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The Effect of Maltodextrin Concentration and Roasting Time on the Physicochemical and Sensory Characteristics of Nori Snack Made from Sea Grape (*Caulerpa* sp.)

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A B S T R A C T

Nori snack is dried edible seaweed, which is made from drying and roasting so its texture is crispy and thin. Commercial nori snack is usually made from *Porphyra* seaweed which cannot be cultivated in Indonesia. Sea grapes (*Caulerpa* sp.), a local seaweed that is widely cultivated in Indonesia, have the potential to be used as an alternative material for nori snacks. The formation of nori with the addition of *Eucheuma cottonii* gives a nori snack texture that tends to be elastic and less crunchy. Crispness is the main parameter to consider in choosing nori snacks. The addition of maltodextrin as a texture enhancer is needed to give a compact and crispy texture, and roasting time can also increase the level of crispness in nori products. This study aims to determine the physicochemical and organoleptic characteristics of sea grape nori snacks (*Caulerpa* sp.). Factorial completely randomized design (CDR) with two factors. Factor I was the maltodextrin concentration (1, 2, and 3%), while factor II was a roasting time (1, 2, and 3 minutes) and two replications. The data were analyzed using Analysis of Variance (ANOVA) and followed by Duncan's New Multiple Range Test (DNMRT) at the 5% significance level. The best treatment was the addition of 3% maltodextrin and a roasting time of 3 minutes. The results obtained were a moisture content of 6.13%, ash content of 12.45%, a protein content of 17,07%, a yield of 6.22%, a breaking strength of 5.23%, and an average score of preference for the aroma of 2.8 (dislike), the colour of 3.5 (standard), the taste of 4.05 (like), and crispness of 4.10 (like).

1. INTRODUCTION

1.1. Research Background

Indonesia, with 6,400,000 km^2 of ocean area and 110,000 km of coastline, and supported by a tropical climate, is a suitable area for the growth of various types of seaweed. Marine commodities are increasingly being developed. Local seaweed cultivation has the potential to be developed evenly in maritime districts in Indonesia. Sea grapes (*Caulerpa* sp.) are one type of commodity from local seaweed that is being developed [1].

The utilization of sea grapes (*Caulerpa* sp.) is still limited, most people use it by consuming it fresh or processing it into salads, *rujak*, and *urap – urap*. Significantly, the usage of sea grapes (*Caulerpa* sp.) was developed, such as an ingredient in noodles and biscuits as well as raw material for candies and sauces [2]. To achieve the diversity of sea grape-based products, it is necessary to develop other products.

The proximate compositions of sea grapes (*Caulerpa* sp.) based on the dry basis were 91.36% of water, 23.81% of ash, 21.370% of protein, 8.681% of fat, 48.679% of carbohydrate and 8.429 of crude fiber [3]. High moisture content causes the quality of sea grapes to decrease during postharvest, therefore, it is necessary to process sea grapes which have a low moisture content and high demand by consumers. One of the products being developed is nori.

Nori is Japan's traditional food which has thin sheets of seaweed form, commercially made with *Porphyra* sp. seaweed which cannot cultivated in Indonesia [4]. Generally, there are two types of nori in the market, namely nori as a snack and nori as a coating or commonly used as a sushi wrapper[5]. Research on sea grapes as the main ingredient for making nori has been carried out, but it is not close enough to the characteristics of commercial

nori [6]. So that *Eucheuma cottonii* was added as an alternative raw material for gel formation in nori, with the result of nori with an elastic texture similar to commercial [7]. Crispy (not tough), but also not easily crushed (not brittle) are the characteristics of nori snacks that are in demand by consumers, or we usually called it crispy [8]. So additional materials are needed to improve the texture according to consumer demand.

to create crispness can be increased by adding modified starch with low DE [9]. Maltodextrin can be used as a filler and as a thin layer coating material in coating the product surface so that it can maintain crispness [10]. In addition, another thing that needs to be considered in making nori snacks is the processing process. Roasting time can increase the crispiness of nori snacks [11].

