Tsel-PakaiMasker 2,38K/s 81 09:44

[OAMJMS] Editor Decision

Kotak Masuk

Assoc. Prof. Dr Sas... 23 Apr
kepada Dr., saya, Reza, Y...

Prof. Dr. Maizer Said Nahdi, M.Si, Fahrul Nurkolis, Reza Sukma Dewi, Yan Nurrezkytaku A, Noor Rezky Fitriani, Aldy Rahman Dharma Putra Sanjaya, Dian Aruni Kumalawati, M.Sc, Dr. Khairun Nisah, Dr. Sitti Ahmiatri Saptari (Author):

We have reached a decision regarding your submission to Open Access Macedonian Journal of Medical Sciences, "SARS Edible Straw from Sea Grapes as an Effort Utilization of Marine Resources for Health: Edible Straw from Sea Grapes", Manuscript ID = OJS9663.

Our decision is: Revisions Required

Sincerely,
Prof. Dr Mirko Spiroski,
Editor-in-Chief, OAMJMS

Sasho Stoleski

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[OAMJMS] Editor Decision

Kotak Masuk

Katerina Spiroska... 25 Mei
kepada Dr., saya, Reza, Y...

Prof. Dr. Maizer Said Nahdi, M.Si, Fahrul Nurkolis, Reza Sukma Dewi, Yan Nurrezkytaku A, Noor Rezky Fitriani, Aldy Rahman Dharma Putra Sanjaya, Dian Aruni Kumalawati, M.Sc, Dr. Khairun Nisah, Dr. Sitti Ahmiatri Saptari (Author):

We have reached a decision regarding your submission to Open Access Macedonian Journal of Medical Sciences, "SARS Edible Straw from Sea Grapes as an Effort Utilization of Marine Resources for Health: Edible Straw from Sea Grapes", Manuscript ID = OJS9663.

Our decision is to:Accept your revised manuscript for publication in OAMJMS.

Reviewer A:
Recommendation: Accept Submission

Comments to the Author

Tsel-PakaiMasker 54,2K/s 82 09:43

[OAMJMS] Regular Publication Fee

Kotak Masuk

Katerina Spiroska... 25 Mei

kepada saya

Dear Fahrul Nurkolis,

Please find details for your Regular Publication Fee of 400 € (EUR) for the manuscript "SARS Edible Straw from Sea Grapes as an Effort Utilization of Marine Resources for Health: Edible Straw from Sea Grapes" [oamjms.2022.9663], which should be prepared for publication in Open Access Maced J Med Sci (OAMJMS) and should be transferred in the next seven days.

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Kotak Masuk

Fahrul Nurkolis 8 Jul

Dear Editorial(s), Especially Dr. Theodora Fildishevska, I hope you're doing well!

---

tfildishevska@id-pr... 11 Jul

kepada saya

Dear Fahrul Nurkolis,

Please find below the comments we received from our copyeditors:

Article have unnumbered reference citations (Author name & Year). Please check and provide the numbered reference citation as per journal style.

I would like to kindly ask you to send me the corrected article and we will continue the publishing process.

With best regards,

Tsel-PakaiMasker 3,19K/s 82 09:42

[OAMJMS] Editor Decision

Kotak Masuk

Teodora Fildishevsk... 8 Agt

kepada Dr., saya, Reza, Y...

Prof. Dr. Maizer Said Nahdi, M.Si, Fahrul Nurkolis, Reza Sukma Dewi, Yan Nurrezkytaku A, Noor Rezky Fitriani, Aldy Rahman Dharma Putra Sanjaya, Dian Aruni Kumalawati, M.Sc, Dr. Khairun Nisah, Dr. Sitti Ahmiatri Saptari (Author):

The editing of your submission, "SARS Edible Straw from Sea Grapes as an Effort Utilization of Marine Resources for Health: Edible Straw from Sea Grapes," Manuscript ID = OJS9663 is complete. We are now sending it to production.

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Balas | Balas ke semua | Teruskan

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

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Abstract[z1]

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. 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. 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. The methods of this study start from cassava flour preparation, Sea grapes extract preparation, and SARS Edible Straw preparation with biodegradability test, water resistance test, and antioxidant test. 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 (SNI) > 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.

Keywords: Edible Straw, Caulerpa, Antioxidant, Biodegradability, Marine resources.

