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Synthesis of cassava analog rice fortified with protein tempe flour using cold extrusion method

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Synthesis of cassava analog rice fortified with protein tempe flour using cold extrusion method

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Abstract. The purpose of this research is food diversification based on the optimal use of local foodstuffs of cassava and tempe flour, and to increase public food consumption pattern of non-rice food by making analog rice fortified with cassava flour and protein tempe flour using cold extrusion method as functional food for vegetarians. This research method consisted of manufacture of cassava flour; manufacture composite flour with ratio of cassava flour and tempe flour (45% : 5%, 40% : 10%, 35% : 15%) wt., synthesis of analog rice, and analog rice characteristics analysis. The parameters observed were proximate analysis which include of carbohydrate, protein, fat, ash, and water content analysis; fiber content analysis; water absorption analysis; bulk density analysis; and rehydration time analysis. The results of this research showed that the variables of 35% wt. of cassava flour and 15% wt. tempe flour results the best analog rice obtained 73,23% carbohydrate content; 18,97% protein content; 3,19% fat content; 1,87% water content; 2,44% ash content; 0,15% fiber content; with water absorption 121,8%; bulk density 0,5633g/ml; and rehydration time 7,1 minutes. it is necessary for technology in analog rice molding so that the products produced are more uniform and shaped like rice. It's necessary to test the resistance of analog rice products.

1. Introduction

The food needs are increasing with the growing population each year. Besides increasing the amount, the fulfillment of food needs can also be done by optimizing the use of a variety of food resources. This is an effort to diversify food by utilizing local food resource according to presidential regulation No. 22 Year 2007 about the acceleration of the consumption of food based on local resources in the form of analog rice from various starches derived from non-rice raw materials which are expected to reduce the dependence of Indonesian people in consuming rice is highest [1].

Non-rice material that can be used as raw material for making analog rice is cassava which is the most important tropical food plant because it has high starch content [2]. Cassava have low protein content (0,7% to 1,3% fresh weight) total amino acid content of cassava is around 100 g, 2,5% lipid, 17% amylose, and 82% amylopectin [3]. The development of analog rice can be done with protein fortification and the addition of analog rice functionally as food for vegetarians. Fortification carried out on analog rice is the addition of protein obtained from tempeh which is a traditional fermented food and has been known in Indonesia which is rich in nutritional components. Tempe has a high protein and vitamin content, especially B12 which is rarely found in plant foods and potentially used as a substitute for animal protein from milk, beef, and chicken eggs. Tempe is also good for health

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because it can reduce cholesterol levels and have lower fat content than soybeans and animal food, anti-cancer, and accelerate blood flow [4]. Analog rice functionality as food for vegetarians is done because at this time vegetarians are increasingly popular in the world, including in Indonesia because plant-based foods can reduce the risk of degenerative diseases. Although vegetarian food has a very beneficial effect, some people still think that a vegetarian diet will be vulnerable to a deficiency of some nutrients such as protein, iron, zinc, and vitamin B12 [5]. Therefore, tempe flour is very suitable for use as a fortified ingredient in analog rice.
The process of making analog rice with cold extrusion method by using a series of pasta making tools consisting of four stages, manufacture of cassava flour; manufacture composite flour with various ratios; synthesis of analog rice; and analog rice characteristics analysis.

2. Methodology

2.1 Materials

The raw materials used in this research were cassava that obtained from Gunungpati, Semarang, Indonesia. Tempe flour produced by Sekar Sari, Gunungpati, Semarang, Indonesia was used in this study, as well as the distilled water were supplied by Chemical Engineering Integrated Laboratory of Universitas Negeri Semarang, Indonesia.

2.2 Research Procedures

The procedure for making analog rice consists of four stages, manufacture of cassava flour; manufacture composite flour, synthesis of analog rice, and analog rice characterization.

2.2.1Manufacture of Cassava Flour

Cassava flour production was completed by cassava stripping and then washed and cut into cubes with a thickness of 2 mm. Cassava cube was washed and dried in an incubator at 70°C for 24 hours. The dried cassava was grinded into flour and sieved using an 80 mesh sieve.

2.2.2 Manufacture of Composite Flour

Making rice analog composite flour by mixing raw materials cassava flour and tempeh flour according to variables, a ratio of cassava flour 45% wt and tempe flour 5%wt, cassava flour 40% wt and tempe flour 10% wt and cassava flour 35%wt and tempe flour 15%wt.

