients [4] which is an effort to be free from dependence on rice consumption [5]. The growing demand for food requires additional rice production, if these efforts are not achieved, there will be a food and nutrition deficit [6].

Functional foods are useful as basic nutrition or can minimize the risk of certain diseases and other health conditions [7] and have proven to be an efficient approach for DM treatment and health improvement [8]. Local food sources are required as part of an effort to diversify non-rice food consumption programs based on local resources, however, the use of local food has not been optimal. Analog rice can be made from locally available ingredients such as tuber and bean starches [5]. Analog rice contributes as a useful alternative to meet the nutritional needs of rice as a daily main dish [9]. Furthermore, it is one of the attractive products of functional food [10].

The relevance and novelty of this research are to create a product in the form of analog rice with a blend of ingredients of different formulas and compositions to obtain optimal nutritional content and be safe from metal contamination, residues, and microbes. The basic ingredients used are sourced from local food to be consumed as a substitute for rice and a strategy to strengthen food availability at the household and community level that can provide health benefits and reduce dependence on the consumption of the staple rice.

2 Materials and Methods

2.1 Material

The analog rice product consists of arrowroot starch (*Maranata arundinaceae* Linn), corn flour (*Zea mays*), and soybean flour (*Glycine Max(L) Merril*). Additional composites include glyceryl monostearate (GMS), and water. Analog rice raw materials include arrowroot tubers, corn, and soybeans obtained from farmers in Gunung Kidul Yogyakarta. The production of analog rice used the extrusion method with an extruder.

Table 1. Formulation of analog rice composition

Composition	Arrowroot starch (%)	Corn flour (%)	Soybean flour (%)	GSM (%)	Water (%)
Main composition	25	65	10	-	-
Additional composition	-	-	-	2	20

The analog rice process was carried out in Small and Medium Enterprises (UKM) Playen Gunung Kidul District, Yogyakarta Special Region that was fostered by the National Research and Innovation Agency (BRIN).

2.2 Formulation

The formulation is an important step in the manufacture of analog rice. The formulation ingredients consist of the main composition of analog rice which is arrowroot starch, corn flour, soybean flour, and additional compositions in the form of GSM, and water. Additional compositions are required as emulsifier binders. The compositions of the formulas are shown in Table 1.

2.3 Nutrient Analysis and Sensory Test

The proximate analysis includes water content and ash content using the gravimetric method, protein content using the Kjeldahl method, fat content using the Soxhlet method with Weibull modification, Total sugar using the Nelson Somogyi method, amylose using the IRRI method, food fiber using the multienzyme method, Na using the Atomic Absorption Spectrophotometer (AAS), antioxidant/Radical Scavenging Activity (RSA) using the DPPH method (*1,1-diphenyl-2-picrylhydrazyl*) according to Yen and Cheng, calories with a calorimeter. The examination was carried out at the Center for Food and Nutrition Studies (PSPG) Laboratory, UGM Yogyakarta. The analysis of vitamins B1, B2, B6, Folic acid, B12, and vitamin E used the High-Performance Liquid Chromatography (HPLC) method. Phosphor analysis based on the spectrophotometry method, reagents used: P 100 ppm parent standard solution, ammonium molybdate solution, ammonium vanadate solution, nitric acid solution, and distilled water. The analysis of Ca, K, Zn, and Fe using the AAS method was carried out at the Testing Laboratory of the Center for Agricultural Postharvest Research and Development, Bogor. The type of analysis of total phenol using the Spectro method was carried out at the Testing Laboratory of the Center for Agricultural Postharvest Research and Development, Bogor. The type of heavy metal test used the method according to SNI 01-2896-1998 and the pesticide residue test used the Thin Layer Chromatography method. The microbial test is based on SNI 19-2897-1992. The place of testing was carried out at the Testing Laboratory of the Surakarta Goods Quality Testing and Certification Center (BPSMB).

