The Fortification Effects of Sea Grapes (Caulerpa racemosa)
Powder on Color and Sensory of Hakau Dim Sum Wrappers

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Abstract. Sea grapes (Caulerpa racemosa) are green seaweeds that include containing dietary fiber, antioxidant compounds, and natural dyeing colours such as chlorophyll and carotenoid pigments. Sea grapes' green tint, when ground into powder, has the potential to be used as a coloring agent. It can be used as an alternative dyeing agent and product diversification on hakau dim sum wrappers. The purpose of this study was to determine how adding sea grapes powder affected the physical properties (color and folding test) and sensory attributes (time-intensity) of hakau dim sum wrappers. The research was conducted by manufacturing sea grape powder and the wrappers by hand. Caulerpa racemosa was added in various concentration (0%; 1.5%; 3%; 4.5%; and 6%) (w/w). The dough was molded with a thickness of no.5 pasta maker with 8 cm diameter. The wrappers were physically tested and steamed for 15 minutes for sensory testing. As a result, wrappers fortified with sea grape powder show green colour and stand up the transparent characteristics. Lightness (L*) and redness (a*) decreased with increasing concentration of sea grape powder which indicated dark green wrappers color. Sea grape powder affected raw wrappers in the folding test. Time-intensity evaluation looked at the gelatinized flour flavor and sea grapes flavor. The result shows the gelatinized flour flavor reached the highest peak in the control wrappers, while the concentration of 6% had the highest intensity of sea grapes flavor and the lowest gelatinized flour flavor. In conclusion, the addition of sea grape powder resulted in a transparent green dim sum wrapper, decreased folding score for raw and the sea grapes flavor was more dominant than the gelatinized flour flavor.

1. Introduction
Caulerpa sp. is a ramuli-bearing green algae. It gives the species its grape-like shaped like, earning it the nick name "sea grapes,"Umibudo (Japan), green caviar (Europe), ar-arosep or lato are some of the other names for sea grapes (Philippines) [1]. Antioxidant substances such as phenol compounds, flavonoids, steroids, saponins, vitamins A, C, and E are among active elements found in sea grapes [2]. Caulerpa racemosa extract has a total phenolic content of 61.69 mgPGEg-1, with antioxidant activity of 1000 ppm at 87.01% [3].

The sea grape species Caulerpa lentillifera and Caulerpa racemosa var. turbinate are often used in salads and vegetables [4], cosmetics, such as lotions [5], masks [6], sunscreens [7] and pharmaceuticals (antidiabetic, anti-inflammatory) [8] are all possible uses for sea grape extract.

Sea grapes have a green appearance. The pigments chlorophyll and carotenoid are responsible for green hue. Caulerpa racemosa has 135.43±5.09 and 24.96±2.53 (µgg-1 FW) total chlorophyll and carotenoids, respectively [3]. By turning it into a powder, its hue has the potential to become a natural dyeing agent. Ice cream, cookies, and dim sum/dumpling wrappers are the goods that consumers favor fortification with sea grapes [9].
Dim sum is a processed Chinese product that is well-known [10]. Dim sum is popular among youth in Indonesia. Hakau/hargow is a type of dim sum with distinctive transparent wrappers and shrimp filling. Researchers found the problem in Micro, Small and Medium Enterprises (MSME) of dim sum/dumpling wrappers, namely the addition of liquid dye in the product was not transparent and could fade when stored. To answer this problem, the fortification of natural dyes from sea grape powder on the wrappers of dim sum hakau was investigated by varying the right concentration.

Time-intensity (TI) is a descriptive sensory test to obtain such temporal information from a product [11]. TI is a well-known method to record and obtain the intensity of specific attributes over time [12]. This method has been successfully applied to very different food matrices over the years including dairy products [13]. The results of time intensity are seen from the intensity of an attribute reaching its peak and the time of loss of sensation from the attribute. The observed TI variables were T init (T initial), T onset, T max, Plateau time, T trun, T ext, I max, AUC (area under the curve)[14]. The calculation of the AUC value is done by calculating the area under the curve using the integral of the second-order regression equation on the TI curve [15].

