Production and Characterization of Analog Rice from Combination of *Maranta arundinaceae L.*, *Dioscorea esculenta,* Carrageenanand Konjac as an Alternative Staple Food

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Abstract. The current high demand for rice with a consumption pattern of around 80% is not balanced by the continuous decline in national rice supply of 0.45% (140.730 tons). Thus, alternatives to rice made from cerealsand tubers are needed. *Maranta arundinaceae L.* has the potential as an ingredient in the production of analogrice but *Maranta arundinaceae L.* has sticky properties, so it is necessary to have a substituent, *Dioscorea esculenta* which will give a hard texture to analog rice products. The research was conducted in order to obtainan analysis of how the influence of *Maranta arundinaceae L.* and *Dioscorea esculenta* in the production of analog rice on the characteristics of the nutritional of analog rice products. The production of analog rice usingextrusion method with the determination of research variables using factorial design method with three independent variables which include steaming temperature, carrageenan mass, and ratio of *Maranta arundinaceae L.*: *Dioscorea esculenta*. The best analog rice characteristics are found in the analog rice formulation with a ratio of *Maranta arundinaceae L.* and *Dioscorea esculenta* of 560:240 grams at a steamingtemperature of 110°C with a mass of carrageenan of 5 grams and a mass of konjac of 10 grams for 30 minuteswhich is determined based on water content of 8.27%, ash content of 0.33%, protein content of 6.95%, fat content of 1.6%, crude fiber content of 0.5%, and carbohydrate content of 82.58%. Based on the data obtained,this states that the nutritional content of the analog rice produced meets the requirements of the permitted ricenutritional content specifications so it can be concluded that the analog rice based on the combination of *Maranta arundinaceae L.*and *Dioscorea esculenta* produced is suitable as an alternative staple food to replace rice.

Keywords: analog rice, *Maranta arundinaceae L.*, *Dioscorea esculenta*.

1 Introduction

The current high demand for rice with a consumption pattern of around 80% of the main carbohydratesource indicates a high dependency. The Central Bureau of Statistics states that there has been a continuousdecline in the national rice supply of 0.45% (140.73 thousand tons) over the past 3 years. Thus, alternativesto rice made from cereals and tubers are needed [3]. Analog rice is processed food from materials whose

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characteristics and nutritional content almost resemble conventional rice, such as cereals and tubers. *Maranta arundinaceae L* and *Dioscorea esculenta* are food ingredients that have the potential as staples for making analog rice [4].

Maranta arundinaceae L are tubers that grow in many parts of Indonesia as a source of carbohydrates.However, *Maranta arundinaceae L* flour has a sticky nature, so there is a need for other ingredients as a substituent. Therefore, to overcome this, *Dioscorea esculenta* flour can be used as a substituent. The *Dioscorea esculenta* is a tuber that grows in tropical areas with loose soil, light soil texture and content, good drainage and contains a lot of organic matter. With the addition of *Dioscorea esculenta* flour in the analog rice production process, it is desirable to function in optimizing the characteristics of analog rice. This can happen because the higher amylose content of *Dioscorea esculenta* flour can give a hard texture to the analog rice produced [9].

Based on this description, research was conducted on the production and analysis of the characteristicsof analog rice made using a combination of *Maranta arundinaceae L* flour with *Dioscorea esculenta* flouras an alternative staple food.

2 Method

2.1 Tools and Ingredients

In the research using grinder, extruder, oven, 80 mesh sieve, hot plate, distillation apparatus, titration apparatus, round bottom flask, erlenmeyer, mortar, pestle, test tube, soxhlet apparatus, condenser, kjeldahl flask, desiccator, deconstruction apparatus, and waterbath.

In the research using *Maranta arundinaceae L* and *Dioscorea esculenta* which are the results of Kabuh rural cultivation, sodium metabisulfite ($Na_2S_2O_5$) 1000 ppm, carrageenan, konjac, selenium, concentrated H_2SO_4, NaOH 40%, H_3BO_3 2%, NaOH 0.313 N, Bromocresol Green-Methyl Red indicator, HCl 0.0235 N, 96% ethanol, H_2SO_4 0.325 N, and chloroform solvent.

2.2 Research Design

The determination of variables in this research used the factorial design method with three independent variables, namely steaming temperature, carrageenan mass, and the ratio of *Maranta arundinaceae L* flour: *Dioscorea esculenta* flour as in Table 1. The fixed variables used in this experiment were 10 grams of konjac mass and 170 ml of distilled water.

