



# SARS Edible Straw from Sea Grapes as an Effort Utilization of Marine Resources for Health

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## Abstract

**BACKGROUND:** Plastic waste is one of the threats to marine life, including plastic straw wastes. SARS edible straw is an edible straw made of cassava pulp flour combined with chitosan and sorbitol and the addition of sea grapes extract. Sea grapes extract contains bioactive compounds such as protein, polysaccharides, polyphenol, flavonoid, and antioxidants which are used as fortification to enhance the benefit of SARS edible straw.

**AIM:** The aim of this study is to increase the added-value and progress of sea grapes as domestic products, on the other hand, to improve maritime-based community development to support sustainable conservation of marine environment, and, furthermore, to reduce the use of plastic straws in daily life, by utilizing sea grapes which are rich in antioxidant to make SARS edible straw.

**MATERIALS AND METHODS:** The methods of this experimental study start from cassava flour preparation, sea grapes extract preparation, and SARS edible straw preparation with biodegradability test, water resistance test, and antioxidant test.

**RESULTS:** The best formulation of SARS edible straw was A2 with a comparison of cassava pulp flour: chitosan:sorbitol: sea grape extract which was 7:5:5:2, respectively, in both essences added and non-essence variation. The results showed that SARS edible straw has the potential as a substitute for plastic straws so that it can reduce plastic waste and is environmentally friendly as indicated by the results of biodegradation tests that meet the Indonesian National Standard >60% for 1 week, SARS edible straw is also beneficial for health by fortifying sea grapes extract which is rich in antioxidants, and can increase the selling value of sea grapes commodities.

**CONCLUSIONS:** Besides its potential as a substitute for the plastic straw, which is more environmentally friendly and also can reduce the use of plastic wastes, SARS edible straw with the fortification of sea grapes extract rich in antioxidants can give more benefits to health as well.

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## Introduction

Environmental problems, for example, the accumulation of plastic waste, are one of the global issues that should be immediately addressed, including in Indonesia. Various types of plastic waste are produced frequently, one of them is straws. Rohmah *et al.* [1] stated that the use of plastic straws in Indonesia during 2019 has reached 10,528 million tons. Compared to 2021, the total number of plastic wastes that have already been produced has reached 11,600 million tons [2].

Plastic waste pollution, especially in the ocean, gives many impacts to the marine environment. For example, seven species of turtle, 14 species of cetacean, 20 species of seals, and 56 species of sea birds were reported trapped and consuming plastics in large amounts. Automatically accumulate the chemical compounds which are contained in the plastic waste in

their body [3], [4], [5]. Many efforts have been performed to overcome the negative effect of plastic waste, for example, degradable straw, stainless steel straw, and edible straw.

The use of SARS edible straw made of sea grapes and cassava pulp gives many benefits for environment and health and also to minimize plastic waste which nowadays uncontrolled. Plastic use is a part of human daily life. However, the maintenance of the waste is difficult because it's not easy to naturally degrade [5]. The responsibility to each individual is to reduce the use of plastic.

Sea grapes, in scientific name known as *Caulerpa racemosa*, are a green algae species which is included in the *Caulerpaceae* family [6]. The shape of *C. racemosa* is almost similar to grape, this is also the reason that makes that *C. racemosa* is commonly known as sea grapes. SARS edible straw has many

advantages because *C. racemosa*, as one of its components, contains several bioactive components such as protein, polysaccharides, polyphenol, flavonoid, and antioxidant [7], [8], [9], [10], [11], [12].

Sea grapes can be used in various aspects, either as directly consumed food or being extracted and combined with other compounds as can be seen in SARS edible straw. In Indonesia, sea grapes are mostly used as food because it's easy to digest. The other advantage of sea grapes is that they are naturally degraded. The use of sea grapes is very beneficial in the purpose of protecting the environment to reduce the impact of plastic waste which nowadays should be controlled and maintained in the best way possible [13].

Research and utilization of sea grapes are very prospective to be developed in the future. This can be considered as the effort to reduce the waste of plastic straws that can harm and damage the ecosystem. It also can increase the benefit for the community who can manage the potential of sea grapes either as food or extracted as a mixture of SARS edible straw. This study aims to utilize sea grapes (*C. racemosa*) into more environmentally friendly straws and to see their physicochemical properties based on biodegradability, water resistance, and antioxidant activity tests.