The purpose of this study was to determine the effect of adding sea grape powder to the physical (color and folding test) and sensory (time intensity) properties of the dim sum hakau wrappers.

2. Materials and Methods

2.1. Research Methods
The method used in this research was experimental. It fortified some different ratios of sea grape powder into dim sum hakau wrappers. This study used the CRD method (Completely Randomized Design) one factor. The concentration of sea grape powder were (R0 = 0%; R1 = 1.5%; R2 = 3%; R3 = 4.5%; and R4 = 6%) (w/w flour). The results of the preliminary study found that the limit concentration for adding sea grape powder to dim sum wrappers was 7% (w/w) because the wrappers were opaque/not transparent. The formulations of sea grape powder and other materials are shown in Table 1.

| Materials                  | Amount          |
|----------------------------|-----------------|
| sea grape powder           | R0, R1, R2, R3, and R4 |
| Tang mien flour            | 100 g           |
| Tapioca flour              | 40 g            |
| Palm oil                   | 10 ml           |
| Hot water                  | 170 ml          |
| Salt                       | 0.5 g           |

2.2. Materials and tools
The materials used in this study were Caulerpa racemosa cultivated at the Brackish Water Cultivation Fisheries Center (BBPBAP) Jepara, Central Java, 1% NaOCl, tang mien flour, tapioca flour, palm oil, water, salt. The tools used in this study included a cabinet dryer/oven, baking sheet, blender (Miyako BL-302, Philips HR2116), 80 mesh sieve (TSING-TAO), pasta maker (Cookmaster CM-2150D), Konica Minolta Cr Portable Colorimeter Nh310 Chroma Meter (Japan) and scoresheet.
2.3. Sea grape powder preparation (Wisnuaji, 2021)[9] modified
Fresh Caulerpa racemosa purified from some materials, such as shellfish, gravel and sand. They were then washed with clean water, and prepared with a ratio of 1% NaOCl:water = 1:3. Then, the researchers soaked them using the ratio of sea grapes: mixed water = 1:2 for 9 hours. Sea grapes were dried in an oven/cabinet dryer at 40°C for 24 hours. The dried sea grapes were mashed inside of a blender and sieve 80 mesh.

2.4. Making dim sum wrappers with sea grape powder (Apriyani et al., 2015)[16]
The researchers mixed the tang mien flour, sea grape powder, tapioca flour, and boiling water, mix well. Then, the researchers covered the dough for 10 minutes, then added oil a little at a time. The next step was to put the dough into a pasta maker with a thickness no.5 (±0,5 mm) then printed it with a diameter of 8 cm. Then the wrappers are steamed for 15 minutes.

2.5. Physical analysis (Color)
Color testing was carried out on raw dim sum wrappers with a Konica Minolta Cr Portable Colorimeter Nh310 Chroma Meter (Japan). The analysis was carried out by attaching the sample to the tool and then pressing the button to bring up the color scale of the sample. The parameters observed were L* (Lightness parameter), a* (redness/greenness), b* (yellowness/blueness).

2.6. Physical analysis (Folding test)(National Standardization Agency of Indonesia 2009)
Folding test obtained by using National Standardization Agency of Indonesia 2009 method on raw and steamed dim sum wrappers. The sample pieces are placed between the thumb and forefinger, then folded to observe whether there are cracks in the product. The folding test scores are as follows: (5) Does not crack when folded twice; (4) Does not crack when folded once; (3) Slightly cracked when folded once; (2) Crack when folded once; (1) Destroys when pressed by finger.

2.7. Time-intensity (TI) (Listyowati, 2017)[15]
The candidate panelists were 18 panelists who are familiar with the appearance of most types of seaweed and algae such as Sargassum sp. and Arthrospira.