1.2. Literature Review

Nori snacks are snacks made from seaweed which are processed by drying and roasting. Nori snacks are an alternative to healthy snacks[12]. Nori snacks are categorized as snacks the same as chips, crackers, chips, and flakes[8].

The texture of nori is dry, smooth, greenish-black in colour and shiny because of the pigment content from marine algae with a uniform size (generally 0.22 mm)[13]. Based on the standard by Codex (2017) nori is required to have a distinctive flavour and taste of seaweed with a black-green colour [14]. Commercial nori has nutritional content was 8.10% of moisture, 8.91% of ash, and 25.49% of protein[4]. Studies on the development of nori made from local seaweed are still limited. some of them, *Ulva lactuca* and *Eucheuma cottonii*, *Ulva lactuca* and *Gracilaria* sp., *Sargassum* sp. and *Euchema spinosum*, *Gracilaria* sp. with eel flour mixture, *Gelidium* sp. and *Eucheuma cottonii* [15].

Sea grapes (*Caulerpa sp*.) based on the dry basis was 91.36% of water, 23.81% of ash, 21.370% of protein, 8.681% of fat, 48.679% of ccarbohydrate, and 8.429 crude fiber [3] and total dietary fibre content of 17.5% [16] which is potential as main ingredients of snack nori. Producing nori closest to commercial nori was the addition of 5% *Eucheuma cottonii*, with characteristics of acceptance by panelists such as dark green colour (close to commercial nori) compact, uunified, and elastic texture[7]. It is necessary to add other ingredients in the formulation of the nori snack because the crisp texture has not been shown.

To increase the crispiness of snack products, it is necessary to add ffillers withhave properties that can provide and maintain crispness during storage. Maltodextrin is a modified starch product with a DE value of less than 20. It is composed of a mixture of small amounts of simple carbohydrates (mono- and disaccharides), relatively high amounts of short-chain ooligosaccharides, and a small amount of long-chained oligosaccharides[17]. In the food industry, the use of maltodextrin is primarily intended to improve product texture, and film formation, and function as a nutrient supplier in a product[18]. Maltodextrin with low DE is non-hygroscopic[17], easier for moisture to evaporate so it can maintain crispness[19]. Leather snack from vegetables produces a leather product texture that is not chewy (hard) with the addition of 2% maltodextrin[20].

In the formation of nori snacks, the most important steps are the formation of gel and the evaporation of water. The linear amylose chains in the dissolved state are responsible for the initiation and acceleration of maltodextrin gel formation. The outer linear chain amylopectin is thought to interact with amylose, thereby reducing the gelling ability of each group separately, and leading to the formation of the same hydrated network[21]. The roasting process in making snacks also influences determining the crispiness of the product. The roasting process at 100°C for 3 minutes has a crispy effect on the nori snacks[11].

1.3. Research Objective

This study aims to determine the physicochemical and organoleptic characteristics of sea grape nori snacks (*Caulerpa* sp.).

2. MATERIALS AND METHODS

2.1. Materials and Tools

The raw materials used in this study were sea grapes (*Caulerpa* sp.) which were cultivated on the Rembang, Middle Java, dried *Eucheuma cottonii obtained by E-commerce,* ,and coconut oil. The chemical used in this research is CH3COOH (Smartlab, pa).

The tools used in making snack nori and this research are a cabinet dryer, Memmert® Oven U055, Muffle Furnace 1.3 L 1100C, micrometer, desiccator, Kirin electric oven, Miyako blender, Rinai gas stove, beaker glass, measuring cup, analytical balance, 20 x 18 x 3 cm baking dish, pan, basin, brush, spoon, etc.

2.2. Design of Experiment and Analysis

This research was designed by Completely Randomized Design (CRD) with two factorials. Factor I was the maltodextrin concentration (1, 2, and 3%), while factor II was a roasting time (1, 2, and 3 minutes) and two replications. Treatment combinations are shown in Table 1.