## Materials and Methods

### Material and tools

The laboratory tools which are used in this study are spatula, spoon, glass stirrer, 250 ml beaker glass, 100 ml beaker glass, 500 ml beaker glass, 50 ml measuring cylinder, 100 ml volumetric flask, 10 ml volumetric flask, 250 ml Erlenmeyer, test tube, volumetric pipette, dropper pipette, blender, extractor Soxhlet, hot plate, magnetic stirrer, spectrophotometer UV-Vis, vortex, thermometer, oven, 140 mesh strainer, micropipette, blue tip, yellow tip, dark bottle, aluminum foil, tray, and acrylic glass. In this study, cassava, sea grapes, lime essence, 1% acetic acid, 30% sorbitol, 96% ethanol, 2,2-difenil-1-pikrilhidrazil (DPPH), methanol, ice cube, and aquades were used as materials to make edible straw.

### Methods

#### Cassava flour preparation

About 1 kg of cassava tubers was peeled and cleaned with water. Clean cassava tubers then grated and soaked in clean water to dissolve the starch. After being soaked, the cassava was squeezed to separate starch and pulp. In this study, cassava flour was obtained from the pulp which was dried at 50°C using

an electric oven. Dried cassava starch was mashed and filtered using 140 mesh strainers. The result was cassava flour which can be used in the next process.

#### Sea grapes extract preparation

Fresh sea grapes (*C. racemosa*) were rinsed with fresh water and then dried at room temperature continued with incubation inside the electric oven at 60°C. Dried sea grapes then mashed with laboratory blender to obtain powdered form. Powdered sea grapes were then extracted using the Soxhlet method in 96% ethanol with 3 times circulation. The comparison between powdered sea grapes and ethanol was 1:5, respectively. Sea grapes extract was kept and prepared to be used in the further process.

#### Cassava flour preparation

Cassava flour was weighed based on a comparison formula among cassava pulp flour: chitosan:sorbitol as follows: A1 (6:5:5:2), A2 (7:5:5:2), A3 (8:5:5:2), A4 (9:5:5:2), and A5 (10:5:5:2). Each formulation was dissolved in 100 ml of distilled water. Meanwhile, 5 g of chitosan dissolved in 25 ml of acetic acid 1%. The two solutions were then mixed and heated using a magnetic stirrer until the temperature reaches 80–82°C (gelatinization temperature).

After the solution was mixed perfectly, 5 ml of sorbitol 30% then added and stirred for 5 min. The solution was then mixed with an extract of sea grapes in 2 ml of volume and stirred until completely mixed. Furthermore, the solution was poured into an acrylic glass and trimmed to obtain 0.5 cm thickness and 20 cm length. After that, the template of straw was placed in the oven at  $T = 70^{\circ}\text{C} \pm 4 \text{ h}$ . Then, the acrylic glass was lifted and cooled at room temperature, then rolled with a straw stainless steel as the template to form a straw shape. Then, the straws were put back inside the oven until they dried. The next process was releasing the straw from the template. The straws were ready to be analyzed on the next various tests. Flowchart of SARS edible straw preparation is shown in Figure 1.

### Quality test

#### Biodegradability test

The aim of this test was to make sure that the materials of SARS edible straw can be perfectly degraded in a natural environment [14]. Biodegradable products already have a standard based on Indonesian National Standard (SNI). Based on SNI 7188.7: 2016, degradability is the function of susceptibility against changes in the chemical structure due to changes of physical and mechanical properties that caused the degradation of a product or material. SNI standards for degradable materials are >60% degraded parts within a

