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The Role of Seaweed Concentration *Gracilaria Sp* with Response Surface Methodology on Optimization of Analog Rice Formulation

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ABSTRACT

Background: Indonesia has potential to be the biggest seaweed exporter in the world due to its fisheries potential. Brackish ponds are not merely used for cultivating fish and shrimp, but it is also used for seaweed cultivation. Thus, this study aimed to produce an innovative product that is staple food from *Gracilaria Sp* seaweed into analog rice, which can support pond formers in Sidoarjo.

Methods: In this experimental study, optimization of analog rice process from *Gracilaria* used Response Surface Methodology with various *Gracilaria* seaweed concentration (X_1%) third levels (60%, 65%, 70%). However, parameter response that has been observed is iodine level (Y_1 ppm), food fiber level (Y_2%), yield (Y_3%), aroma value (Y_4), taste value (Y_5), and texture level (Y_6).

Results: According to the organoleptic test, analog rice from *Gracilaria* seaweed which composed of 65.84% seaweed, modified cassava flour 31.16%, and vegetable oil and glycerin 3% had optimum way of taste, aroma, and texture. Food fiber of seaweed composition (65%), modified cassava flour (32%), and vegetable oil as well as glycerin (3%) was 2.39% bigger than rice food fiber standard (1.3%). The iodine composition in the form of analog rice from *Gracilaria* seaweed was 74.55 ppm (74550µg) more than the average standard of human iodine needs of 150 µg/day.

Conclusion: Anolog rice made from *Gracilaria Sp* had good quality to consume.

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Introduction

Indonesia has potential to be the biggest seaweed exporter in the world. Fisheries potential in Indonesia is big enough, where there is two million hectares of the sea that is very suitable for the development of seaweed. The type of seaweed which is the most favorite in the market is *Euchemacottoni* and *Gracilaria Sp.* Nowadays, brackish ponds in Sidoarjo is not merely used to shrimp and milkfish cultivation, but also to seaweed. Seaweed cultivated in the ponds is *Gracilaria Sp. Gracilaria* is staple food of pudding or it is commonly called as agarophyte. *Gracilaria* potential that is big enough in Sidoarjo is necessary to be improved not only about its beneficial to be sold as raw seaweed, but also can be used as additional product that has more

value such as staple food and analog rice. Thus, seaweed is expected to be processed product that can support the national food program (1).

The product development can also help to market the seaweed from ponds which in turn can also increase farmer's income. Another diversification product is possibly to be developed from the staple food of *Gracilaria* is baked seaweed or nori, candy, *dodol*, and another processed product. The product development is not only inseparable from food consumption, but must also be healthy, because there is a lot of iodine content and dietary fiber (2). Producing *Gracilaria* in Sidoarjo reaches 10233.5 tons/year (wet condition), and if it is converted to be dry, thus it reaches about 1460.5 tons/year (3).

In the latest year, the condition of cultivators in Sidoarjo's ponds was run into commodity shifting, especially that is lived in Jabon, Sedati. They started to develop their cultivation into seaweed cultivation. The cultivators predicted that seaweed cultivation has more advantages and more potential if it was supported by Seaweed Industrialization to be real. The abundant seaweed that is produced by pond formers is not absorbed in the industrial sector, as a result, the price drops and only used for milkfish food as well as formers' income falls. This condition is interesting for the writers to conduct the research about the utilization of *Gracilaria* as a staple food product in the form of analog rice from *Gracilaria Sp* (4). This study assessed optimization of analog rice formulation to be dependent on seaweed concentration *gracilaria sp* with response surface methodology.

Materials and Methods

This experimental study was conducted in the value added laboratory, modern processing laboratory, and traditional processing laboratory of Fisheries and Marine Polytechnic Sidoarjo, Biochemical Laboratory of Food technology Program Study in Brawijaya University, and Mulatama Laboratory of West Tanjung, Jakarta, Indonesia. Optimization process of analog rice product from *Gracilaria* used Response Surface Methodology (RSM) with *Gracilaria* seaweed concentration (X_1%) third level (60, 65, 70%); however, parameter response that was analyzed was iodine level (Y_1 ppm), fiber food level (Y_2%), yield (Y_3%), aroma value (Y_4), taste value (Y_5), and texture level (Y_6). Here is the formula of analog rice of *Gracilaria Sp* shown in Table 1. SPSS software (Version 20, Chicago, IL, USA) was used for comparison using ANOVA for statistical analysis. A p value less than 0.05 was considered significant.