2.7.1. Panelist selection: trained panelists were obtained from 2-stage selection through the triangle test. Interviews were conducted to determine the willingness and seriousness of the panelists. Furthermore, the panelists did two triangle tests with the first sample saltwater and the second sample dim sum wrappers. Panelists were those who successfully answered with a percentage of 100% correct answers at the first step and 85% at the second step. Each step of the triangle test was a 7 series sample.

2.7.2. Time-intensity test: 7 trained panelists were trained using dim sum wrappers samples to make them more sensitive. Panelists evaluated the attributes for 90 seconds by chewing the sample for 30-40 seconds. They were then testing the aftertaste. The measurement of taste intensity was seen every 5 seconds for 90 seconds and filled into the scoresheet. Data analysis was performed by calculating the variables Text, Imax, AUC (area under the curve). The AUC value was calculated by calculating the area under the curve using the integral of the second-order regression equation obtained from the TI curve and entered on the web https://www.integral-calculator.com.

2.8. Data Analysis
The data were tested with a normality test to determine the distribution of data with Kolmogorov Smirnov and a homogeneity test to determine data variance with Levene Test (95% confidence level). When normality and homogeneity complied with the requirements, the data would be tested with the One Way Anova and further tested with the Least Significant Different (LSD)/Duncan test. Data that did not comply with the requirements were tested with the Kruskal Wallis test and further tested with the Mann-Whitney test. The application used is the IBM SPSS statistics 22 software.
3. Results

Hakau/hargow dim sum wrappers have characteristic transparency because of that main material is starch. Fortification sea grape powder is used for dyeing the wrappers. It made the result green colour and still stand the transparent appearance.

3.1. The effect of sea grape powder on dim sum wrappers color

Color was the first consideration when choosing food because it was the main characteristic of a product [17]. Colors could be obtained from natural or synthetic dyes. Natural dyes were the alternatives to dye because they are non-toxic, renewable, easily degraded, and environmentally friendly [18]. Color measurement results are presented in Table 2.

Table 2. The result sea grape powder affected color raw hakau dim sum wrappers

| Treatments | L*   | a*   | b*   |
|------------|------|------|------|
| R0         | 66.70 | 1.15  | 3.61  |
| R1         | 54.80 | -2.49 | 13.98 |
| R2         | 48.83 | -3.61 | 14.57 |
| R3         | 48.00 | -3.87 | 15.67 |
| R4         | 42.97 | -4.56 | 16.26 |

Means with common letters in the same column indicate that there is not a significant difference between samples (p<0.05)

The result showed that sea grape powder significantly affected (P<0,05) lightness (L*) of raw hakau dim sum wrappers. The control treatment or R0 without the addition of sea grape powder showed the highest lightness at 66.7 because of its white color. The boiling water made the starch gelatinized so R0 did not reach L* 100. Raw wrappers were not completely gelatinized because the inner region would have enough water but its temperature would be restricted to the boiling point of water. Therefore, it would be lower than the gelatinization temperature [19]. The lowest lightness was found in R4 at 42.97 because it had a dark green color. The addition of a higher concentration of sea grape powder reduced the lightness of the dim sum wrappers.

Redness (a*) of raw hakau dim sum wrappers showed significantly different (P<0,05) between treatments. R1, R2, R3, R4 showed green color because −a*, while R0 shows +a* which was 1.15. The difference between the treatments was in the concentration, higher fortification of sea grape powder made the dim sum wrappers greener. R4 showed the highest green color, which was -4.56.

The green color of Caulerpa racemosa came from the pigment chlorophyll. The total chlorophyll pigment contained in fresh Caulerpa racemosa was 135.43 ± 5.90 (µg g⁻¹ FW) [3].