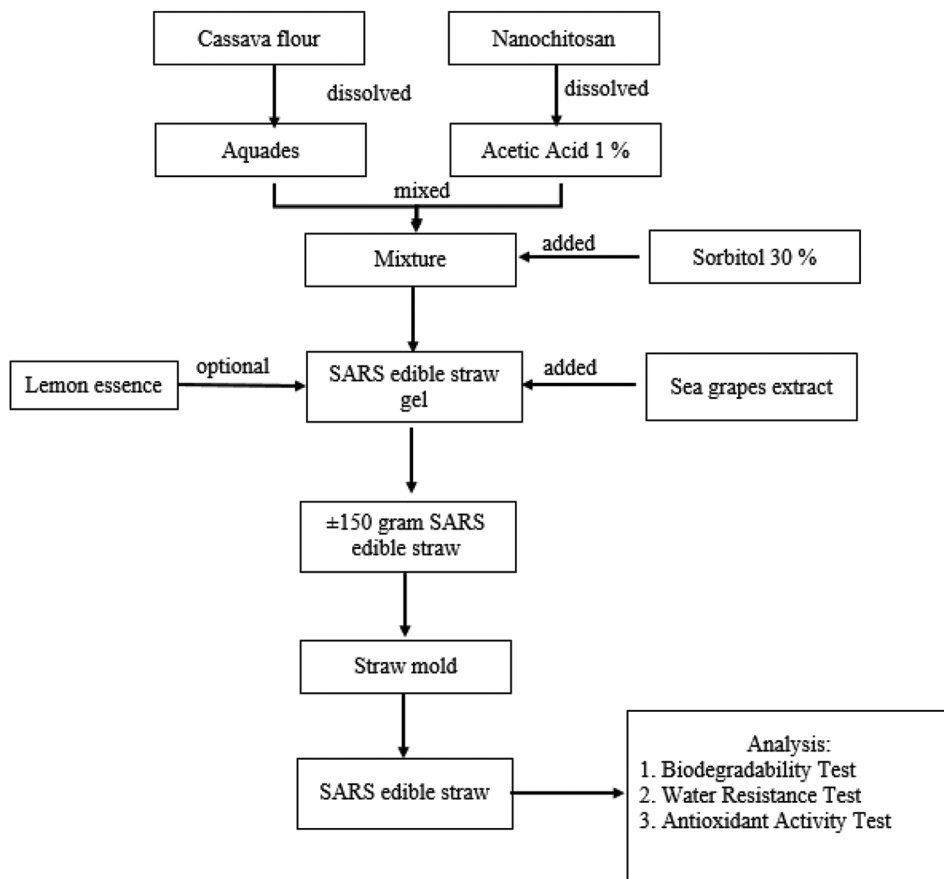


Figure 1: Flowchart of SARS edible straw study

week [1]. Based on Pimpan *et al.* [15], biodegradability test of SARS edible straw was begun with cutting the straw to get 1.5 cm length with 1 cm diameter. The sample was then weighed and buried in semi-wet soil with a depth of 5–10 cm in 3 days. Sample then dried and weighed until it reached constant weight. Biodegradability testing begins with finding the percentage of weight loss in the calculation as follows:

$$\% \text{ weight lose} = x = \frac{W_o - W}{W_o} \times 100\%$$

Notes:  $W_o$  = sample weight before buried (g)

$W$  = sample weight after buried (g)

Estimated time of complete degradation (100%) was calculated based on weight lost percentage using the following formula:

$$\text{Estimated time of degradation} = \frac{100\%}{\% \text{weight lose}} \times \text{test duration}$$

Notes: Duration in this biodegradability test was 3 days

The degradability rate was calculated using the following formula:

$$\text{Degradability} = \frac{W_o - W}{3 \text{ days}}$$

Notes:  $W_o$  = sample weight before buried (g)

$W$  = sample weight after buried (g)

#### Water resistance test

Water resistance is one of the main characteristics of SARS edible straw. Water resistance is related to the ability of SARS edible straw to dissolve in water. So that, when it is ingested, it can be digested properly, and when it is released to the environment, it can be decomposed perfectly [16]. This study was using Gontard *et al.* [17], procedure to measure water resistance. Samples were placed in a Petri dish and weighed to get the initial dry weight. The percentage of water resistance can be calculated by measuring parts of the sample that is dissolved in water after it was soaked in three treatments which vary in temperature (10°C, 25°C, and 50°C) for 10 min and 20 min. Samples which are not dissolved were dried at 100°C temperature inside the oven for 30 min. The samples were then reweighed in dry condition and the weight after the soaking process was obtained and determined as  $W_1$ . The percentage of water resistance was calculated using the following formula:

$$S = \frac{W_0 - W_1}{W_0} \times 100\%$$

Notes: W<sub>0</sub>= sample weight before soaked (g)

W<sub>1</sub>= sample weight after soaked (g)

S= Percentage of resistance to water (%)

#### Antioxidant test

Antioxidant content can be tested using DPPH [18]. DPPH solution was made dissolving 0.1 mg DPPH stock in 100 mL absolute methanol [19]. Sea grapes extract solution sample was made in various concentrations which are 10 µg/mL, 15 µg/mL, 20 µg/mL, 25 µg/mL, and 30 µg/mL. The test was carried out by pipetting each extracted sample with various concentrations in 0.4 mL volume into an amber bottle. Each sample was then added with 2.8 mL of free radical DPPH solution, then vortexed and incubated for 30 min. Then, the absorbance of each sample was measured at a wavelength of 517 nm with 3 times repetitions [19]. The antioxidant test was calculated using the following formula:

$$\% \text{ inhibition} = \frac{A_{\text{control}} - A_{\text{sample}}}{A_{\text{control}}} \times 100\%$$