Results

Regarding the optimization condition process of *Gracilaria* analog rice processing, the measuring result of *Gracilaria* analog rice processing toward iodine level, food fiber level, yield, aroma value, taste value, and texture level was demonstrated in Table 2. Based on table 2, it was shown that the iodine level was 56.18 ppm (5618 µg) till 95.173 ppm (95173 µg), however, the response of food fiber was between 0.992% and 3.474%. Rice yield value was between 5 and 6. Organoleptic response value of taste was from 5 to 6.5, while texture organoleptic value was from 3 to 5.

The various analysis (ANOVA) (Table 3) showed that selected model to iodine response and food fiber levels was linier (linier model), because this model had R2 bigger than other models such as 0.83 for iodine level and 0.998 for food fiber level.

Table 1: The formulation of analog rice of *Gracilaria*.

Treatment	*Gracillaria* (%)	Mocaf (%)	Vegetable oil (%)	Monostearate glycerin (%)
A	60	37	2	1
B	65	32	2	1
C	70	27	2	1

Table 2: Tested data to create response function model of RSM one factor.

No	Parameter Level	Factor	Response					
	x1	*Gracillaria* Concentrate (%)	Iodine Level (ppm)	Food fiber level (%)	Yield (%)	Aroma	Taste	Texture
1	1	70	95.173	3.362	41.5	5	5	3
2	1	70	84.572	3.474	41.5	5	5	3
3	-1	60	56.18	0.997	42.3	5	5.5	4
4	-1	60	57.48	0.992	42.3	5	5.5	4
5	0	65	71.702	2.2	45.6	6	6.5	5
6	0	65	76.956	2.153	45.6	6	6.5	5
7	0	65	60.45	2.153	45.6	6	6.5	5

Table 3: Model analysis to share the response.

Response	Model	Equation	Significant (P<0.05)	*Lack of fit test* (P<0.05)	R^2
Iodine level	Linier	Y=71.78+16.52X	0.0043	0.5356	0.830977
Food fiber level	Linier	Y=2.19+1.21X	<0.0001	0.3264	0.99827
Yield	Quadratic	$Y=45.6-0.4X-3.7X^2$	<0.0001	-	1
Aroma	Quadratic	$Y=6-X^2$	<0.0001	-	1
Taste	Quadratic	$Y=6.5-0.25X-1.25X^2$	<0.0001	-	1
Texture	Quadratic	$Y=5-0.5X-1.5X^2$	<0.0001	-	1

Besides that, this model was significant (P=0.004) for iodine level and for food fiber level (P<0.0001). The ANOVA's result showed that the factor of seaweed concentration significantly influenced iodine response level, food fiber level, yields, organoleptic aroma value, organoleptic taste value, and organoleptic texture value that were selected models to yield response, organoleptic aroma value, organoleptic taste value, and organoleptic texture value as quadratic model.

Quadratic model was suggested model by Design Expert Program 7.1.5. R2 value toward those four responses (yield, aroma, taste, and texture) was 1. Lack of Fit F-Value Response of iodine level with p value greater than 0.05 (0.54) and 0.05 (0.33) for food fiber level showed that lack of fit was not significant. Lack of fit value was not significant and was a requirement of good model, because it showed that it was compatible with the yield response data and model. Regarding the analysis of iodine response level, the RSM formula for optimization process of analog rice to get the maximum iodine level was 71.78+16.52X, where X was the seaweed concentration. This formula revealed that iodine level increased as well as the increasing of the seaweed concentration.

This formula revealed that iodine level increased as well as the increasing of the seaweed concentration. Normal plot of residual graphic that illustrated the relationship between actual value and expected value was presented in Figure 1. Contour Plot Graphic was shown in Figure 1 illustrating that seaweed concentration factor influenced the iodine response value. The RSM formula for optimization process of analog rice to get the maximum food fiber level was food fiber level=2.19+1.21X, where X was the seaweed concentration. This formula showed that food fiber level increased as well as the increase in the seaweed concentration. Overall, the value of food fiber level was about 0.992-3.474% (Figure 2).