Table 1. Treatment combinations Nori snack

Maltodextrin	**Roasting Time**		
	B_1	**B_2**	**B_3**
A_1	$A_1 B_1$	$A_1 B_2$	$A_1 B_3$
A_2	$A_2 B_1$	$A_2 B_2$	$A_2 B_3$
A_3	$A_3 B_1$	$A_3 B_2$	$A_3 B_3$

Wherein,
A1B1 = maltodextrin 1% & roasting time 1 minute
A1B2 = maltodextrin 1% & roasting time 2 minute
A1B3 = maltodextrin 1% & roasting time 3 minute
A2B1 = maltodextrin 2% & roasting time 1 minute
A2B2 = maltodextrin 2% & roasting time 2 minute
A2B3 = maltodextrin 2% & roasting time 3 minute
A3B1 = maltodextrin 3% & roasting time 1 minute
A3B2 = maltodextrin 3% & roasting time 2 minute
A3B3 = maltodextrin 3% & roasting time 3 minute

The product observation data were analyzed using ANOVA and followed by Duncan's New Multiple Range Test (DNMRT) at a 5% significance level. Obtained observational data were then tabled and plotted in the form of a regression curve so that a linear regression would be obtained using the *Microsoft Excel 2019* program.

2.3. Research Procedure

The process of making nori snacks in this study was based on a modification of previous research [11] method with washed with water until clean, then boiled at 100°C for ± 3 minutes and drained, then mashed with a blender. then weighed 100 grams and

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added *Eucheuma cottonii* 5 grams and added with each treatment of maltodextrin. Then heated at 80°C for ± 3 minutes. Printed on a 20 x 18 x 3 cm baking dish. Then the drying process was carried out at 40°C for ± 4 hours. Then the roasting process was carried out with each treatment at 100°C.

2.4. Observations

2.4.1. Raw Material Observation

Analysis of raw materials sea grapes include moisture content (%) & ash content (%) using gravimetric method and Kjeldahl method for analyzing protein content (%).

2.4.2. Nori Snack Physicochemical Observations

Analysis parameters include moisture content (%) & ash content using gravimetric methods, Kjeldahl method for analyzing protein content (%), yield (%), and a breaking tensile was measured by a texture analyzer.

2.4.3. Nori Snack Sensory Observations

Sensory attributes selected to assess the quality of nori snacks are aroma, color, taste and crispness. There are 20 panelists are asked to rate the acceptability of the product on a scale. of 5 points, ranging from "like extremely" to "dislike extremely". Data analysis involved the Friedman test.

3. RESULT AND DISCUSSION

3.1. Physicochemical Analysis

3.1.1. Raw Material Analysis

Raw material analysis includes moisture content, ash content, and protein content. The results of the raw material analysis are shown in **Table 2.**

Table 2. Raw Material Analysis

Variable	Result
Moisture content (%)	78.09 ± 0.297
Ash content (%)	7.07 ± 0.40
Protein content (%)	13.88 ± 0.46

Based on the result of raw materials analysis presented on the Table 2. The moisture content of the sea grapes (*Caulerpa* sp.) is 78,09%, which is not much different with a previous study by [22] with a moisture content of sea grapes is 77.57%. The ash content of this study is 7.07% higher than the previous study by [23] which is 5.38%. The protein content of the sea grapes (*Caulerpa* sp.) is 13.88%, less than the previous study by [24] which is 17.28%. Differences in raw material analysis results are influenced by several factors, the most important of which are different cultivation areas and harvesting times [25].

3.1.2. Snack Nori Analysis

The physicochemical analysis of nori snack includes moisture content (%), ash content protein content (%), yield (%), thickness (mm), and a breaking strength (N) are shown in Table 3.