The color parameter of b* (yellowness) was the intensity of the yellow color on a product. The result b* showed significantly different (P<0,05) between treatments. A higher concentration of sea grape powder produced a higher yellowness on the sample. R0 shows a value of 3.61 while the treatment R4 showed a result of 16.26. Yellowness on sea grape powder could be from pigment chlorophyll b and carotenoid. Chlorophyll is divided into two forms, namely chlorophyll a is blue-green, while chlorophyll b is yellow-green [20]. Fresh Caulerpa racemosa contains chlorophyll a 91.04 (µg g⁻¹ FW) and chlorophyll b 44.39 (µg g⁻¹ FW), in addition Caulerpa racemosa contains carotenoid pigments 24.96 (µg g⁻¹ FW) [3].
3.2. Folding test

Table 3 shows the results of the folding test of raw and steamed samples. The raw samples showed significantly different results ($P<0.05$) between treatments. Sea grape powder decreased folding score on raw samples. Lower scores indicate cracks in the dough that can affect its application. Cracks in the wrappers caused by starch are not completely gelatinized. In the steamed sample, the starch was perfectly gelatinized, resulting in elastic dim sum wrappers.

Table 3. Folding test scores using trained panelist on hakau dim sum wrappers

| Treatments | Raw     | Steamed |
|------------|---------|---------|
| R0         | 5$^a$   | 5$^a$   |
| R1         | 5$^a$   | 5$^a$   |
| R2         | 4.67$^a$| 5$^a$   |
| R3         | 2.17$^b$| 5$^a$   |
| R4         | 2.33$^b$| 5$^a$   |

Note: 5: Does not crack when folded twice  
4: Does not crack when folded once  
3: Slightly cracked when folded once  
2: Crack when folded once  
1: Destroys when pressed by the finger  

Common letters in the same column indicate that there is not a significant difference between samples ($P<0.05$)

![Figure 1. Caulerpa racemosa dimsum wrappers folding test](image)

Sample R0 obtained good folding test results, namely 5 (no cracks when folded twice). The high amylopectin content in tang mien and tapioca can form dim sum wrappers with flexible characteristics and there are no cracks when folded [16]. R1 and R2 showed results 5 and 4.67 were not significantly different from the control ($P>0.05$). Through Figure 1. it can be seen that the result R3 and R4 have cracks in the first fold. Cracks can be caused by the addition of more sea grape powder. Sea grape powder has a water holding capacity (WHC) between 4.17-4.22 [9]. High WHC will lead to the hardening of the dough because the water content of the dough is absorbed by the ingredients (sea grape powder). The water that should be absorbed by the starch granules for gelatinization was reduced, because sea grape powder absorbed it. This is supported by research on the substitution of 10% sea grape powder in cookies resulting in a hard cookie texture [21].

Steamed samples were tested with a significance level of 95% the results were not significantly different ($P>0.05$) between treatment, namely 5 (no cracks when folded twice). In Figure 1. can be seen that all treatments obtained good results, it was because the starch gelatinized due to steaming. Gelatinization is the process of entering water into the starch granules which causes swelling so that the food product becomes like an elastic gel [22]. Steaming produces fully gelatinized starch which is viscoelastic because it reaches the gelatinization temperature of starch and there is an interaction with water during steaming [23].
3.3. Time-intensity
Average TI curves allowed a comparison of the changes in the intensity of the gelatinized flour flavor and the sea grapes flavor between different treatments. Intensity is rated on a scale of 0-10 with 0 no flavor and 10 strong flavors.

Table 4. Time-intensity of gelatinized flour flavor and the sea grapes flavor on dim sum hakau wrappers

|        | Gelatinized flour flavor | Sea grapes flavor |
|--------|--------------------------|-------------------|
| R0     | T ext = 80 s T max = 25 s I max = 6.7 AUC = 66.75 T ext = 0 s T max = 0 s I max = 0 s AUC = 0 | |
| R1     | T ext = 75 s T max = 5 s I max = 46.91 AUC = 70 s T ext = 25 s T max = 5.7 s I max = 48.80 s AUC = 57.06 | |
| R2     | T ext = 70 s T max = 25 s I max = 4.4 AUC = 38.04 T ext = 70 s T max = 6.3 s I max = 57.60 | |
| R3     | T ext = 70 s T max = 25 s I max = 4.4 AUC = 38.43 T ext = 80 s T max = 7.3 s I max = 71.63 | |
| R4     | T ext = 65 s T max = 30 s I max = 4.1 AUC = 34.41 T ext = 85 s T max = 7.6 s I max = 74.61 | |