1. Introduction[z2]

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* (2019), 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 (Trypolska *et al*., 2022). [z3]

Plastic waste pollution, especially in the ocean, gives many impacts to the marine environment. For example, 7 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 (Katsanevakis, 2008; Tanaka *et al*., 2013; Acampora *et al*., 2014). 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. But the maintenance of the waste is difficult because it’s not easy to naturally degrade. The responsibility to each individual is to reduce the use of plastic.

Sea grapes, in scientific name known as *Caulerpa racemosa*, is a green algae species which is included in the Caulerpaceae family (Pakki *et al*., 2020). The shape of *C. racemosa* is almost similar to grape, this is also the reason that make *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 (Yang *et al*., 2015; Yang *et al*., 2020).

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 (Sedayu *et al*., 2018).

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.

2. Materials and methods[z4]

2.1 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 erlenmayer[z5], test tube, volumetric pipette, dropper pipette, blender, extractor soxhlette, hot plate, magnetic stirrer, spectrophotometer UV-Vis, vortex, termometer, 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, DPPH, methanol, ice cube, and aquades were used as materials to make edible straw.

2.2 Methods

2.2.1 Cassava Flour Preparation

About 1 kilogram 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 strainer. The result was cassava flour which can be used in the next process.

2.2.2 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 further process.

2.2.3 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 grams 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 minutes. 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 °C ± 4 hours. 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 can be seen in Figure 1.

2.3 Quality Test

2.3.1 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 (Saputro & Ovita, 2017). Biodegradable products already have a standard based on SNI (Indonesian National Standard). 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 is > 60 % degraded parts within a week (Rohmah *et al*., 2019). Based on Pimpan *et al* (2001), 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:

$$\text{\% weight lose} = x = \frac{W0 - W}{W0} \times 100\%$$

Notes: WO = 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:

$$\text{Degradability} = \frac{W0 - W}{3\ \text{days}}$$

Notes: WO = sample weight before buried (g)
W = sample weight after buried (g)

2.3.2 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 (Pitak & Rakshit, 2011). This study was using Gontard *et al* (1993), 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 are dissolved in water after it was soaked in 3 treatments which vary in temperature (10 °C, 25 °C, and 50 °C) for 10 minutes and 20 minutes. Samples which are not dissolved were dried at 100 °C temperature inside the oven for 30 minutes. The samples were then re-weighed in dry condition and the weight after the soaking process was obtained and determined as W1. The percentage of water resistance was calculated using the following formula:

$$S = \frac{W0 - W1}{W0} \times 100\%$$

Notes: W_O = sample weight before soaked (g)
W_1 = sample weight after soaked (g)
S = Percentage of resistance to water (%)

2.3.3 Antioxidant Test

Antioxidant content can be tested using 2.2-difenil-1-pikrilhidrazil (DPPH) (Batubara *et al*., 2015). DPPH solution was made dissolving 0.1 mg DPPH stock in 100 mL absolute methanol (Brand-Williams et al., 1995). Sea grapes extract solution sample were made in various concentrations which are 10 µg/mL, 15 µg/mL, 20 µg/mL, 25 µg/mL, 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 minutes. Then the absorbance of each sample was measured at a wavelength of 517nm with 3 times repetitions (Brand-Williams *et al*., 1995). The antioxidant test was calculated using the following formula:

$$\%\text{inhibition} = \frac{\text{A control} - \text{A sample}}{\text{A control}} \text{ x } 100\%$$

The concentration values of 5 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_{50} value (inhibitor concentration 50%) of each sample by stating the y value of 50 and the x value to be obtained from IC_{50}. The IC_{50} value represents the concentration of the sample solution needed to reduce DPPH free radicals by 50% (Rahmayani, 2013).

3. Results and discussion[z6]

3.1 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.

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 Figure 2. and Figure 3, respectively.

3.2 Result of Water Resistance Test

The results of the water resistance test were carried out with 3 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 3 kinds of treatment based on temperature. The following is the test result data for each temperature treatment.

According to Tripathi *et al* (2009), 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.

3.2.1 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 10 minutes and 20 minutes can be seen 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 minutes is in the A3 essence variation of 0.0445 grams with a percentage of weight loss (S) of 4%, while at 20 minutes it is in the A5 variation non-essence of 0.07795 grams with a percentage of weight loss (S) of 7%.

3.2.2 Normal Temperature

The results of the SARS Edible Straw water resistance test (swelling test) at cold temperatures using an initial temperature of 25 ^{o}C with variants of 10 minutes and 20 minutes can be seen in table 2 and the graph in Figure 5.