The percentage of moisture content in nori snacks ranges from 6.13 – 8.22%. The variance analysis shows a significant interaction between maltodextrin concentration and roasting time on the moisture content of nori snack ($P \leq 0.05$), which is shown in **Fig 1**. That there is a strong correlation between the two factors on the moisture content of nori snacks. The increase of maltodextrin and roasting time causes a large amount of evaporated water during the process. Maltodextrin is formed by incomplete hydrolysis of starch so it has low DE (less than 20), it causes maltodextrin has low molecular weight (less than 4000) and low hygroscopicity, so it is not too good to bind of moisture[26][27]. Thermal radiation helped moisture of the nori snack evaporate more[28]. The lowest moisture content of the nori snack is not much different from the standard.

The results of the analysis of the ash content of the nori snack product ranged from 11.67 - 12.45% it is shown in table 3. The analysis of variance showed that the maltodextrin concentration had not statistically significant effect ($p \geq 0.05$). Maltodextrin is formed by organic element specifically carbon (C), hydrogen (H), and oxygen (O) and has low ash content [29]. While the analysis of variance showed that the roasting time had a statistically significant effect ($p \leq 0.05$), it caused by low moisture content in the product thereby increasing the percentage of ash content in the product[30]. The ash content indicates the mineral content in snack nori.

The results of the analysis of the protein content of the nori snack product ranged from 15.36 - 17.05% it is shown in table 3. The analysis of variance showed that the maltodextrin concentration had not statistically significant effect ($p \geq 0.05$). Maltodextrin is formed by organic element specifically carbon (C), hydrogen (H), and oxygen (O) and does not have nitrogen (N) element in its structure [31]. While the analysis of variance showed that the roasting time had statistically significant effect ($p \leq 0.05$), it caused by sea grape protein being composed of amino acids such as glutamate and aspartate. The increase in glutamate levels in protein is caused by a decrease in the amount of free moisture in nori percentage of protein content in the product[32].

The percentage of yield in nori snacks ranges from 5.22 – 6.68%. The variance analysis shows a significant interaction between maltodextrin concentration and roasting time on the moisture content of nori snack ($P \leq 0.05$), which is shown in Fig 2. The correlation between the two factors on the moisture content of nori snacks is strong. The increase in the use of maltodextrin and roasting time causes a large amount of evaporated moisture during the process, it causes the increase of total solids in the product so that when the roasting process is carried out, the solids are not reduced, the increase of the weight product affect to the yield will be increased[33].

The percentage of breaking strength in nori snacks ranges from 3.13 – 5.23N. The variance analysis shows a significant interaction between maltodextrin concentration and roasting time on the moisture content of nori snack ($P \leq 0.05$), it is shown in Fig 3. The correlation between the two factors on the moisture content of nori snacks is strong. The maltodextrin and roasting time increased causes a large amount of moisture was evaporated during the process, it causes the increase of total solids in the product so that when the roasting process is carried out, the breaking strength of the product will be increased[34]. A breaking strength indicates the crispness level of the product, a lower breaking strength represents nori snack that is not crispy (tends to be mushy), it because the higher moisture content. Meanwhile, a low moisture content indicates a crisper product so that the breaking strength is higher[35].

3.2. Sensory Analysis

3.2.1. Aroma

Based on Table 4. the highest aroma score is 2.80 (quite liked). According to the panelists, the nori snack product has a very distinctive marine aroma. The sea grape (*Caulerpa* sp.) has a distinctive sea aroma that is similar to the aroma of other marine products (fishy). Volatile compounds found in marine products such as green and brown macroalgae are aldehydes[36].

Table 3. Physicochemical analysis of sea grapes nori snack (*Caulerpa* sp.)