Regarding the yield response analysis, the optimization process of analog rice got maximum yield level of 45.6-0.4X-3.7X2 exhibiting that yield level increased as well as decreasing of the seaweed concentration. Contour plot graphic in Figure 3 showed that seaweed concentration affected the yield response value. The score of aroma preferring was from 5 (prefer enough) to 6 (prefer). The score of preferring taste of analog rice was from 5 (prefer enough) to 6.5 (prefer). The score of preferring texture was from 3 (does not prefer) to 5 (prefer enough). The RSM formula for optimization process of analog rice to get the maximum preferring score was shown as taste=6-X2, aroma=$6.5-0.25X-1.25X_2$, and texture=$5-0.5X-1.5X_2$, where X was the seaweed concentration. This formula revealed that aroma, taste, and texture preferring scores increased as well as the decrease in the seaweed concentration. Contour plot graphic in Figure 4 showed that the factor of seaweed concentration influenced

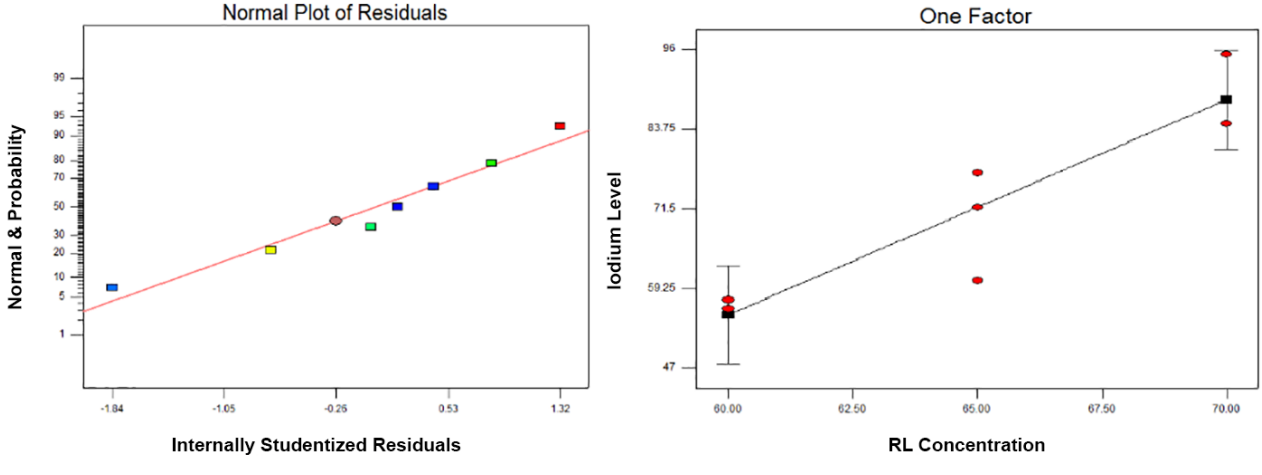

Figure 1: Residual normality and graphic contour of the iodium level response.

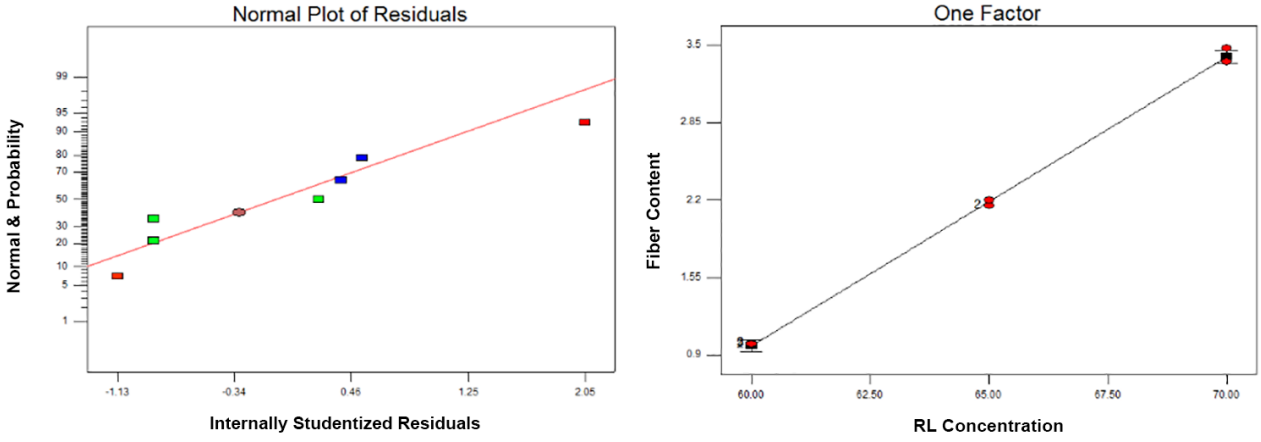

Figure 2: Residual normality a contour plot of food fiber respond level.