The concentration values of five SARS edible straw samples and % of inhibition were plotted on the x and y axes, respectively, in the linear regression equation. The linear regression equation obtained in the form of the equation  $y = mx + c$ , is used to find the IC<sub>50</sub> value (inhibitor concentration 50%) of each sample by stating the y value of 50 and the x value to be obtained from IC<sub>50</sub>. The IC<sub>50</sub> value represents the concentration of the sample solution needed to reduce DPPH free radicals by 50% [20].

## Results and Discussion

### Result of SARS edible straw

SARS edible straw is one of the innovative products that can be used as a substitute for plastic straws that can be a solution to the problem of plastic straw waste. Several environmentally friendly straws have been developed and commercialized, but the studies about innovations of straws that are edible and beneficial for health were not much [13].

This study utilizes sea grape extract which is added as a fortification in making edible straws combined with cassava pulp flour, chitosan, and sorbitol. The use of sea grapes that are rich in antioxidants in SARS edible straw innovation products can potentially

protect cells from free radical damage and increase the selling value of sea grape commodities.

The reason for utilizing cassava pulp as flour which is added to the composition of edible straws is because it has a low starch content so that it can reduce the hydrophilic character of the innovative straws made. In addition, cassava pulp is a waste from the tapioca flour production process that has not been used optimally and has a lot of availability. The results of non-essence and essence-added SARS edible straw are shown in Figures 2 and 3, respectively.



Figure 2: SARS edible straw non-essence overview



Figure 3: SARS edible straw essence overview

### Result of water resistance test

The results of the water resistance test were carried out with three different temperature parameters including cold temperature (10°C), normal temperature (25°C), and hot temperature (50°C). This test aims to determine the effectiveness of SARS edible straw in use in everyday life which is represented by three kinds of treatment based on temperature. The following is the test result data for each temperature treatment.

According to Tripathi *et al.* [21], the more use of chitosan, the lower the percent mass loss. This is because chitosan has hydrophobic properties and has antimicrobial properties so that it takes longer to damage and shrink.

#### Cold temperature

The results of the SARS edible straw water resistance test (swelling test) at cold temperatures using an initial temperature of 10°C with variants of



**Table 1: Cold temperature of SARS edible straw test**

| Variant | 10 min% | 20 min% |
|---------|---------|---------|
| A1 n    | 12      | 16      |
| A2 n    | 14      | 15      |
| A3 n    | 7       | 10      |
| A4 n    | 5       | 13      |
| A5 n    | 7       | 7       |
| A1 e    | 11      | 14      |
| A2 e    | 7       | 10      |
| A3 e    | 4       | 10      |
| A4 e    | 4       | 18      |
| A5 e    | 6       | 16      |

n: Non-essence; e: With essence.

10 min and 20 min are shown in Table 1 and the graph in Figure 4.

Based on the data, it can be seen that the lowest value of weight loss for SARS edible straw in cold water for 10 min is in the A3 essence variation of 0.0445 g with a percentage of weight loss (S) of 4%, while at 20 min, it is in the A5 variation non-essence of 0.07795 g with a percentage of weight loss (S) of 7%.

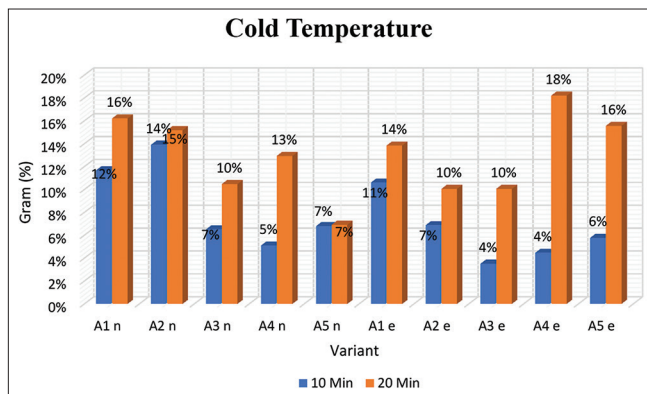


Figure 4: Cold temperature chart of SARS edible straw

**Normal temperature**

The results of the SARS edible straw water resistance test (swelling test) at cold temperatures using an initial temperature of 25°C with variants of 10 min and 20 min are shown in Table 2 and the graph in Figure 5.