A sensory test is a test that used the human senses as the main tool and requires an honest response from the panelists to the product. This test involved the senses of sight,

smell, and touch. Sensory testing used a hedonic test parameter which was a method to assess the level of preference for the product by filling out the assessment form that has been provided. The assessment was carried out by untrained panelists, the number of panelists was 30 participants. The hedonic test used a scale of 1–5, namely: 1 = dislike, 5 = like. Statistical analysis used univariate analysis to obtain the descriptive illustration of the frequency distribution based on the parameter indicators of each raw material and analog rice. Data analysis used Statistical Package for the Social Sciences (SPSS).

3 Results

3.1 Analog Rice Nutrition Content

Mixtures of cereals and legumes such as soybeans can be explored to provide better protein alternatives that meet the nutrition for children aged 2–5 years. The nutritional content of raw materials and analog rice is presented in Table 2.

Analog rice carbohydrate is lower than milled rice, the sodium content is 27.52 mg, which is very low not exceeding 0.04 g. The dietary fiber content is high (5.53 g). The protein and energy content of analog rice is higher than milled rice due to the contribution of high protein content supply from soybean flour as raw material. The protein and energy levels are suitable for supplementary feeding (PMT) for toddlers that meet the nutritional quality requirements: protein 8–12 g, energy > 400 Cal. Arrowroot starch raw material has higher carbohydrates and amylose than milled rice. The raw material of corn flour has higher energy sources, fat, total phenols, and antioxidants compared to milled rice. Meanwhile, the raw material of soybean flour is higher in energy sources, protein, total phenol, antioxidants, and dietary fiber compared to other ingredients, and milled rice. Analog rice in this study has more benefits compared to milled rice, including a higher content of energy, fat, protein, dietary fiber, total phenol, antioxidants, phosphorus, and vitamin B1. Analog rice has amylose content, the majority of which comes from arrowroot starch and corn flour.

This study shows that the proximate composition of maize-soybean gruel is as follows: water content ranging from 25.97%–35.22%, protein content 6.56%–16.75%, crude fiber 0.74%–2.71%, ash 1.21%–3.77%, fat 1.25%–4.88%, carbohydrates 46.51%–55.01%. However, in our study, the amylose content was by the starch components.

This study found that raw materials and analog rice are sources of energy, protein, dietary fiber, and antioxidants, and have low sodium content. Functional food from strategic local food ingredients is another benefit of these ingredients. Arrowroot starch raw material has higher carbohydrates and amylose than milled rice. The raw material of corn flour has higher energy sources, fat, total phenols, and antioxidants compared to milled rice. Meanwhile, the raw material of soybean flour is higher in energy, protein, total phenol, antioxidants, and dietary fiber compared to other ingredients and milled rice. Vitamin and mineral content such as vitamin B1 and phosphorus in analog rice is higher than in milled rice. The proximate composition of raw rice and analog rice (Garut starch, corn flour, soybean flour) showed that the water content of analog rice is lower than that of raw and milled rice. This means that analog rice has drier properties and is superior in storage life, which can provide better resistance to material damage.

Table 2. The nutritional content of raw material and analog rice

Composition	Arrowroot Starch	Corn Flour	Soybean Flour	Analog Rice	Milled Rice*
Water content (g)	12.63	11.89	8.23	9.58	12.0
Ash content (g)	0.23	0.89	4.76	1.15	0.8
Energy (Cal)	367.5	404.4	537.6	432.8	357
Fat (g)	0.079	3.22	18.23	3.19	1.7
Protein (g)	1.57	8.18	39.57	9.54	8.4
Carbohydrate (g)	84.49	75.82	29.21	76.54	77.1
Total sugar (g)	69.42	63.16	8.36	61.17	-
Amylose (g)	26.51	21.93	0.38	20.54	-
Dietary fiber (g)	0.79	4.16	27.19	5.53	0.2
Sodium (mg)	27.43	45.65	137.24	27.52	27
Total phenol (mgGAE)	7.88	94.54	124.47	27.29	-
Antioxidant (%)	7.50	58.65	82.23	16.07	-
Phosphor (mg)	-	-	-	225.34	81
Calcium (ppm)	-	-	-	851.57	147**
Potassium (ppm)	-	-	-	2068.48	71**
Zinc (ppm_	-	-	-	3.89	0.5**
Iron (ppm)	-	-	-	3.71	1.8**
Vitamin B1/thiamine (ppm)	-	-	-	13.5	0.20**
Vitamin B2 /riboflavin (ppm)	-	-	-	0.01	0.08**
Vitamin B6 (ppm)	-	-	-	2.49	-
Folic acid (ppm)	-	-	-	55.37	-
Vitamin B12 (ppm)	-	-	-	1.73	-
Vitamin E (ppm)	-	-	-	0.04	-