Table 1. Research Treatment Design

Run	Steaming Temperature (°C)	Carrageenan Mass (gram)	*Maranta arundinaceae L*: *Dioscorea esculenta* Flour Ratio (gram)
1.	80	5	720:80
2.	110	5	720:80
3.	80	10	720:80
4.	110	10	720:80

5.	80	5	560:240
6.	110	5	560:240
7.	80	10	560:240
8.	110	10	560:240

2.3 *Maranta arundinaceae L* Flour Making

The procedure for making *Maranta arundinaceae L* flour refers to the research of Irmawati, etal, 2014. The first production process of *Maranta arundinaceae L* flour is by washing *Maranta arundinaceae L* with fresh water and then soaking whole *Maranta arundinaceae L* in water at 80°Cfor 1 minute. Peel and slice the *Maranta arundinaceae L* using a knife. Put the sliced *Maranta arundinaceae L* in 1000 ppm sodium metabisulfite solution for 15 minutes. Rinse the soaked *Maranta arundinaceae L* thoroughly. Dry the *Maranta arundinaceae L* in an oven at 60°C for 5 hours. Grind the dried *Maranta arundinaceae L* slices in a grinder. Sift the *Maranta arundinaceae L* flour with 80 mesh size.

2.4 *Dioscorea esculenta* Flour Making

The procedure for making *Dioscorea esculenta* flour refers to the research of Irmawati, et al., 2014. The first *Dioscorea esculenta* flour production process is by washing the *Dioscorea esculenta*with fresh water and then soaking whole *Dioscorea esculenta* in water at 80°C for 1 minute. Peel and slice the *Dioscorea esculenta* using a knife. Put the sliced *Dioscorea esculenta* bulbs in 1000 ppm sodium metabisulfite solution for 15 minutes. Rinse the soaked *Dioscorea esculenta* bulbs thoroughly. Dry the *Dioscorea esculenta* in an oven at 60°C for 5 hours. Grind the dried *Dioscoreaesculenta* slices in a grinder. Sift the flour with 80 mesh size.

2.5 Analog Rice Production

The production of analog rice in this research was carried out by preparing the ingredients andweighing all the ingredients according to the research design. Mix all ingredients that have been weighed until homogeneous. Steam the dough using variable temperature according to each researchdesign for 30 minutes. Put the steamed dough into the extruder. Dry the rice using an oven at 60°Cfor 3 hours. Put the finished rice into the package and close it tightly.

2.6 Moisture Content Analysis

In Marjan's research (2014), to analyze the water content of the analog rice produced, the firstcan be done by drying an empty cup using an oven for 1 hour and then weighing the cup. Then put3 grams of sample in the cup. Then dry the sample using an oven at 105°C for 3 hours. Cool the sample using a desiccator for 15 minutes and weigh the sample. Put the sample in the oven again for 30 minutes, cool it using a desiccator and weigh the sample. Do this process repeatedly until thefixed weight of the sample is reached which is analyzed using the formula:

$$\% \, Moisture\ Content = \frac{Initial\ weight\ (g) - Final\ weight\ (g)}{Final\ weight\ (g)} \ x\ 100\%$$

2.7 Ash Content Analysis

In Marjan's research (2014), the ash content analysis of analog rice was carried out by drying the porcelain cup using an oven at 200°C for 1 hour, then cooling it using a desiccator for 20 minutesand weighing the cup. Put 3 grams of sample in the cup. Place the porcelain cup in an oven at 200°Cfor 3 hours until it turns to ash and weigh the cup. After that, cool the sample using the desiccator again and weigh the cup. Ash content was analyzed using the formula:

$$\% \, Ash\ Content = \frac{Ash\ weight\ (g)}{Sample\ weight\ (g)} \ x\ 100\%$$

2.8 Protein Content Analysis

In Marjan's research (2014), the Kjeldahl method was used to test the protein content of analogrice. When the volume is up to 10 mL and the sample changes color to bluish green, the distillationprocess is stopped and titrate the results obtained with 0.0235 N HCl until the color turns pink. Perform the same process on the blank sample. Protein content was analyzed using the formula:

$$\% \, Protein\ Content = \frac{(V_a - V_b)\ HCl\ x\ N\ HCl\ x\ 14{,}007\ x\ 6{,}25}{W\ x\ 1000} \ x\ 100\%$$

Where Va is mL HCl for sample titration, Vb is mL HCl for blank titration, 6.25 is the proteinconversion factor, and 14.007 is the atomic weight of nitrogen.