2.2.3 Synthesis of Rice Analog

The first step of rice analog synthesis was pragelatinization of composite flour. Water as much as 50% wt. is heated; it reached a temperature following a variable is 60 °C. Water that has been heated then mixed with composite flour according to variables, ratio of cassava flour 45% wt. and tempe flour 5% wt., cassava flour 40% wt. and tempe flour 10% wt. and cassava flour 35% wt. and tempe flour 15% wt. then stirred slowly until the mixture becomes smooth.
The second step was steaming the dough corresponds to the variable that has undergone pragelatinization and then put into the steamer with a temperature of 100 °C for 20 minutes. The purpose of this process is to cook raw dough into half-cooked with solid physical properties because in this process there will be a process of gelatinization and coagulation.
The third step was the formation of rice which is done by grinding and molding the steamed dough using a pasta maker as a cold extrusion device. The dough was shaped like a sheet with a thickness of 2 mm and then cut into 1 cm length using a knife to produce grain size that resembles rice. After rice was formed, rice was dried using an oven at 60°C for 5 hours

3. Results and Discussion

3.1 Proximate Analysis of Rice Analog

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Analog rice can have a variety of content which is suitable of raw material used [6] Proximate analysis is a chemical test to determine of nutritional content of food such as carbohydrates, fat, protein, water content, and ash content [7].

3.1.1 Carbohydrate Analysis of Rice Analog

Carbohydrate is the most important nutrient for humans because it functions as a main energy source and sweetener in food, saves protein, regulates fat metabolism, helps fecal expenditure [8]. Carbohydrate can contribute 60-70% of energy requirements [9]. The results of the analysis of carbohydrate content of analog rice made from cassava and tempe flour can be seen in Table 3.1 as follows:

Table 3.1 Carbohydrate Analysis of Analog Rice

Sample	Carbohydrate (%)
1	83.67
2	77.23
3	73.53

Table 3.1 shows that the highest carbohydrate content in sample 1 was 83,67% and the smallest in sample 3 was 73,53%, this is because in sample 1 the composition of cassava flour was more than in samples 2 and 3 so the carbohydrate content produced is large. The results obtained are quite high compared to ordinary rice. Juliano [10] stated that ordinary rice has a carbohydrate content of 78%. Staple food quality requirements are containing carbohydrate content ≥ 70% by weight of raw materials [11] so analog rice can be used as a staple food. Analog rice made from raw tubers has a low glycemic index level so it is suitable for consumption for people who have blood sugar disease [12]. Good analog rice in this research is analog rice sample 3 because of its low carbohydrate content making it suitable for vegetarians.

3.1.2 Protein Analysis of Rice Analog

Protein is one of the nutrients that play a role in forming biomolecules. Results of analysis of analog rice protein content made from cassava and tempe flour can be seen in Table 3.2 as follows:

Table 3.2 Protein Analysis of Rice Analog

Sample	Protein (%)
1	8.77
2	11.80
3	18.97

Based on Table 3.2 the highest protein content is in sample 3 of 18,97% and the smallest is in sample 1 which is 8,77%. In sample 3 content of tempe flour is more than in sample 1 and sample 2, because tempe flour is used to get a large protein content. The yield obtained compared to paddy-rice which is 7% [10]. This is because analog rice is given extra tempe flour. The higher the composition of tempe flour in a sample, the higher a protein content produced [13]. This analog rice is very suitable for vegetarians. Vegetable protein from tempe is used as a suitable for animal protein from milk, beef, and chicken eggs so that analog rice is also good for health because it can reduce cholesterol levels, anti-cancer, and can accelerate blood flow. Analog rice it is best used for vegetarians is analog rice in sample 3 because it has large protein content.

3.1.3 Fat Analysis of Rice Analog

Fat is a source of energy for the body. Usually, the energy produces per gram of fat is large from the energy produces by 1 gram of carbohydrate or 1 gram of protein. 1 gram of fat produces 9 calories (cal), therefore fat is a more effective source of energy compared to carbohydrate and protein. The results of the analysis of analog rice fat content made from cassava and tempe flour can be seen in Table 3.3 as follows:

Table 3.3 Fat Analysis of Rice Analog

Sample	Fat Content (% b)
1	1.93
2	3.19
3	5.37

Based on Table 3.3, the highest fat content is in sample 3, which is 5.37% and the lowest is in sample 1, which is 1,93%. Based on research of analog rice from daluga tubers showed the results of the fat content of 5,42% to 5,66% [14]. This is because the addition of tempe flour formulation affects the fat content of analog rice produced. According on research of evaluating the quality of tempe flour protein said that the fat content contained in tempe flour was 25.36 ± 0,15 (% bk) [23]. Meanwhile, according to [15 in her research on the physicochemical properties of cassava flour, it was stated that the fat content contained in cassava flour was 0.60%. So that the fat content which is quite high in tempe flour then affects the fat content contained in analog rice made from cassava fortified protein of tempe flour in this study. Fat content is directly proportional to the time of fat oxidation, therefore the relativity low-fat content in analog rice can cause analog rice can be stored longer because of the relatively low-fat oxidation [16]. Fat also functions as a shortening and influences the texture so that the analog rice produces becomes softer and fat can improve physical structure such as development, softness, texture, and aroma [13].