**Table 2: Normal temperature of SARS edible straw test**

| Variant | 10 min% | 20 min% |
|---------|---------|---------|
| A1 n    | 6       | 13      |
| A2 n    | 11      | 18      |
| A3 n    | 7       | 45      |
| A4 n    | 5       | 31      |
| A5 n    | 4       | 10      |
| A1 e    | 3       | 17      |
| A2 e    | 9       | 28      |
| A3 e    | 9       | 12      |
| A4 e    | 4       | 16      |
| A5 e    | 10      | 26      |

n: Non-essence; e: With essence.

Based on the data, it can be seen that the lowest value of weight loss of SARS edible straw in normal temperature water within 10 min is in the variation of A1 essence of 0.06135 g with a percentage of weight loss (S) of 3%. While at 20 min, there is also variation A5 non-essence of 0.1678 g with a percentage of weight loss (S) of 10%.

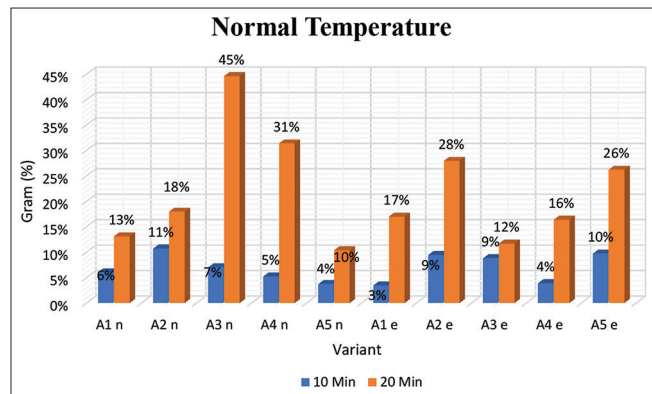


Figure 5: Normal temperature chart of SARS edible straw

**Hot temperature**

The results of the SARS edible straw water resistance test at cold temperatures using an initial temperature of 50°C with variants of 10 min and 20 min are shown in Table 3 and the graph in Figure 6.

**Table 3: Hot temperature of SARS edible straw test**

| Variant | 10 min% | 20 min% |
|---------|---------|---------|
| A1 n    | 10      | 5       |
| A2 n    | 8       | 19      |
| A3 n    | 10      | 14      |
| A4 n    | 8       | 5       |
| A5 n    | 11      | 2       |
| A1 e    | 9       | 5       |
| A2 e    | 4       | 5       |
| A3 e    | 7       | 4       |
| A4 e    | 17      | 6       |
| A5 e    | 13      | 7       |

n: Non-essence; e: With essence.

Based on the data, it can be seen that the lowest value of SARS edible straw weight loss in hot water for 10 min is in the A2 essence variation of 0.0402 g with a percentage of weight loss (S) of 4%, while at 20 min, it is in the A5 variation non-essence of 0.02665 g with a percentage of weight loss (S) of 2%.

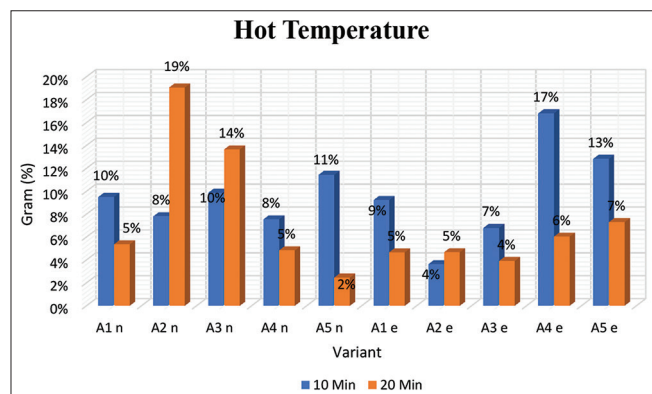


Figure 6: Hot temperature chart of SARS edible straw

**Result of biodegradability test**

Biodegradability test is one of the observation parameters that can show that SARS edible straw is environmentally friendly or not. The biodegradation test was carried out to determine how quickly SARS edible straw was degraded by microorganisms in an environment. The media used is soil because in the

soil, there are many types of microorganisms (fungi, bacteria, and algae) and in large quantities [16] so that it will support the degradation process that will be carried out. The degradation test for SARS edible straw was carried out by testing the soil burial test [22]. This test method is carried out by embedding a sample of SARS edible straw in the soil to determine the degradation ability of each sample. Samples of SARS edible straw were planted in the soil at a depth of 10 cm for 3 days. The observational data obtained are as follows.