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 minutes is in the variation of A1 essence of 0.06135 grams with a percentage of weight loss (S) of 3%. While at 20 minutes there is also variation A5 non-essence of 0.1678 grams with a percentage of weight loss (S) of 10%.

3.2.3 Hot Temperature

The results of the SARS Edible Straw water resistance test at cold temperatures using an initial temperature of 50 ^{o}C with variants of 10 minutes and 20 minutes can be seen in table 3 and the graph in Figure 6.

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

3.3 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, 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 (Haryati *et al*., 2017). 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 grams of cassava pulp flour, while the longest degraded was obtained by sample A2e with a composition of 7 grams of cassava pulp flour. 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.

According to Asiah (2010), 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.

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 (Rohmah *et al*., 2019). 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.[z7]

3.4 Result of Antioxidant Test

Antioxidant test was conducted to determine the antioxidant activity of SARS Edible Straw using the DPPH method. The measurement results can be seen from the acquisition of the inhibition concentration for each concentration (IC_{50}). 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 in order to obtain a linear regression equation. The results of calculations using simple linear regression analysis can be seen in Figure 4 with the IC_{50} value obtained from the equation $y = 0.0009x + 0.5955$. The x value is the IC_{50} value and the y value is 50.

4. Conclusion[z8]

The best formulation of SARS Edible Straw was A2 with a comparison of cassava pulp flour : chitosan : sorbitol : Sea grape extract was 7 : 5 : 5 : 2 respectively in both essence added and non-essence variation. SARS Edible Straw preparation was started with the preparation of cassava flour and Sea grape extraction using the solid-liquid soxhlet method which was then molded and analyzed with various tests. For example, the water resistance test showed that SARS Edible Straw has the best resistance in three treatments which are low temperature (10°C), room temperature (27°C), and high temperature (50°C). The Biodegradability test showed that all variations were well decomposed and it considered that they had met the Indonesian National Standard (SNI) > 60 % for 1 week. The result of the antioxidant test showed that SARS Edible Straw had reached 70% inhibition against the free radical compound. The IC_{50} value of the SARS Edible Straw is 55,489 ppm. 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 economical value of Sea grapes as a natural marine resource to keep them sustain and conserved.

Conflict of interest

The authors declare no conflict of interest.

Acknowledgments

The researcher would like to thank those who have provided support so that this study research is completed. Especially thanks to the State Islamic University of Sunan Kalijaga who has facilitated us during the course of the research.

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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%

Notes:
n = Non essence; e = With Essence

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%

Notes:
n = Non essence; e = With Essence

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%

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

Notes:
n = Non essence; e = With Essence

Table 5. Antioxidant Test of SARS Edible Straw

Concentration (µg/ml)	% inhibition	IC_{50} (ppm)
100	60%	
150	84%	
200	78%	55,489
250	82%	
300	84%	