2.9 Fat Content Analysis

In Marjan's research (2014), the Soxhlet method was used to analyze the fat content of analogrice products. Weigh the round bottom flask that has been filled with fat until a fixed weight is obtained. Fat content was analyzed using the formula:

$$\% \, Fat\ Content = \frac{Weight\ of\ flask\ and\ extracted\ product\ (g) - Weight\ of\ empty\ flask\ (g)}{Sample\ weight\ (g)} \ x\ 100\%$$

2.10 Crude Fiber Content Analysis

In Marjan's research (2014), to test the crude fiber content of analog rice can be done byperiodically baking until the weight is constant. Crude fiber content was analyzed using the formula:
In Marjan's research (2014), the analysis of carbohydrate content in analog rice uses thecalculation method by differences which is analyzed using the formula:

% Carbohydrate Content = 100% - (Moisture + ash + protein + fat content)

3 Research Results
3.1 Characteristic Analysis of Analog Rice

The production of analog rice carried out in this research uses the extrusion method. The analog rice products obtained can be seen in Figure 1 and Figure 2.

Figure 1. Analog rice produced (S1-S2-S3-S4)

Figure 2. Analog rice produced (S5-S6-S7-S8)

Analysis of the characteristics of Analog Rice produced through the extrusion method with raw materials in the form of a combination of *Maranta arundinaceae L* and *Dioscorea esculenta* produced products with the results listed in Table 2. Determination of variables in this research usingthe factorial design method with three independent variables, namely steaming temperature, carrageenan mass, and the ratio of *Maranta arundinaceae L* flour: *Dioscorea esculenta* flour.

Table 2. Results of Production Analog Rice Using Three Independent Variables

Run	Independent Variable			Interaction				Output (%)					
	T	K	R	TK	TR	KR	TKR	Moisture	Ash	Protein	Fat	Crude Fiber	Carbohydrate
1	-	-	-	+	+	+	-	10,621	0,6667	6,267	1,95	1	80,4955405
2	+	-	-	-	-	+	+	8,8154	0,3333	6,421	1,85	1	82,5802397
3	-	+	-	-	+	-	+	9,8677	0,6667	6,874	1,7	1,5	80,5583427
4	+	+	-	+	-	-	-	9,526	0,6667	6,857	1,75	1	81,2002892
5	-	-	+	+	-	-	+	8,9558	0,6667	6,636	1,8	0,5	81,6081601
6	+	-	+	-	+	-	-	8,271	1	6,834	1,6	1	82,2950419
7	-	+	+	-	-	+	-	10,75	1,3333	6,949	1,65	1,5	79,3175803
8	+	+	+	+	+	+	+	9,4595	1	6,951	1,7	1	80,8895405

Description:

- Steaming Temperature (T): - = 80°C
  + = 110°C
- Carrageenan Mass (K): - = 5 grams
  + = 10 grams
- *Maranta arundinaceae L* Flour: *Dioscorea esculenta* Flour Ratio (R):
  - = 720:80 grams
  + = 560:240 grams

Variables that have a high impact on the research can be analyzed with the quicker method, this method uses the calculation of main effects as well as interaction effects on water content, ash content, protein content, fat content, crude fiber content and also carbohydrate content.

3.2 Moisture Content Analysis

The results of the analysis using the quicker method obtained if the main effect of water contentanalysis research is steaming temperature obtained as much as -1.030621938 with the interaction effect, namely the mass of carrageenan and the ratio of *Maranta arundinaceae L* flour: *Dioscorea esculenta* flour as much as 0.756316582.

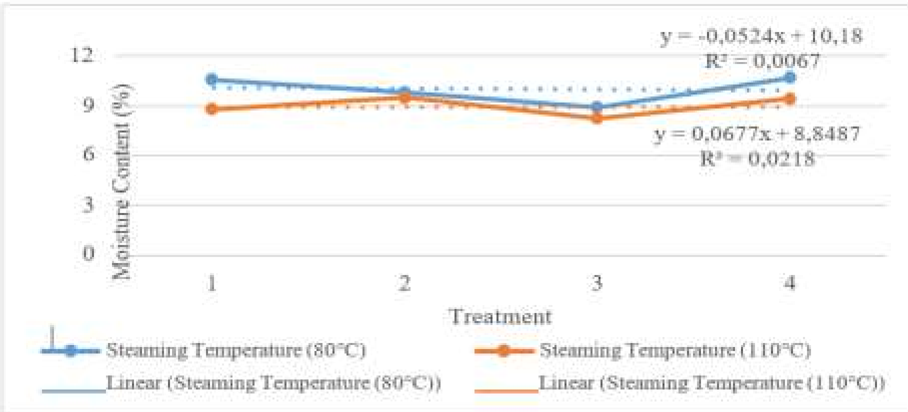

Figure 3. Graph of Relationship between Steaming Temperature and Water Content of AnalogRice