Based on the data, it can be seen that the SARS edible straw sample that degraded the fastest was sample A1e with a composition of 6 g of cassava pulp flour, while the longest degraded was obtained by sample A2e with a composition of 7 g of cassava pulp flour (Figure 7 and Table 4). When viewed from the samples obtained from the SARS edible straw sample, the more cassava pulp flour composition added to the SARS edible straw formulation, the longer it will be degraded. This is caused by differences in the concentration of cassava pulp flour dissolved in distilled water in each variation. The greater the solubility concentration of cassava pulp flour, the bonds between polymers will be stronger and the structure of SARS edible straw will be denser making it difficult to degrade.

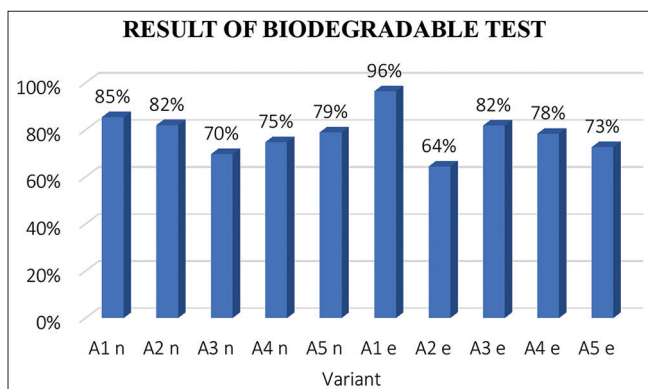


Figure 7: Biodegradable test chart of SARS edible straw

According to Asiah [23], starch is a natural biopolymer that can be completely degraded in nature, while chitosan has a relatively slow rate of biodegradation compared to starch because it is hydrophobic.

Table 4: Biodegradability test of SARS edible straw samples

| Variant | Degradability rate | % loss of weight | Estimated degradation time |
|---------|--------------------|------------------|----------------------------|
| A1 n    | 0.6375             | 85               | 3.5294                     |
| A2 n    | 0.7332             | 82               | 3.6585                     |
| A3 n    | 0.5763             | 70               | 4.2857                     |
| A4 n    | 0.4598             | 75               | 4.0000                     |
| A5 n    | 0.6735             | 79               | 3.7975                     |
| A1 e    | 0.2680             | 96               | 3.1250                     |
| A2 e    | 0.3560             | 64               | 4.6875                     |
| A3 e    | 0.3933             | 82               | 3.6585                     |
| A4 e    | 0.2897             | 78               | 3.8462                     |
| A5 e    | 0.5091             | 73               | 4.1096                     |

n: Non-essence; e: With essence.

Meanwhile, the decrease of hydrophilic characteristic of cassava pulp when compared to cassava starch makes SARS edible straw more easily degraded if a small amount of cassava pulp flour is added.

In this study, the SARS edible straw samples were degraded on average 78–79% for 3 days. This is in accordance with SNI which states that it is degraded by >60% for 1 week [1]. The highest degradation rate was found in the A2n sample of 0.733 g/day. Meanwhile, the average degradation time of SARS edible straw was 4 days. These results indicate that the SARS edible straw sample has a large degradation ability.

Table 5: Antioxidant test of SARS edible straw

| Concentration (µg/ml) | % inhibition | IC50 (ppm) |
|-----------------------|--------------|------------|
| 100                   | 60           | 55,489     |
| 150                   | 84           |            |
| 200                   | 78           |            |
| 250                   | 82           |            |
| 300                   | 84           |            |

n: Non-essence; e: With essence.

### Result of antioxidant test

Antioxidant test was conducted to determine the antioxidant activity of SARS edible straw using the DPPH method (Table 5). The measurement results can be seen from the acquisition of the inhibition concentration for each concentration (IC50). Based on the value of % inhibition, then a regression analysis graph of % inhibition was made on the concentration of SARS edible straw that had been prepared to obtain a linear regression equation. The results of calculations using simple linear regression analysis are shown in Figure 8 with the IC50 value obtained from the equation  $y = 0.0009x + 0.5955$ . The x value is the IC50 value and the y value is 50.