Notes:
n = Non essence; e = With Essence

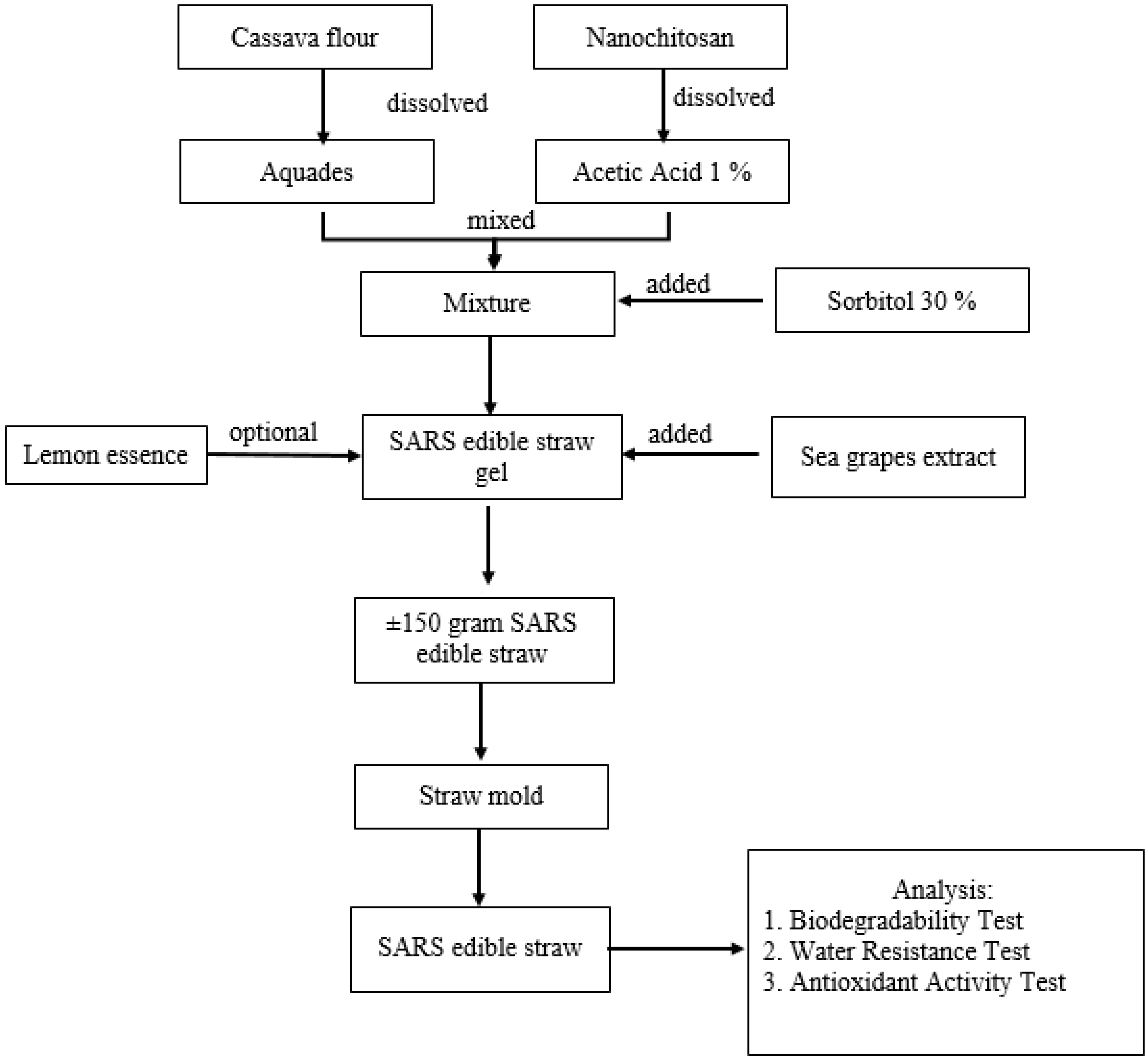

Figure 1. Flowchart of SARS Edible Straw Study

Figure 2. SARS Edible Straw non-Essence Overview

Figure 3. SARS Edible Straw Essence Overview

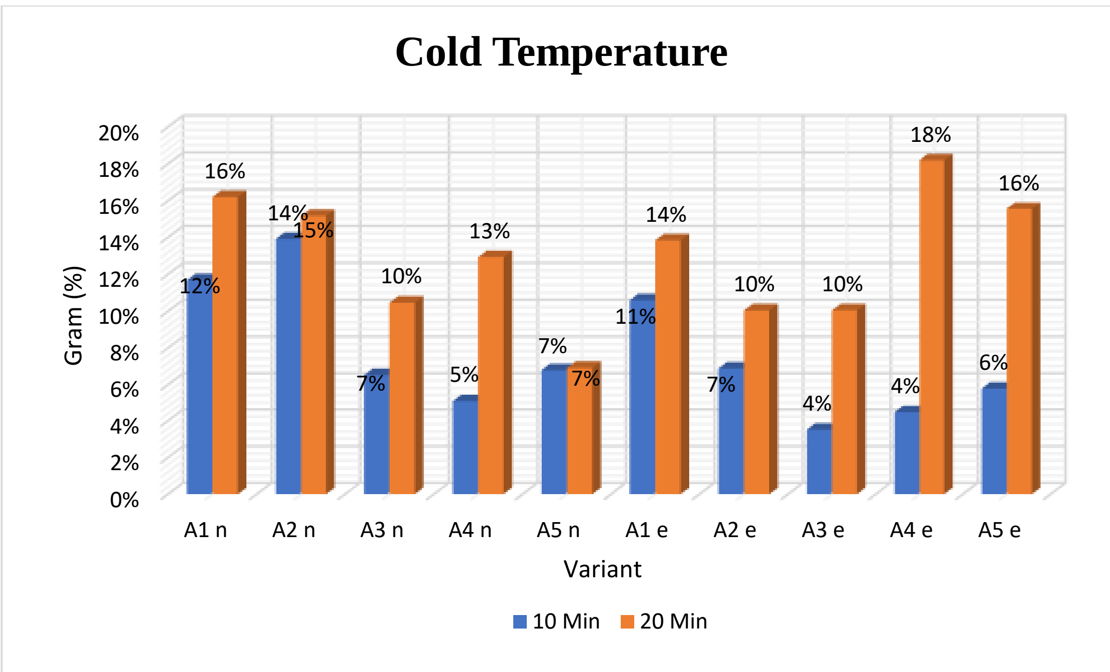

Figure 4. Cold Temperature Chart of SARS Edible Straw

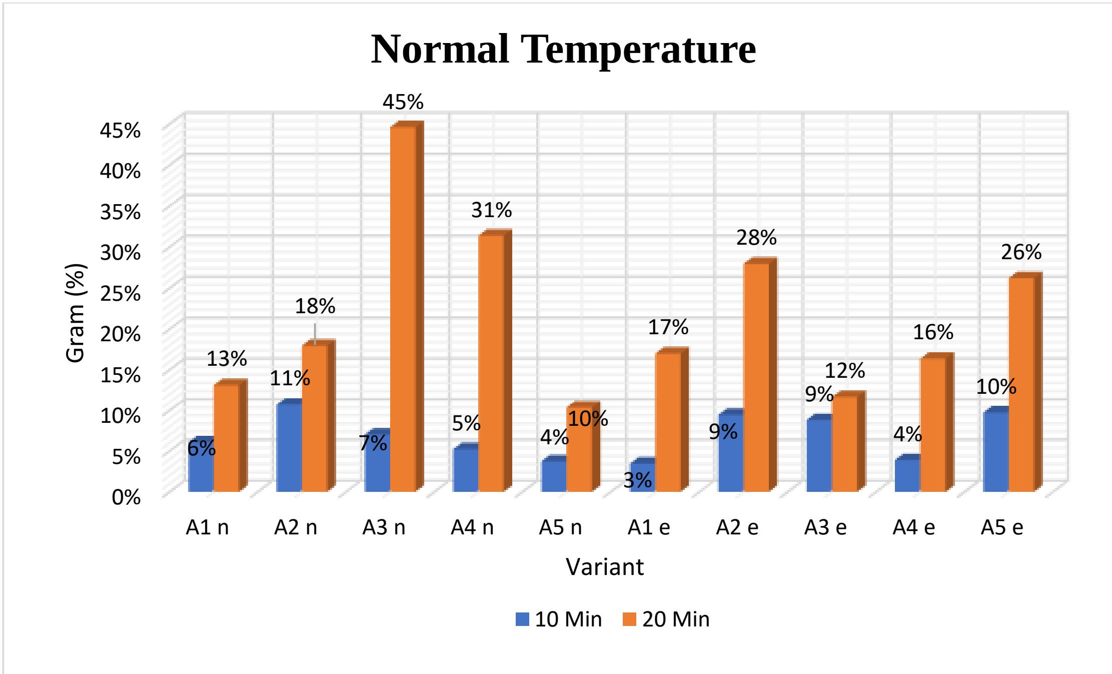

Figure 5. Normal Temperature Chart of SARS Edible Straw

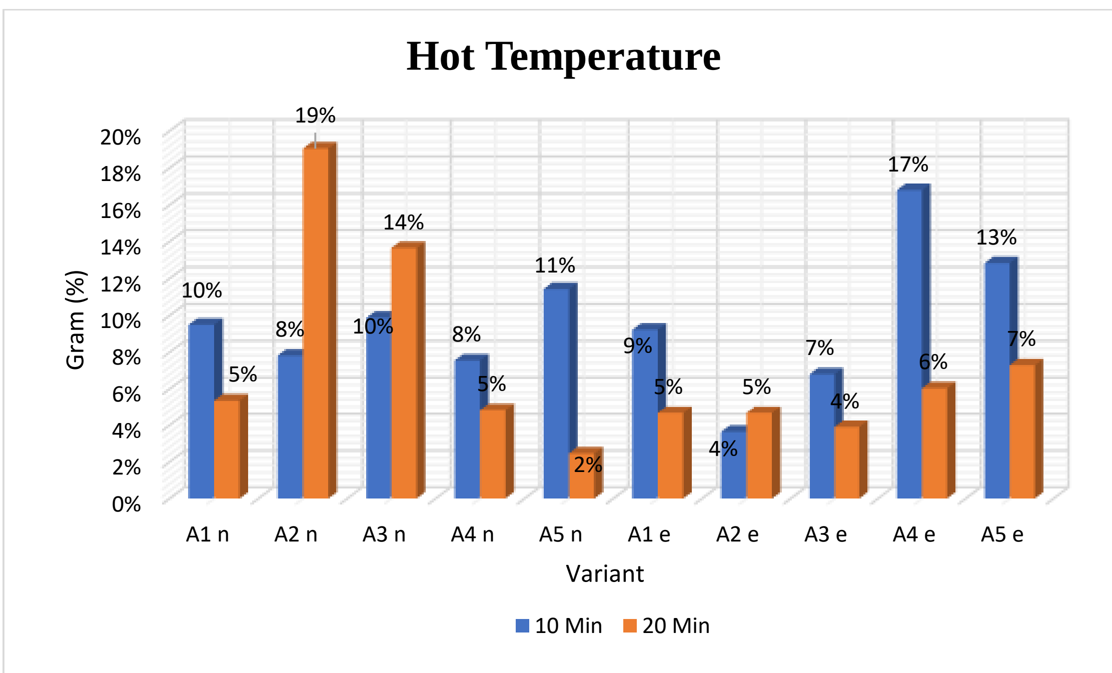

Figure 6. Hot Temperature Chart of SARS Edible Straw

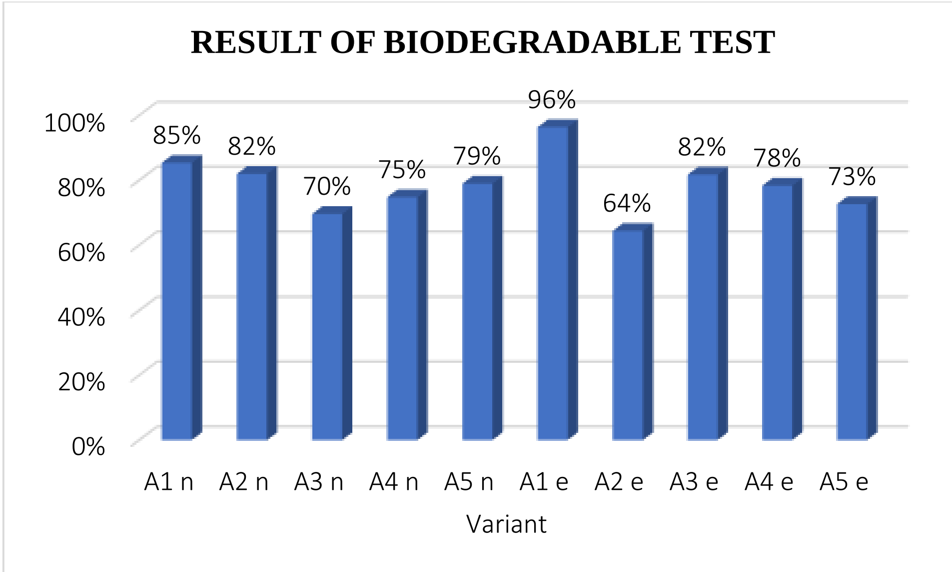

Figure 7. Biodegradable Test Chart of SARS Edible Straw

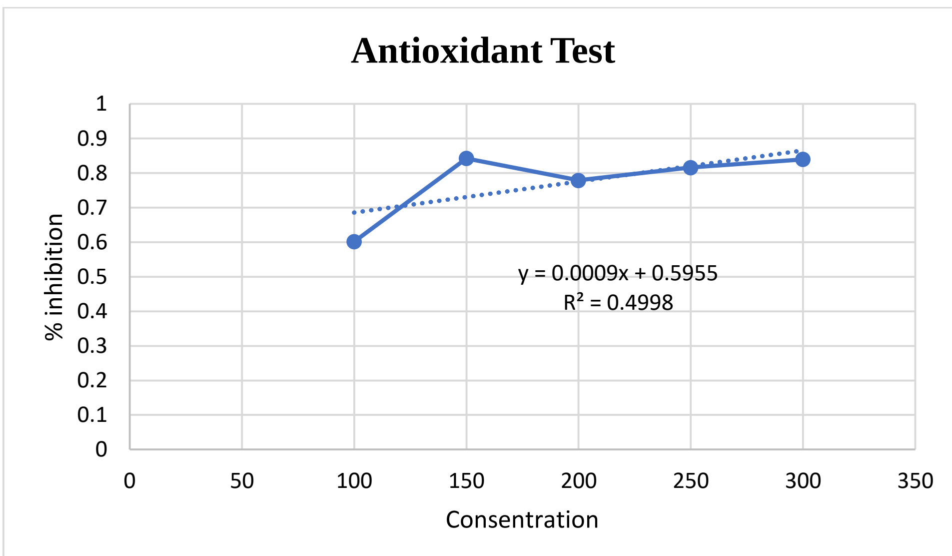

Figure 8. Antioxidant Test Chart of SARS Edible Straw

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

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Abstract

BANCKGROUND: 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. 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. 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.

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MATERIAL AND METHODS: The methods of this study start from cassava flour preparation, Sea grapes extract preparation, and SARS Edible Straw preparation with biodegradability test, water resistance test, and antioxidant test.

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RESULT: 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 (SNI) > 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.

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Keywords: Edible Straw, Caulerpa, Antioxidant, Biodegradability, Marine resources.