Treatments	Physicochemical analysis				
	Moisture content (%)	Ash content (%)	Protein content (%)	Yields (%)	Breaking Strength (N)
A1B1	$8.22^{e} \pm 0.14$	$11.67^{a} \pm 0.45$	$15.36^{a} \pm 0.10$	$5.22^{a} \pm 0.03$	$3.13^{a} \pm 0.02$
A1B2	$7.68^{d} \pm 0.16$	$12.64^{b} \pm 0.33$	$16.25^{b} \pm 0.28$	$5.14^{a} \pm 0.13$	$3.22^{a} \pm 0.06$
A1B3	$7.32^{c} \pm 0.15$	$12.97^{c} \pm 1.17$	$17.04^{c} \pm 0.15$	$5.05^{a} \pm 0.14$	$3.47^{b} \pm 0.07$
A2B1	$7.04^{bc} \pm 0.12$	$11.36^{a} \pm 0.02$	$15.49^{a} \pm 0.30$	$6.22^{f} \pm 0.03$	$3.78^{c} \pm 0.04$
A2B2	$6.86^{b} \pm 0.11$	$11.56^{b} \pm 0.11$	$16.14^{b} \pm 0.26$	$6.17^{d} \pm 0.04$	$3.91^{d} \pm 0.06$
A2B3	$6.37^{a} \pm 0.11$	$12.22^{c} \pm 0.11$	$17.14^{c} \pm 0.26$	$6.14^{c} \pm 0.05$	$4.21^{e} \pm 0.11$
A3B1	$6.25^{a} \pm 0.15$	$11.36^{a} \pm 0.02$	$15.92^{a} \pm 0.13$	$6.68^{g} \pm 0.02$	$4.62^{f} \pm 0.05$
A3B2	$6.16^{a} \pm 0.07$	$12.15^{b} \pm 0.01$	$16.07^{b} \pm 0.06$	$6.51^{g} \pm 0.02$	$5.03^{g} \pm 0.10$
A3B3	$6.13^{a} \pm 0.02$	$12.45^{c} \pm 0.43$	$17.05^{c} \pm 0.25$	$6.22^{e} \pm 0.07$	$5.23^{g} \pm 0.06$

The average value accompanied by different letters shows a significant difference at $p \leq 0.05$

Table 4. Sensory analysis of sea grapes nori snack (*Caulerpa* sp.)

Treatments	Sensory attributes			
	Aroma	Color	Taste	Crispness
A1B1	2.45	2.9	3.25	2.85
A1B2	2.50	3.05	3.65	3.20
A1B3	2.75	3.55	3.35	3.20
A2B1	2.50	2.85	3.15	3.10
A2B2	2.60	2.85	3.25	3.40
A2B3	2.80	3.05	4.05	3.80
A3B1	2.45	2.80	3.35	3.60
A3B2	2.75	3.25	3.05	3.45
A3B3	2.75	3.20	3.50	4.10

Note: The higher the value, the more preferred

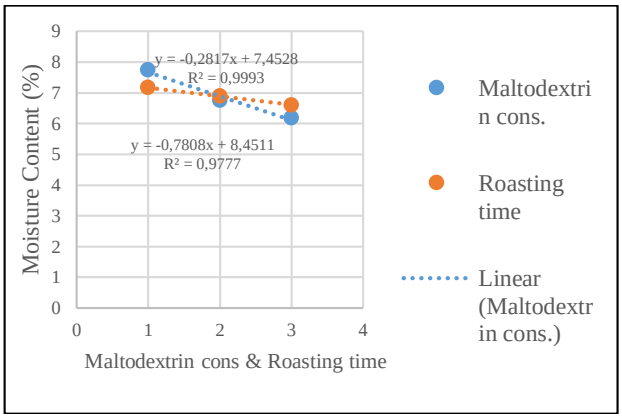

Fig 1. Linear regression correlation between maltodextrin concentration and roasting time on nori snack moisture content

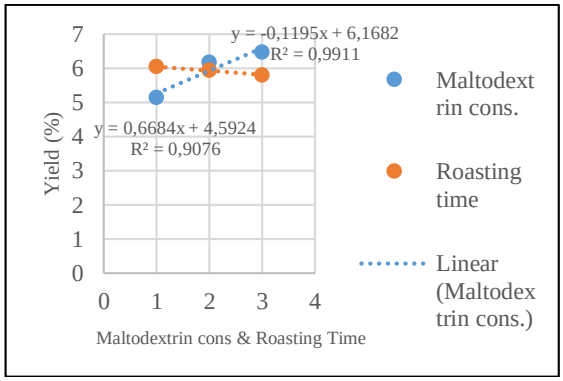

Fig 2. linear regression correlation between maltodextrin concentration and roasting time on nori snack yields