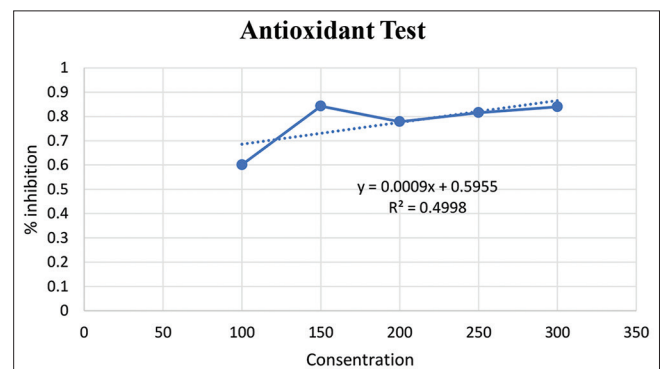


Figure 8: Antioxidant test chart of SARS edible straw

## Conclusions

The best formulation of SARS edible straw was A2 with a comparison of cassava pulp flour: chitosan:sorbitol: sea grape extract which was 7:5:5:2, respectively, in both essences added and non-essence variation. Besides its potential as a substitute for the plastic straw, which is more environmentally friendly and also can reduce the use of plastic wastes, SARS edible straw with the fortification of sea grapes extract rich in antioxidants can give more benefits to health

as well. In addition, it also can increase the economic value of sea grapes as a natural marine resource to keep them sustain and conserved. This formulation can be used as a reference for manufacturers to produce it commercially.