1. 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* (2019), 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 (Trypolska *et al*., 2022).

Plastic waste pollution, especially in the ocean, gives many impacts to the marine environment. For example, 7 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 (Katsanevakis, 2008; Tanaka *et al*., 2013; Acampora *et al*., 2014). 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. But the maintenance of the waste is difficult because it's not easy to naturally degrade. The responsibility to each individual is to reduce the use of plastic.

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Sea grapes, in scientific name known as *Caulerpa racemosa*, is a green algae species which is included in the Caulerpaceae family (Pakki *et al*., 2020). The shape of *C. racemosa* is almost similar to grape, this is also the reason that make *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 (Yang *et al*., 2015; Yang *et al*., 2020).

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 (Sedayu *et al*., 2018).

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.

2. Materials and methods

2.1 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 erlenmayer, test tube, volumetric pipette, dropper pipette, blender, extractor soxhlette, hot plate, magnetic stirrer, spectrophotometer UV-Vis, vortex, termometer, 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, DPPH, methanol, ice cube, and aquades were used as materials to make edible straw.

2.2 Methods

2.2.1 Cassava Flour Preparation

About 1 kilogram 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 strainer. The result was cassava flour which can be used in the next process.

2.2.2 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 further process.

2.2.3 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 grams 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 minutes. 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 °C ± 4 hours. 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 can be seen in Figure 1.

2.3 Quality Test

2.3.1 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 (Saputro & Ovita, 2017). Biodegradable products already have a standard based on SNI (Indonesian National Standard). 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 is > 60 % degraded parts within a week (Rohmah *et al*., 2019). Based on Pimpan *et al* (2001), 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:

$$\text{\% weight lose} = x = \frac{W0-W}{W0} \text{ x } 100\%$$

Notes: WO = 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:

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

Notes: duration in this biodegradability test was 3 days

The degradability rate was calculated using the following formula:

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

Notes: WO = sample weight before buried (g)
W = sample weight after buried (g)

2.3.2 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 (Pitak & Rakshit, 2011). This study was using Gontard *et al* (1993), 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 are dissolved in water after it was soaked in 3 treatments which vary in temperature (10 °C, 25 °C, and 50 °C) for 10 minutes and 20 minutes. Samples which are not dissolved were dried at 100 °C temperature inside the oven for 30 minutes. The samples were then re-weighed in dry condition and the weight after the soaking process was obtained and determined as W1. The percentage of water resistance was calculated using the following formula:

$$S = \frac{W0-W1}{W0} \text{ x } 100\%$$

Notes: W_O = sample weight before soaked (g)
W_1 = sample weight after soaked (g)
S = Percentage of resistance to water (%)

2.3.3 Antioxidant Test

Antioxidant content can be tested using 2.2-difenil-1-pikrilhidrazil (DPPH) (Batubara *et al*., 2015). DPPH solution was made dissolving 0.1 mg DPPH stock in 100 mL absolute methanol (Brand-Williams et al., 1995). Sea grapes extract solution sample were made in various concentrations which are 10 µg/mL, 15 µg/mL, 20 µg/mL, 25 µg/mL, 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 minutes. Then the absorbance of each sample was measured at a wavelength of 517nm with 3 times repetitions (Brand-Williams *et al*., 1995). The antioxidant test was calculated using the following formula:

$$\%\text{inhibition} = \frac{\text{A control} - \text{A sample}}{\text{A control}} \text{ x } 100\%$$

The concentration values of 5 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_{50} value (inhibitor concentration 50%) of each sample by stating the y value of 50 and the x value to be obtained from IC_{50}. The IC_{50} value represents the concentration of the sample solution needed to reduce DPPH free radicals by 50% (Rahmayani, 2013).