* Table of Nutrition Composition in Indonesia [11] ** in milligrams (mg)

3.2 Contamination Levels of Heavy Metals, Pesticide Residues, and Microbes in Analog Rice

Unsafe food can be contaminated with microbes, chemicals, individual hygiene, and the environment. Contamination levels of heavy metals, pesticide residues, and microbes in raw materials and analog rice are shown in Table 3.

Table 3. Contamination level of heavy metals, pesticide residues, microbes in raw materials, and analog rice

Component	Food Stuff				Indicator
	Arrowroot Starch	Corn Flour	Soybean Flour	Analog Rice	
Arsenic (mg/kg)	0.057	0.024	0.345	0.28	0.5*
Cadmium (mg/kg)	<0.007	<0.007	<0.007	<0.007	0.4*
Mercury (mg/kg)	<0.0013	<0.0013	<0.0013	<0.0013	0.05*
Tin (mg/kg)	<0.019	<0.019	<0.019	<0.019	250.0*
Lead (mg/kg)	<0.035	<0.035	<0.035	<0.035	0.3*
Organochlorine	negative	negative	negative	negative	negative**
Organophosphorus	negative	negative	negative	negative	negative**
Total plate count (kol/g)	4.1×10^3	4.2×10^3	4.8×10^3	1.6×10^4	10^6**
Mold (kol/g)	2.0×10^2	2.1×10^2	<10	<10	10^4**
Escheria coli (kol/g)	7	7	4	3	11**

Maximum contamination limit (* [18] and ** [13])

The raw materials of arrowroot starch, corn flour, soybean flour, and analog rice showed the heavy metal content of arsenic, cadmium, mercury, tin, and lead are safe, that is under the maximum contamination limit based on the Indonesian National Standard (SNI). The raw material that has been processed into analog rice is safe and there was no change in the heavy metal content. Pesticide residues in the form of organochlorine and organophosphorus in arrowroot starch, corn flour, soybean flour, and analog rice showed negative and safe values by the required value. Total plate count (TPC), mold, and Escherichia coli are below the maximum contamination limit for arrowroot starch, corn flour, soybean flour, and analog rice. The content of mold and Escherichia coli in analog rice is lower than in raw ingredients.

3.3 Sensory Tests of Cooked Rice and Cooked Analog Rice

Figure 1 describes the sensory test of cooked rice and cooked analog rice. Sensory quality attributes include texture, smell, color, and taste. Panelists stated that the texture of cooked analog rice is neutral, neither soft nor hard (33.3%), meanwhile 43.3% of panelists slightly like and like the texture. One-third (33.3%) of panelists stated that they kind of don't like the smell of cooked analog rice. Regarding color, half of the panelists slightly like (33.3%) and liked (20%) the color of cooked analog rice. A percentage of panelists stated that they kind of don't like or slightly like and like the taste of cooked analog rice is similar (33.3%). The sensory test also shows that the panelists prefer milled cooked rice to cooked analog rice.