3.1.4 Moisture Content Analysis of Analog Rice

Moisture content is one of the parameters that are very influential in the process of storing rice. The results of the analysis of moisture content of analog rice made from cassava and tempe flour can be seen in Table 3.4 as follows:

Table 3.4 Moisture Content Analysis of Analog Rice

Sample	Moisture Content (%)
1	2.75
2	2.78
3	1.87

Based on Table 3.4 the biggest water content is in sample 2 which is 2.78% and the smallest in sample 3 is 1.87%. Cristensen and Sauer, 1982 [17] stated that the main factors that cause damage during storage are Moisture content, followed temperature, and storage time. Low moisture content in rice products is desirable because it is to maintain the durability of rice products. The amount of water content in analog rice affects the resistance of analog rice from microbial attack. According to SNI 6128: 2008 the requirement for safe water content is <14% [18], with a water content <14% will prevent the growth of mold that often lives on cereals / seeds. Rice analog to a moisture content of more than 14% will cause the rice to be easily damaged and rotten. All analog rice cassava flour and tempe flour samples have a longer shelf life because of the water content <14%.

3.1.5 Ash Content Analysis of Rice Analog

Ash is a mineral residue that remains after the combustion process in high temperatures [19]. Ash content and composition depends on the type of material and the method of ashes used. The results of

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the analysis of analog ash content of rice made from cassava and tempe flour can be seen in Table 3.5 as follows:

Table 3.5 Ash Content Analysis of Rice Analog

Sample	Ash Content (%b)
1	2.88
2	2.82
3	2.44

Table 3.5, the highest ash content in sample 1 is 2.88% while the lowest in sample 3 is 2.44%. The higher the percentage of tempe flour or the lower the percentage of cassava flour, the percentage of ash content obtained will also be smaller. This is caused by the main raw material for making analog rice is cassava. Ash content in cassava flour will be even greater with a large composition [20]. The higher ash content of a food item also shows the higher mineral content of that food ingredient [21]. Analog rice produced in this study is still said to be suitable as food ingredients because it is in accordance with the Food and Drug Monitoring Agency standards, the ash content in a food should not exceed 4%.

3.2 Fiber Content Analysis of Analog Rice

Food fiber is a component of plant tissue that is resistant to the hydrolysis process by enzymes in the stomach and small intestine. Total food fiber consists of soluble and insoluble food fibers where the soluble food fiber has a function to slow down the speed of digestion in the intestine, provide a longer sense of fullness, and slow the appearance of blood glucose so that insulin is needed to transfer glucose into the body's cells and converted into energy will also be less [10]. While the main function of insoluble dietary fiber is to prevent the emergence of various diseases related to the digestive tract by slowing the digestion of starch, helping the bowel movement, and expediting bowel movements [22]. According to the Nutrition Adequacy Figures table (2013), the daily fiber requirements of adult human bodies aged between 25-35 years are at least 30 g per day. The results of the analysis of analog rice fiber content made from cassava and tempe flour can be seen in Table 3.6 as follows:

Table 3.6 Fiber Content Analysis of Analog Rice

Sample	Fiber Content (%b)
1	0.15
2	0.15
3	0.15

The results of the analysis of analog rice fiber content made from cassava with fortification of tempe flour in various compositions amounted to 0.15%. In this study, the composition of tempe flour did not affect the fiber content contained in analog rice. This happens because the fiber content in small tempe flour is 0.46 ± 0.16 (% bk) [23]. While the fiber content of cassava like the study conducted by [24] is 1.18 ± 0.10%. Based on research on the analysis of the physiochemical characteristics of white rice, brown rice and black rice [10], the fiber content of white rice was 0.4021%. Based on this, it can be concluded that analog rice made from cassava fortified protein tempeh flour has a lower fiber content than white rice due to the fiber content of the analog rice raw material namely cassava and tempe fortification which is also small.

3.3 Bulk Density Analysis of Rice Analog

The bulk density of analog rice cages is determined to determine the volume and porosity of rice and needs to be known for product packaging, storage and transportation of products. Bulk density values will require smaller spaces and vice versa [25]. The analysis results of analog rice bulk density made from cassava and tempe flour can be seen in Table 3.7 as follows:

Table 3.7 Bulk Density Analysis of Rice Analog

Sample	Bulk Density
1	0.590085
2	0.57309
3	0.5633

Based on the data in Table 3.7, it is known the density of analog rice made from raw cassava flour fortified tempe flour with a composition of 5%, 10%, and 15% of tempe flour respectively is 0 , 590085 g / ml, 0.57309 g / ml, 0.5633 g / ml. Analog rice from Muslikatin research [25] ranges from 0.57 to 0.69 g / ml [26]. Research on bulk density on IR-64 rice is 0.79 gr / ml. Low density of analog rice shows that analog rice has high productivity. Widara [27] stated that high porosity can be influenced by the nutritional content of analog rice and the process of drying after printing rice [25]. Analog rice from mocaf flour produced ranged from 0.53 to 0.57 g / ml. Based on these data, it can be concluded that the analog rice from cassava flour and tempe flour composites produced by this study is included in the criteria.