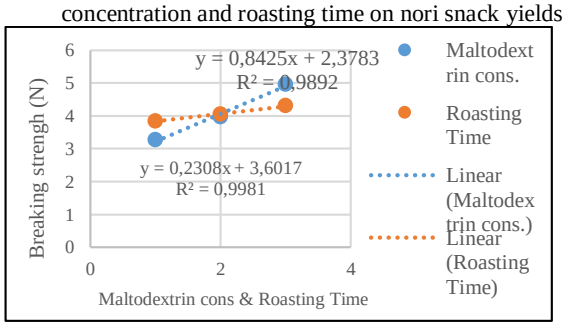

Fig 3. Linear regression correlation between maltodextrin concentration and roasting time on nori snack breaking strength

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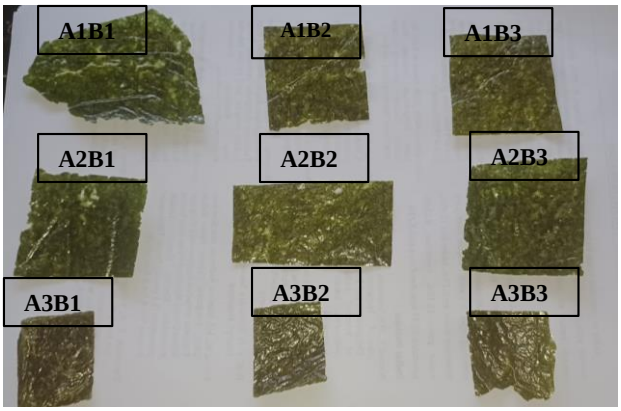

Fig 4. Picture of nori from maltodextrin concentration levels and roasting time

3.2.2. Color

Based on Table 4. the highest color score is 3.25 (standard). According to the panelists, the color of nori snack pproductsis a little bit ddifferentcompared to commercial nori. It is because tof he difference in igment between Caulerpa sp. and Porphyra sp. Caulerpa sp. has chlorophyll a and b which gives greenish pigment to nori snack[37].

3.2.3. Taste

Based on Table 4. the highest color score is 4.05 (liked). According to the panelists, the taste of nori snack product is umami aand the alty taste is made from seaweed. This umami taste from the presence of L-glutamate and L-aspartate The salty taste is formed due to the presence of mineral salts in sea grapes[38].

3.2.4. Crispness

Based on Table 4. the highest color score is 4.10 (liked). The highest taste score was in the treatment of maltodextrin concentration (3%) and roasting time (3 minutes). The high concentration of maltodextrin and the roasting time cause evaporated water content to be higher, thus forming air voids so the product is more crispy[39].

Based on the decision analysis with Bayes method, results on the physicochemical and organoleptic characteristics of nori snack were the addition of 3% maltodextrin and a roasting time of 3 minutes. The results obtained were a moisture content of 6.13%, ash content of 12.45%, protein content of 17,07%, a yield of 6.22%, a breaking strength of 5.23%, and an average score of preference for the aroma of 2.8 (dislike), the color of 3.5 (standard), the taste of 4.05 (like), and crispness of 4.10 (like).

4. CONCLUSION

There is a significant interaction in the treatment of the maltodextrin concentration and roasting time on moisture content, yield, breaking power, crispness, and organoleptic. And there were no significant interactions in ash content, protein content, organoleptic color, taste and aroma. The best treatment was the addition of 3% maltodextrin and a roasting time of 3 minutes. The results obtained were a moisture content of 6.13%, ash content of 12.45%, protein content of 17.07%, a yield of 6.22%, a breaking strength of 5.23%, and an average score of preference for the aroma of 2.8 (dislike), the color of 3.5 (standard), the taste of 4.05 (like), and crispness of 4.10 (like).

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