Based on Table 2, the results of the analysis obtained that the best analog rice water content isfound in the ratio of *Maranta arundinaceae L* flour and *Dioscorea esculenta* flour 560:240 grams at a steaming temperature of 110°C with a mass of carrageenan as much as 5 grams for 30 minutes,which is 8.270958084%. It can be concluded that the water content of the analog rice obtained is sufficient for the applicable water content requirements in rice, which is <14% according to the provisions of the Indonesian National Standard (SNI) 01-6128-2015. The water content of <14% serves to extend the shelf life of analog rice by preventing mold growth that often occurs during food storage [10].

3.3 Ash Content Analysis

The results of the analysis using the quicker method obtained if the main effect of ash contentanalysis research is the ratio of *Maranta arundinaceae L* flour: *Dioscorea esculenta* flour obtained an analysis result of 0.416666667 with interaction effects in the form of steaming temperature, carrageenan mass and the ratio of *Maranta arundinaceae L* flour: *Dioscorea esculenta* flour as muchas -0.25.

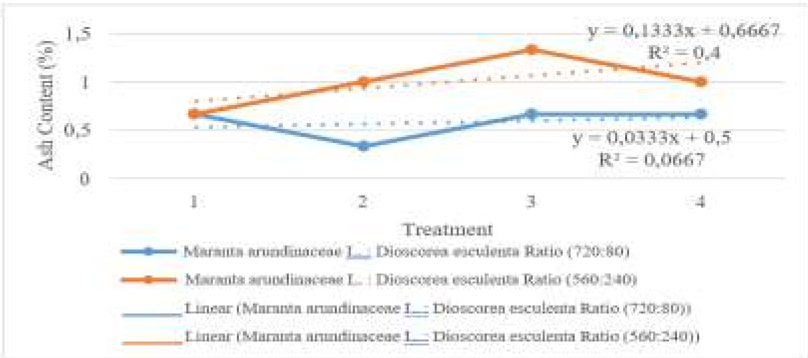

Figure 4. Graph of Relationship between the Ratio of *Maranta arundinaceae L* Flour: *Dioscoreaesculenta* Flour and Ash Content of Analog Rice

Based on Table 2, the results of the analysis obtained that the best analog rice ash content is found in the ratio of *Maranta arundinaceae L* flour and *Dioscorea esculenta* flour 720:80 grams ata steaming temperature of 110°C with a mass of carrageenan as much as 5 grams for 30 minutes, which is 0.33%. The ash content is due to the large number of mineral components in *Dioscorea esculenta* flour [8].

3.4 Protein Content Analysis

The results of the analysis using the quicker method obtained if the main effect of protein content analysis research is the mass of carrageenan obtained as much as 0.36825 with theinteraction effect in the form of carrageenan mass and the ratio of *Maranta arundinaceae L* flour: *Dioscorea esculenta* flour as much as -0.15325.

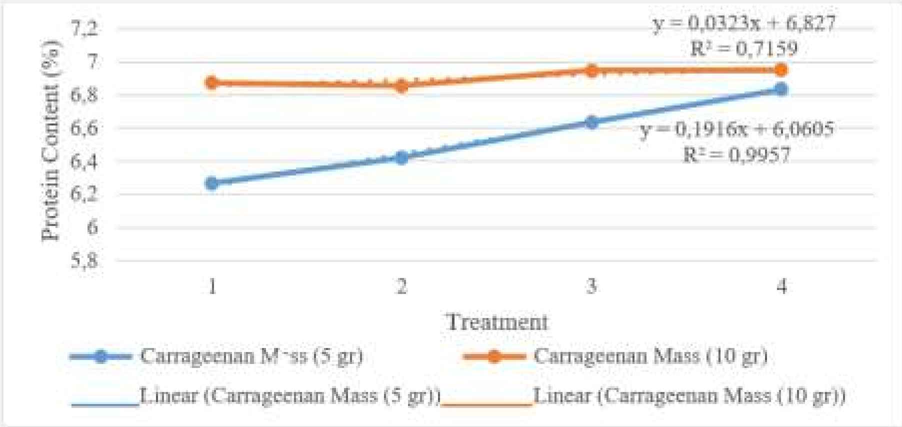

Figure 5. Graph of Relationship between Mass of Carrageenan and Protein Content in Analog Rice