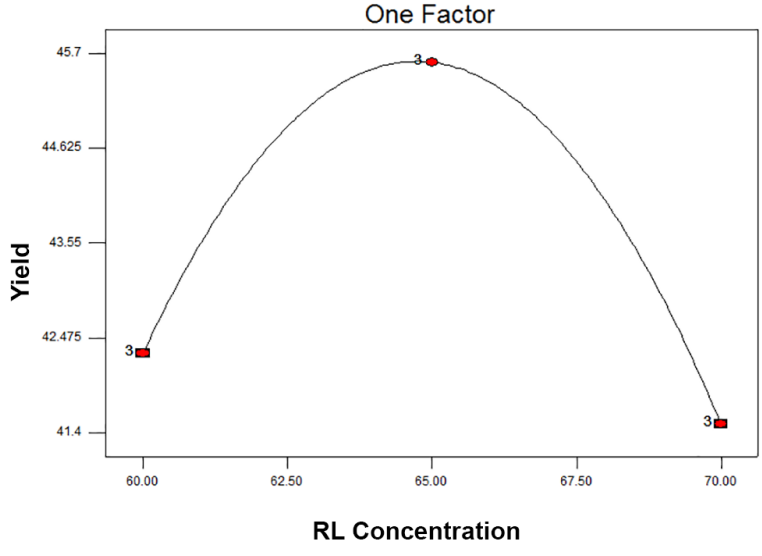

Figure 3: Contour plot graphic of the yield response.

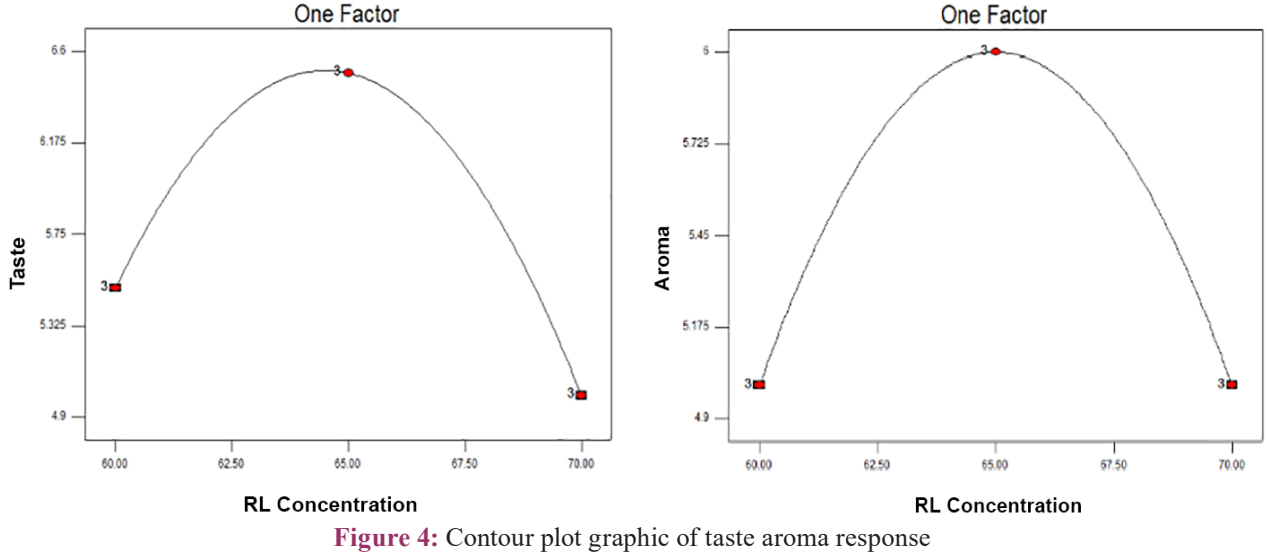

Figure 4: Contour plot graphic of taste aroma response

significantly toward aroma, taste, and texture value of analog rice.