Figure 2 presents the natural color appearance of raw ingredients of arrowroot starch, corn flour, and soybean flour. The analog formula for raw rice resembles milled rice

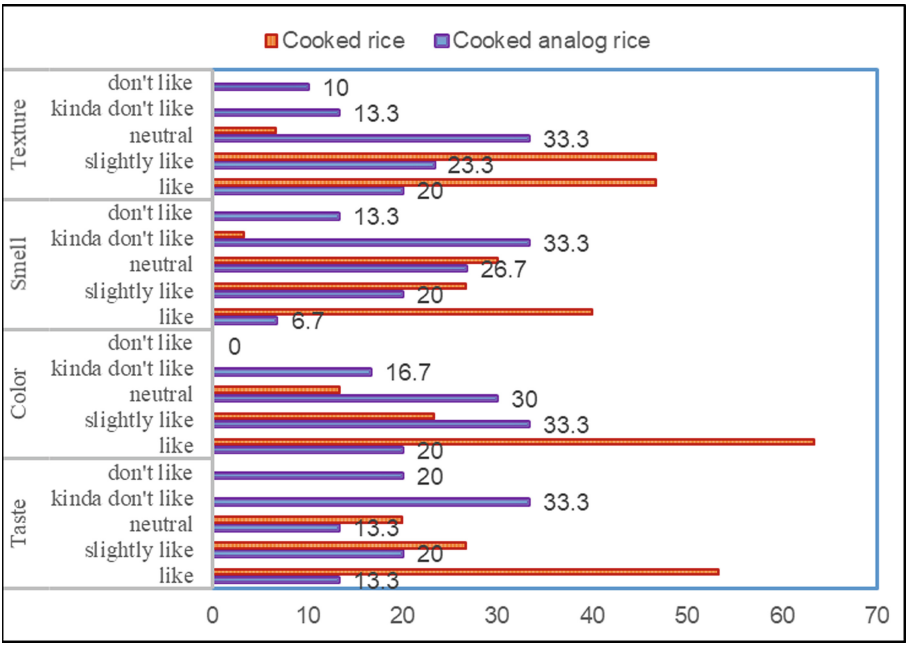

Fig. 1. Sensory test of cooked rice and cooked analog rice

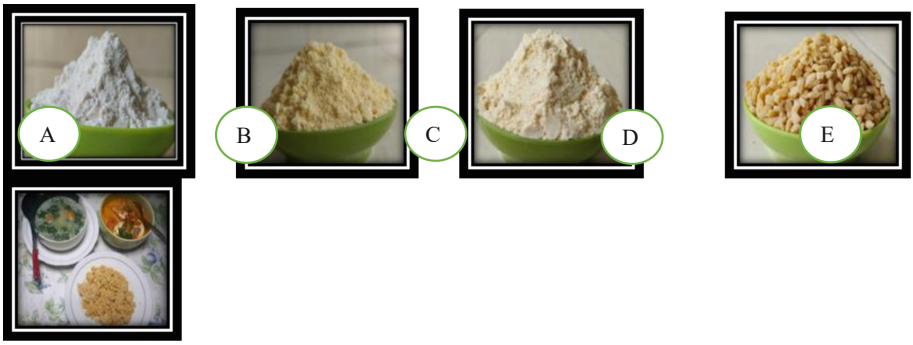

Fig. 2. Arrowroot starch, corn flour, soybean flour, analog rice, and cooked analog rice appearance (A = arrowroot starch, B = corn flour, C = soybean flour, D = analog rice, E = cooked analog rice)

grains. The appearance of t cooked analog rice is complemented by vegetables and side dishes.

4 Discussion

The results of our research have good and complex nutritional content that is needed by the body, as well as support for the selection of appropriate local food ingredients, and

are an option for preparing nutritious food and complementary foods that are acceptable, available, affordable, and optimally nutritious [11]. The formulation of several local food ingredients can encourage the realization of food diversification that complements each other's nutritional composition. The resulting corn flour and soybean composite had a good increase in nutrients: fiber, protein, proximate, and minerals. The composites provide nutritious complementary foods to combat malnutrition and improve food security [11]. In addition, the presence of antioxidants is very useful, especially for health because antioxidants work by preventing free radical attacks on basic body components such as nucleic acids or lipids [12].