The use of a temperature of 60°C is the optimal temperature for drying analog rice, this is done to keep the protein from denaturing on a large scale (Natsir, 2018). Based on Table 2, the results ofthe analysis obtained that the best analog rice protein content is found in the ratio of *Maranta arundinaceae L* flour and *Dioscorea esculenta* flour 560:240 grams at a steaming temperature of 110°C with a mass of carrageenan as much as 10 grams for 30 minutes, which is 6.951%. High levels of protein can control the insulin response so that blood sugar is maintained stable [1].

3.5 Fat Content Analysis

The results of the analysis using the quicker method obtained if the main effect of fat content analysis research is the ratio of *Maranta arundinaceae L* flour: *Dioscorea esculenta* flour obtainedan analysis result of -0.125 with an interaction effect in the form of steaming temperature and carrageenan mass of 0.1.

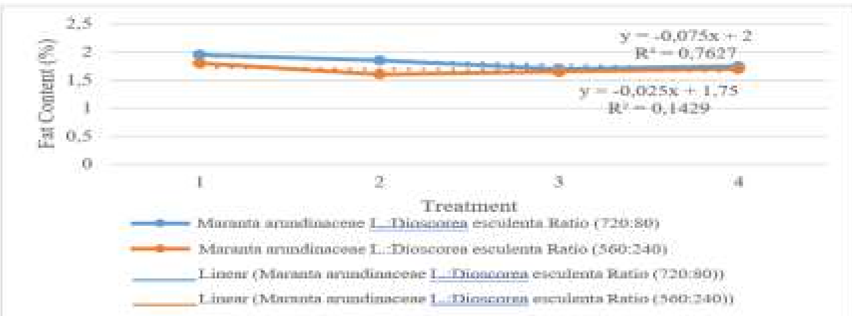

Figure 6: Relationship Graph of the Ratio of *Maranta arundinaceae L* Flour: *Dioscorea esculenta* Flour to Fat Content in Analog Rice

Based on Table 2, the results of the analysis obtained that the best analog rice fat content is found in the ratio of *Maranta arundinaceae L* flour and *Dioscorea esculenta* flour 560:240 grams at a steaming temperature of 110°C with a mass of carrageenan as much as 5 grams for 30 minutes,which is 1.6%. Foods with a lot of fat will usually be processed by the stomach slowly, resulting inthe digestive process in the small intestine slowing down. The presence of fat in analog rice production materials also plays a role in improving the physical characteristics of analog rice in theability to expand, soften the texture, and assist in the process of clay formation in the extruder machine [4].

3.6 Crude Fiber Content Analysis

The results of the analysis using the quicker method showed that the main effect of crude fibercontent analysis research, namely carrageenan mass, obtained an analysis result of 0.375 with an interaction effect in the form of steaming temperature and carrageenan mass of -0.375.

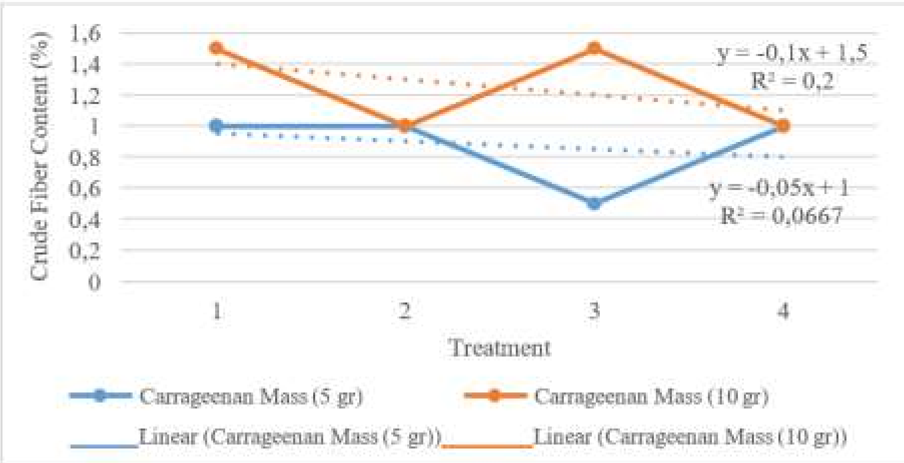

Figure 7: Graph of the Relationship of Carrageenan Mass to Crude Fiber Content in Analog Rice