3.4 Water Absorption Analysis of Analog Rice

Water absorption is the ability of a material to absorb or bind water. Water absorption of an ingredient is influenced by the characteristics of the material itself and the composition of starch in a food material [21]. Foodstuffs with high levels of starch will more easily absorb water due to the availability of amylopectin molecules which are reactive to water molecules so that the amount of water absorbed into food will also increase [21]. The ability of analog rice grains to absorb water again when dry rice grains are determined from the composition of the ingredients of the analog rice such as crude fiber content, carbohydrates, protein, and other components. The more mixture added in making analog rice the lower the water absorption capacity of the analog rice grains of each treatment. The results of the analysis of analog rice water absorption from cassava and tempe flour can be seen in Table 3.8 as follows:

Table 3.8 Water Absorption Analysis of Analog Rice

Sample	Water Absorption (%)
1	149,36
2	133,32
3	121,8

Table 3.8 the highest absorption in sample 1 was 149.36% and the lowest in sample 3 was 121.8%. This is consistent with the theory that the higher the starch content in analog rice, the greater water absorption [20]. Analog rice in this study which has a high starch content is sample 1 so it has a large water absorption capacity. This happens because the starch contained in analog rice will split into starch granules which will change the structure of the original starch crystalline to amorphous and porous which causes the starch's ability to bind water to increase because water entering the material will be trapped to get porous [28]. Therefore, it can be concluded that the more starch content contained in analog rice, the more amorphous and porous analog rice and the greater the water absorption of the analog rice. Analog rice from cassava flour and tempe flour composites has lower absorption than organic rice, which is 250-295% [29]. So it can be concluded that the analog rice from

cassava flour and tempe flour compositions have a water absorption rate that is not too much and requires water to cook rice that is not too much too.

3.5 Rehydration Time (Cooking Time)

Rehydration time is the time needed for a material to re-absorb water so that a homogeneous texture is obtained [18]. Rehydration time is related to the absorption capacity of analog rice water. The higher the water absorption, the lower the cooking time. In other words, the time needed is getting shorter. The results of the analysis of rehydration time on analog rice from the composite of sweet potato flour and tempe flour can be seen in Table 3.9 as follows:

Table 3.9 Analysis Result of Rehydration Time

Sample	Rehydration Time (minutes)
1	5
2	6,5
3	7,1

Table 3.9 shows that the rehydration time on analog rice from cassava flour and tempe flour takes 5-7.1 minutes. This is due to perfect starch gelatinization and drying. If the analog rice pregelatinization is perfect, the rehydration time will be shorter. Good drying is done at a temperature of 100-120°C for 2 hours or with a temperature of 60-80°C for 5-6 hours. In this study the drying process with a temperature of 60°C in 5 hours. Therefore, analog rice is rapidly cooking within 5-7 minutes through the rehydration process [30]. The effect of fast analog rice time is also due to the treatment before the analog rice is steamed ie previously soaked with warm water, soaking makes the texture of the semi-instant product become more porous. After drying the structure of the starch, the shaft makes it easy for water to seep into the semi-instant product during rehydration [31]. The time needed for analog rice from cassava flour composite and tempeh flour is faster than rice from traditionally cooked rice which usually takes about 1 hour including preparation, if using a rice cooker the cooking time takes 20-30 minutes, whereas if with a pressure cooker cooking time is 5-15 minutes [40].

4. CONCLUSIONS AND SUGGESTIONS

Research on analog rice production with a formulation of 35% wt. cassava flour and 15% wt. tempe flour was the best composition with proximate analysis results of 73.53% carbohydrate, 18.97% protein, 3.19% fat, 1.87% content water, and 2.44% ash content. Based on the results of fiber analysis this formulation also produces fiber of 0.15%. In the research of analog rice production mixed with cassava flour and tempeh flour based on physical analysis conducted, the absorption capacity of analog rice water in this study was 121.8%, then the other physical analysis was the bulk density of 0.59633%. The analog rice produced has also been tested for cooking to determine the cooking time of the analog rice. The amount of time needed to cook analog rice is 7.1 minutes. It is necessary for technology in analog rice molding so that the products produced are more uniform and shaped like rice. It's necessary to test the resistance of analog rice products.

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