Note: T = gelatinized flour flavor, C = Sea grapes flavor
T ext = time when the stimulus disappears
T max = time needed to reach maximum intensity
I max = maximum intensity of the stimulus received by the senses
AUC = area under the curve that shows the size of the area that is detected by sensory sensation

Based on Table 4, the variables T ext, T max, I max, and AUC were obtained based on the time-intensity curve shown in Fig. R0 the sea grapes flavor did not appear because it is sample control (without sea grapes powder). The taste of gelatinized flour referred to the flour that through gelatinization due to interactions with water and hot temperatures. The researchers heated the starch at high temperature (120-140°C) then cooled it to make amylase in it produce a gel and increase the elasticity of the product [24]. The gelatinized flour flavor in R0 appeared at the 5th second and disappeared at the 80th second. R0 had the highest and longest intensity because it was made of starch, water, and salt. The maximum intensity appeared in the 25th second with an intensity of 6.7. The intensity showed the highest gelatinized flour flavor compared to other treatments with an AUC 57.75.

The highest sea grapes flavor intensity in the R4 treatment was indicated by I max and AUC values of 7.6 and 74.61. At R4 sea grapes flavor has a higher intensity than gelatinized flour flavors. This happens because sea grapes have a distinctive taste with savory and umami-like seafood flavor [25]. The salt intensity score of sea grape powder is 7.5-8 with a maximum score of 9, which is a 10% salt solution [9]. High intensity can lead to excessive taste that can affect consumer preferences for products [15]. The development of the time–intensity sensory profile could improve the quality and improvement of flavor products that were accepted by consumers [12].

Based on Figure 2 the time-intensity curve, the gelatinized flour flavor decreases with the addition of sea grape powder. The more intense sea grapes flavor is indicated by the larger UAC area. The sea grapes flavor shows a sharp increase starting in the fifth second. Sea grapes flavor has a longer duration than gelatinized flour flavor between 70-85 seconds. Perceptual changes that appear depend on the interaction of chemicals content dissolved in saliva [12]. The gelatinized flour dissolves faster than the chemical content sea grapes in saliva can be caused by the main ingredient’s wheat starch (tang mien) and tapioca is amylopectin.
Figure 2. Time-intensity curve for the gelatinized flour flavor and sea grapes flavor on the dim sum wrappers.

Tang mien/wheat starches contain a ratio of 25% amylose, 75% amylpectin [26]. Tapioca contains 17.41% amylose and 82.13% amylpectin [27]. Amylopectin is easier to digest than amylose because in the body amylose will form a gel so that the digestive system becomes slower [28]. The taste of sea grapes has a longer duration because it contains volatile compounds from bioactive and secondary metabolites. The volatile content of sea grapes can be derived from secondary metabolites (Caulerpin) and belongs to the class of alkaloid compounds containing N atoms, originating from the bisindol family [29]. The taste of sea grape sauce is similar to the taste of seafood from the content of nonanal, hexanal, (E)-2-octenal, and octanoic acid [25]. Volatile compounds that are smelled by the nose or enter the mouth will cause a sensation which can then affect the acceptance of panelists or consumers of a food product [30].

4. Conclusion
Research on sea grape powder can be used as a natural green dyeing agent. The results showed that the fortified dim sum wrappers showed a green and transparent sample. Color analysis detected that the sample was greenish and yellowish due to the pigment content in it. Time-intensity obtained the highest sea grape flavor with a concentration of 6% and more dominant than the gelatinized flour flavor. Sea grapes flavor similar to seafood flavor and contain volatile compounds that affect the taste.

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