Table 4 represents the components that were optimized, the target, and minimum and maximum borders, as well as the importance level of optimization formula. The seaweed concentration was shown to be about 60-70%. It was the optimization component with the minimal target (60%) with the third importance level (+++). Iodine response level, food fiber level, yield, aroma, taste, and texture of analog rice were the optimized response with the maximum target and the third important level (+++).

According to the optimization process, and program DX 7.1.5, the optimum formula was shown

Table 4: Optimized, targeted, bordered, and important optimization formula steps.

Name	Goal	Lower limit	Upper limit	Lower weight	Upper weight	Importance
RL Concentrate	To be in range	60	70	1	1	3
Iodine level	Maximize	56.18	95.173	1	1	3
Fiber level	Maximize	0.992	3.474	1	1	3
Yield	Maximize	41.5	45.6	1	1	3
Aroma	Maximize	5	6	1	1	3
Taste	Maximize	5	6.5	1	1	3
Texture	Maximize	3	5	1	1	3

in Table 5 denoting to the seaweed concentration of 65.84% as the solution of the optimum formula, with the desirability value of 0.78. It was predicted to produce analog rice with iodine level of 74.55 ppm, fiber food level of 2.39%, yield of 45.43%, aroma value of 5.97, taste value of 6.42, and texture value of 4.87. The selected optimum point solution using the program and the comparison with the results of verification in the laboratory was shown in Table 6. The verification of optimum condition recommended by DX 7.1.5 program using RSM one factor by *Gracilaria* analog rice was demonstrated as iodine level of 74.55 ppm, food fiber level of 2.39%, yield of 45.43%, aroma of 5.97, taste of 6.42, and texture of 4.87.

Discussion

The RSM formula revealed that iodine level increased as well as the increasing of the seaweed concentration. Normal plot of residual graphic was close to the standard line which showed that iodine level was spread out, thus actual result would be close to the expected result (2). The Contour Plot Graphic displayed that seaweed concentration factor could affect the iodine response value. The higher seaweed concentration, then the higher the iodine level would be. Overall, the value of iodine level was fulfilling the minimum standard of the iodine needs of human. The number of iodine in the body was about 15-23 mg. Iodine is very important for mammals' body and human body as a hormone for formation of the embryo and to maintain the metabolism flow and calorie production or energy (3).

Regarding the analysis of food fiber response level, Anik defined that food fiber was a part of plant walls cell which was not hydrolyte or digested by human digestive enzymes that consisted of hemicellulose, cellulose, lignin, oligosaccharide, pectin, gum, and wax counting (4). Fiber consumption can prevent the degenerative illness such as millets diabetes, heart attack, and another illness related to the obesity (5). The RSM formula for optimization process of analog rice to get the maximum food fiber level was 2.19+1.21X. This formula showed that food fiber level increased as well as the increase in the seaweed concentration. Overall, the value of food fiber level had already fulfilled the minimum standard of the food fiber needs of human.

According to the Ministry of Health (6), the number of food fiber in the males' body was reported 38 g/day and for females' body to be about 30 g/day. Therefore, to fulfill the needs of food fiber, each person has to consume 100-200 g analog rice each day. The composition of food fiber in rice was considered 1.3%. Regarding the yield response analysis, the optimization process of analog rice got maximum yield level for 45.6-0.4X-3.7X2. This

Table 5: The optimization formula steps.

Number	RL concentrate	Iodine level	Fiber level	Yields	Aroma	Taste	Texture	Desirability	
1	65.84	74.55	2.39	45.43	5.97	6.42	4.87	0.78	Selected

Table 6: The optimum point solution and selected criteria verification.

	Independent variable	Response				
	RL concentrate	Iodine level	Fiber level	Yield	Aroma	Taste	Texture
Prediction*	65.84	74.55	2.39	45.43	5.97	6.42	4.87
Prediction interval*	65.84	56.18-92.92	2.27-2.52	45.3-45.3	5.97-5.97	6.42-6.42	4.87-4.87
Verification**	65.84	74.46	2.41	45.84	6.09	6.74	5.08
Comparison of response value and verification		0.12	0.83	0.89	1.97	4.75	4.13

*The result of Design Expert Program DX 7.1.5, **The data of actual research

formula exhibited that yield level increased as well as decreasing of the seaweed concentration. The more seaweed concentration, the lower yield of analog rice.