Arrowroot starch rhizome (*Maranta arundinacea*) is reported to contain 12% dry arrowroot in flour form and 1.7% protein [1]. Arrowroot-based analog rice has a high amylose content that affects the soft texture [13]. Storage reserve compounds available per 100 g of maize grain: energy, carbohydrates, fats, protein, water, zinc, phosphorus, potassium, vitamin C, iron, and magnesium [2]. Sweet corn can be a better substitute for commonly consumed vegetables that contain phenolic and antioxidant activity [14]. The total phenolic content of sweet corn showed significant varietal differences and phenolics were present mainly in the free form [14]. Consumption of corn-soybean ingredients should be encouraged because it has good nutritional value as a complete food [15]. Soybeans are a source of protein, vitamins, minerals, and fiber. Soybean is considered equivalent to animal foods in protein quality, soy protein concentrate is more refined than corn flour and contains at least 70% protein [16]. Soybean flour is one of the derivative products from soybean processing that is famous for its rich protein content [17].

Food safety is a complex nature that must be maintained from the beginning from the level of production to the consumption level and can be contaminated anytime and anywhere in the food chain system [18]. Policy strategy improved food safety based on the implementation of good manufacturing practices (GMP). Development of functional foods enriched with antioxidants to prevent disease and free radicals [19]. Adequate and stable dietary intake may reduce the risk of cardiovascular disease by lowering blood lipid levels, reducing plaque formation, scavenging free radicals, and inhibiting platelet aggregation. The exploration of safe functional foods provides future insight into the use of bioactive food components in cardiovascular disease therapy [20].

The growing interest in the relationship between food ingredients and health led to the development of functional foods. Functional foods help health and minimize the risk of disease, these foods include fortified foods or fruits or vegetables that are developed into beneficial components for promoting health. Therefore, functional foods are very important not only for human nutrition but also for protecting against certain diseases. Functional food products from new formulation ingredients or their active ingredients will still be a challenge for the scientific community [21].

The focus of the food security strategy includes increasing the synergy between the government and the micro, small, and medium business sector for the development of local food products, Improving the quality and quantity of local food products by utilizing agricultural vacant land [22]. It is possible to attain food sovereignty and ensure food security by expanding local output [23].

5 Conclusion

The benefits of this analog rice are safe for consumption, has good energy, protein, and dietary fiber, and has low sodium content. Analog rice has the potential to help the body's health. Arrowroot starch raw material has a higher advantage in carbohydrate content and amylose than milled rice. While the raw material of corn flour contains higher energy sources, fat, total phenols, and antioxidants compared to milled rice. The raw material of soybean flour is higher in the content of energy sources, protein, total phenol, antioxidants, and dietary fiber compared to other ingredients and milled rice.

The vitamin and mineral content in analog rice can contribute to the nutritional value needed by the body, even showing a higher vitamin B1 and phosphorus content than milled rice. Analog rice from the raw material formulation of arrowroot starch, corn flour, and soybean flour is a better energy source than milled rice, therefore analog rice has the potential as an energy source to replace milled rice so that it can reduce dependence on rice consumption. Analog rice in this study has more benefits compared to milled rice, including a higher content of energy, fat, protein, dietary fiber, total phenol, antioxidants, phosphorus, and vitamin B1.

The content of heavy metals of arsenic, cadmium, mercury, tin, and lead in raw materials such as arrowroot starch, corn flour, soybean flour, and analog rice is safe based on the Indonesian National Standard (SNI). Likewise, the microbes of the total plate count (TPC), mold, and Escherichia coli are safe and are below the maximum contamination limit according to The National Agency of Drug and Food Control (BPOM). Pesticide residues in organochlorine and organophosphorus forms showed negative and safe values. The content of mold and Escherichia coli decreased; thus, it becomes safer after being processed into analog rice compared to raw materials even though it is known as safe raw materials.

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