Based on Table 2, the results of the analysis obtained that the best analog rice crude fiber content is found in the ratio of *Maranta arundinaceae L* flour and *Dioscorea esculenta* flour 560:240 grams at a steaming temperature of 80°C with a carrageenan mass of 5 grams for 30 minutes, whichis 0.5%. The high level of crude fiber in analog rice can control the absorption of nutrients, thus prolonging satiety and slowing the increase in blood sugar. Fiber also plays a role in extruded products because it affects changes in the properties of the analog rice produced. The high fiber content in the ingredients used, the low swelling power of analog rice [7].

3.7 Carbohydrate Content Analysis

The results of the analysis using the quicker method obtained if the main effect of carbohydratecontent analysis research is the mass of carrageenan obtained as much as -1.25330738 with the interaction effect in the form of carrageenan mass and the ratio of *Maranta arundinaceae L* flour: *Dioscorea esculenta* flour as much as -0.761399915.

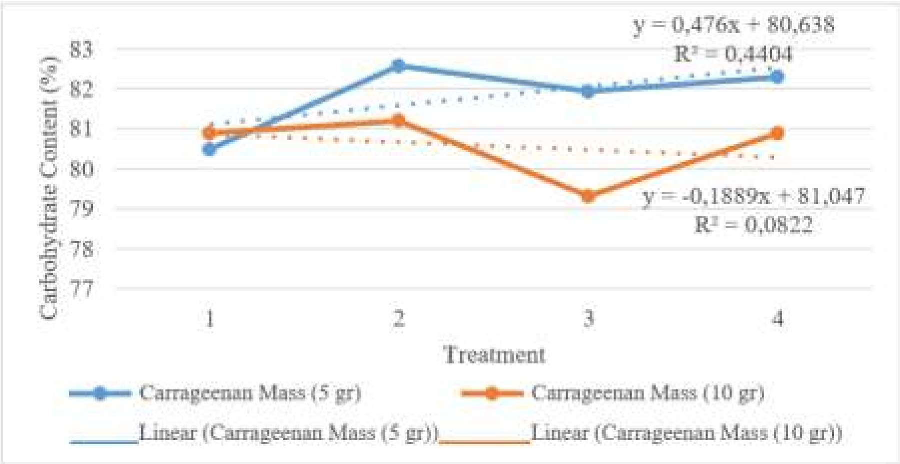

Figure 8: Graph of the Relationship between Carrageenan Mass and Carbohydrate Content ofAnalog Rice

Based on Table 2, the results of the analysis obtained that the best carbohydrate content of analog rice is found in the ratio of *Maranta arundinaceae L* flour and *Dioscorea esculenta* flour 720:80 grams at a steaming temperature of 110°C with a mass of carrageenan as much as 5 grams for 30 minutes, which is 82.58023967%. The carbohydrate content of analog rice was found to be higher than the carbohydrate content of conventional rice by 79%. It can be concluded that the analog rice produced can be used as an alternative staple food that provides higher carbohydrates than conventional rice. The high carbohydrate content can be due to the ingredients used, including *Maranta arundinaceae L*, where the carbohydrate content of *Maranta arundinaceae L* flour is 79.5%. With the production of high-carbohydrate extruded products, it is desirable to reduce the consumption of rice for carbohydrate providers to fulfill basic food needs [6].

4 Conclusion

Analog rice is a processed food from ingredients whose characteristics and nutritional content almostresemble conventional rice, such as cereals and tubers. In this research, the best analog rice characteristicswere found in the analog rice design with a ratio of *Maranta arundinaceae L* flour and *Dioscorea esculenta*flour of 560:240 grams at a steaming temperature of 110°C with a mass of carrageenan of 5 grams and a mass of konjac of 10 grams for 30 minutes which was determined based on a water content of 8.27%, ash content of 0.33%, protein content of 6.95%, fat content of 1.6%, crude fiber content of 0.5%, and carbohydrate content of 82.58%. Based on the data obtained, this states that the nutritional content of the analog rice produced meets the requirements of the permitted rice nutritional content specifications so thatit can be concluded that the analog rice based on the combination of *Maranta arundinaceae L.*and *Dioscorea esculenta* produced is suitable as an alternative staple food to replace rice.

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