The lowest yield using seaweed concentration was 70% that had yield value of about 41.5%. However, the greater the yield level using seaweed concentration was 65% with the yield value of 45.6%. The higher seaweed concentration, the higher yield level and after reaching the maximum level, yield value decreased as well as the increase in seaweed concentration. Regarding the analysis of aroma, taste, and texture preferring response level, the score of aroma, taste, and texture preferring on analog rice was the accepted score from the panelists toward analog rice. The RSM formula for optimization process of analog rice to get the maximum preferring score revealed that aroma, taste, and texture preferring scores increased as well as the decrease in the seaweed concentration.

Analog rice aroma that is liked by the panelists is the analog rice with the less concentration of seaweed, however taste and texture that is liked is within 65% concentration of seaweed. It can be happened because *Gracilaria* seaweed has a particular aroma so that the panelists do not like the aroma. Contour plot graphic showed that the factor of seaweed concentration influenced significantly toward aroma, taste, and texture value of analog rice. The higher seaweed concentration, the more increase the preferring of taste, aroma, and texture and after reaching the maximum, so the value would be decreased as well as the increasing of seaweed concentration.

To determine the point of response and verify the optimum, optimization was done after getting the mathematic formula on each response. The optimization was done to get the suitable response with the expected response (desirability). The aim of the optimization was to minimize the effort that was necessary or the operational cost and optimizing what the analog rice inventors wanted. Table 4 denotes to the components that were optimized, the target, and minimum and maximum borders, as well as the importance level of optimization formula. The seaweed concentration was about 60-70%. It is the optimization component with the minimal target (60%) with the third importance level (+++). Iodine response level, food fiber level, yield, aroma, taste, and texture of analog rice were the optimized response with the maximum target and the third important level (+++). Iodine level, food fiber level, yield, aroma, taste, and texture were the response which were shown as the main quality or the specialty of analog, thus this response should be optimized with the maximum target.

Iodine level and food fiber level were the responses stating the total iodine and food fiber which consisted the analog rice. High iodine and fiber content in the analog rice were the nutritional superiority of analog rice that were as healthy rice to fulfill the intake of iodine and food fiber needs of human. Yield was the important response to determine the efficiency of process, and the relationship between economy value that gave the beneficial, however, the preferring value of aroma, taste, and texture was a parameter to be used to know how far the panelist accepted the analog rice.

According to the optimization process, program DX 7.1.5 gave a solution of optimum formula that could be seen in Table 5. The condition process with the seaweed concentration of 65.84% was recommended to be the solution of the optimum formula, because this process had high desirability value of 0.78. Desirability value that was close to one and higher than the optimization accuracy value, so the seaweed concentration of 65.84% would produce the seaweed analog rice with characteristic of the optimum target as 78%. It was predicted to produce analog rice with iodine level of 74.55 ppm, fiber food level of 2.39%, yield of 45.43%, aroma value of 5.97, taste value of 6.42, and texture value of 4.87.

The next step after determining the optimum point was the verification from the selected solution by doing a research form the given solution. Solution that was derived from Design Expert DX 7.1.5 Program as the optimum point of seaweed concentration of analog rice processing. The selected optimum point solution using the program and the comparison with the results of verification in the laboratory was shown in Table 6. The verification of optimum condition recommended by DX 7.1.5 program using RSM one factor by *Gracilaria* analog rice was demonstrated as iodine level of 74.55 ppm, food fiber level of 2.39%, yield of 45.43%, aroma of 5.97, taste of 6.42, and texture of 4.87.

Conclusion

According to the result of organoleptic test toward a staple food of analog rice from *Gracilaria*, the composition of seaweed (65.84%), modified cassava flour (31.16%), and vegetable oil as well as glycerin (3%) were optimized for taste, aroma, and texture. Fiber food of seaweed (65%), Modified cassava flour (32%), and vegetable oil as well as glycerin (3%) were shown to be 2.39% higher than rice food fiber standard (1.3%). The iodine composition in the form of analog rice from *Gracilaria* seaweed was demonstrated to be 74.55 ppm (74550 µg) which was more than the average standard of human

iodine needs (150µg/day). The yield of staple food ingredient was as a staple food of analog rice from *Gracilaria* seaweed (45.43%).

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Conflict of Interest

None declared.

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