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## References

- Rohmah D, Windarwati S, Luketsi W. Pengaruh penambahan karagenan dan sorbitol pada kuat tarik edible straw dari nanas subgrade. *Agroindus Technol J*. 2019;3(2):70-77. <https://doi.org/10.21111/atj.v3i2.3807>
- Trypolska G, Kurbatova T, Prokopenko O, Howaniec H, Klapakiv Y. Wind and solar power plant end-of-life equipment: Prospects for management in Ukraine. *Energies*. 2022;15(5):1662. <https://doi.org/10.3390/en15051662>
- Katsanevakis S, Debris M. *A Growing Problem: Sources, Distribution, Composition, and Impacts*. New York: Nova Science Publishers; 2008. p. 53-100.
- Tanaka K, Takada H, Yamashita R, Mizukawa K, Fukuwaka M, Watanuki Y. Accumulation of plastic-derived chemicals in tissues of seabirds ingesting marine plastics. *Mar Pollut Bull*. 2013;69(1-2):219-22. <https://doi.org/10.1016/j.marpolbul.2012.12.010>  
PMid:23298431
- Acampora H, Schuyler Q, Townsend K, Hardesty B. Comparing plastic ingestion in juvenile and adult stranded short-tailed shearwaters (*Puffinus tenuirostris*) in Eastern Australia. *Mar Pollut Bull*. 2014;78(1):63-8. <https://doi.org/10.1016/j.marpolbul.2013.11.009>  
PMid:24295596
- Pakki E, Tayeb R, Usmar U, Ridwan IA, Muslimin L. Effect of orally administered combination of *Caulerpa racemosa* and *Eleutherine Americana* (Aubl) merr ekstrak on phagocytic activity of macrophage. *Res Pharm Sci*. 2020;15(4):401-9. <https://doi.org/10.4103/1735-5362.293518>  
PMid:33312218
- Yang P, Liu D, Liang T, Li J, Zhang H, Liu A, et al. Bioactive constituents from the green alga *Caulerpa racemosa*. *Bioorg Med Chem*. 2015;23(1):38-45. <https://doi.org/10.1016/j.bmc.2014.11.031>  
PMid:25497963
- Yang S, Loro E, Wada S, Kim B, Tseng W, Li K, et al. Functional effects of muscle PGC-1 $\alpha$  in aged animals. *Skeletal Muscle*. 2020;10(1):14. <https://doi.org/10.1186/s13395-020-00231-8>  
PMid:32375875
- Kuswari M, Nurkolis F, Mayulu N, Ibrahim FM, Taslim NA, Wewengkang DS, et al. Sea grapes extract improves blood glucose, total cholesterol, and PGC-1 $\alpha$  in rats fed on cholesterol- and fat-enriched diet. *F1000Res*. 2021;10:718. <https://doi.org/10.12688/f1000research.54952.2>  
PMid:35136575
- Permatasari HK, Nurkolis F, Augusta PS, Mayulu N, Kuswari M, Taslim NA, et al. Kombucha tea from seagrapes (*Caulerpa racemosa*) potential as a functional anti-ageing food: *In vitro* and *in vivo* study. *Heliyon*. 2021;7(9):e07944. <https://doi.org/10.1016/j.heliyon.2021.e07944>  
PMid:34541352
- Ngadiarti I, Nurkolis F, Handoko MN, Perdana F, Permatasari HK, Taslim NA, et al. Anti-aging potential of cookies from sea grapes in mice fed on cholesterol- and fat-enriched diet: *In vitro* with *in vivo* study. *Heliyon*. 2022;8(5):e09348. <https://doi.org/10.1016/j.heliyon.2022.e09348>
- Permatasari HK, Firani NK, Prijadi N, Irandi DF, Riawan W, Yusuf M, et al. Kombucha drink enriched with sea grapes (*Caulerpa racemosa*) as potential functional beverage to contrast obesity: An *in vivo* and *in vitro* approach. *Clin Nutr ESPEN*. 2022;49:232-40. <https://doi.org/10.1016/j.clnesp.2022.04.015>
- Sedayu B, Widiyanto T, Basmal J, Utomo B. Utilization of solid waste processing seaweed *Gracilaria* sp. for the manufacture of particleboard. *J Pascapanen Biotekol Kelautan Perikanan*. 2018;3(1):1-10. <https://doi.org/10.15578/jpbkp.v3i1.5>
- Saputro A, Ovita A. Synthesis and Characterization of Bioplastic from Chitosan-Ganyong Starch (*Canna edulis*). *J Kimia Pendidikan Kimia (JKPK)*. 2017;2(1):13-21. <https://doi.org/10.20961/jkpk.v2i1.8526>
- Pimpan V, Ratanarat K, Pongchawanakul M. Preliminary study on preparation of biodegradable plastic from modified cassava starch. *J Sci Chulalongkom Univ*. 2001;26(2):117-26.
- Pitak N, Rakshit S. Physical and antimicrobial properties of banana flour/chitosan biodegradable and self sealing films used for preserving fresh cut vegetables. *Lwt Food Sci Technol*. 2011;44(10):2310-5. <https://doi.org/10.1016/j.lwt.2011.05.024>
- Gontard N, Guilbert S, Cuq J. Water and glycerol as plasticizer affect mechanical and water vapor barrier properties of an edible wheat gluten film. *J Food Sci*. 1993;58(1):206-11. <https://doi.org/10.1111/j.1365-2621.1993.tb03246.x>
- Batubara I, Julita I, Darusman L, Muddathir A, Mitsunaga T. Flower bracts of temulawak (*Curcuma xanthorrhiza*) for skin care: Anti-acne and whitening agents. *Procedia Chem*. 2015;14:216-24, 2015. <https://doi.org/10.1016/j.proche.2015.03.031>
- Brand-Williams W, Cuvelier M, Berset C. Use of a free radical method to evaluate antioxidant activity. *LWT Food Sci Technol*. 1995;28(1):25-30. [https://doi.org/10.1016/s0023-6438\(95\)80008-5](https://doi.org/10.1016/s0023-6438(95)80008-5)
- Rahmayani U, Pringgenies D, Djunaedi A. Antioxidant activity test of crude snail extract (*Telescopium telescopium*) with different solvents against the DPPH (Diphenyl picril hydrazil) method. *J Mar Res*. 2013;2(4):36-45. <https://doi.org/10.33772/jma.v5i3.15646>
- Tripathi S, Mehrotra G, Dutta P. Physicochemical and bioactivity of cross-linked chitosan-PVA film for food packaging applications. *Int J Biol Macromol*. 2009;45:72-6. <https://doi.org/10.1016/j.ijbiomac.2009.07.006>  
PMid:19643129
- Haryati S, Rini A, Safitri Y. Utilization of durian seed waste as biodegradable plastic with variation of gelatination temperature and addition of cacao. *J Atmosphere*. 2020;1(1):1-8. <https://doi.org/10.36040/atmosphere.v1i1.2955>
- Asiah M. Biodegradation Test of Bioplastic based Chitosan from Shrimp Waste and Starch. *J Biol Edukasi*. 2010;2(1):13-18.