3. Results and discussion

3.1 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.

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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 Figure 2. and Figure 3, respectively.

3.2 Result of Water Resistance Test

The results of the water resistance test were carried out with 3 different temperature parameters including cold temperature (10 ^oC), normal temperature (25 ^oC), and hot temperature (50 ^oC). This test aims to determine the effectiveness of SARS Edible Straw in use in everyday life which is represented by 3 kinds of treatment based on temperature. The following is the test result data for each temperature treatment.

According to Tripathi *et al* (2009), 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.

3.2.1 Cold Temperature

The results of the SARS Edible Straw water resistance test (swelling test) at cold temperatures using an initial temperature of 10 ^{o}C with variants of 10 minutes and 20 minutes can be seen 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 minutes is in the A3 essence variation of 0.0445 grams with a percentage of weight loss (S) of 4%, while at 20 minutes it is in the A5 variation non-essence of 0.07795 grams with a percentage of weight loss (S) of 7%.

3.2.2 Normal Temperature

The results of the SARS Edible Straw water resistance test (swelling test) at cold temperatures using an initial temperature of 25 ^{o}C with variants of 10 minutes and 20 minutes can be seen in table 2 and the graph in Figure 5.

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 minutes is in the variation of A1 essence of 0.06135 grams with a percentage of weight loss (S) of 3%. While at 20 minutes there is also variation A5 non-essence of 0.1678 grams with a percentage of weight loss (S) of 10%.

3.2.3 Hot Temperature

The results of the SARS Edible Straw water resistance test at cold temperatures using an initial temperature of 50 ^{o}C with variants of 10 minutes and 20 minutes can be seen in table 3 and the graph in Figure 6.

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

3.3 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, 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 (Haryati *et al*., 2017). 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 grams of cassava pulp flour, while the longest degraded was obtained by sample A2e with a composition of 7 grams of cassava pulp flour. 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.

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According to Asiah (2010), 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.

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 (Rohmah *et al*., 2019). 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.

3.4 Result of Antioxidant Test

Antioxidant test was conducted to determine the antioxidant activity of SARS Edible Straw using the DPPH method. The measurement results can be seen from the acquisition of the inhibition concentration for each concentration (IC_{50}). 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 in order to obtain a linear regression equation. The results of calculations using simple linear regression analysis can be seen in Figure 4 with the IC_{50} value obtained from the equation y = 0.0009x + 0.5955. The x value is the IC_{50} value and the y value is 50.

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4. Conclusion

The best formulation of SARS Edible Straw was A2 with a comparison of cassava pulp flour : chitosan : sorbitol : Sea grape extract was 7 : 5 : 5 : 2 respectively in both essences added and non-essence variation. SARS Edible Straw preparation was started with the preparation of cassava flour and Sea grape extraction using the solid-liquid soxhlet method which was then molded and analyzed with various tests. For example, the water resistance test showed that SARS Edible Straw has the best resistance in three treatments which are low temperature (10°C), room temperature (27°C), and high temperature (50°C). The Biodegradability test showed that all variations were well decomposed and it considered that they had met the Indonesian National Standard (SNI) > 60 % for 1 week. The result of the antioxidant test showed that SARS Edible Straw had reached 70% inhibition against the free radical compound. The IC_{50} value of the SARS Edible Straw is 55,489 ppm. 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.

Conflict of interest

The authors declare no conflict of interest.

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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%

Notes:
n = Non essence; e = With Essence

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%

Notes:
n = Non essence; e = With Essence

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%

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

Notes:
n = Non essence; e = With Essence

Table 5. Antioxidant Test of SARS Edible Straw

Concentration (µg/ml)	% inhibition	IC_{50} (ppm)
100	60%	
150	84%	
200	78%	55,489
250	82%	
300	84%	

Notes:
n = Non essence; e = With Essence

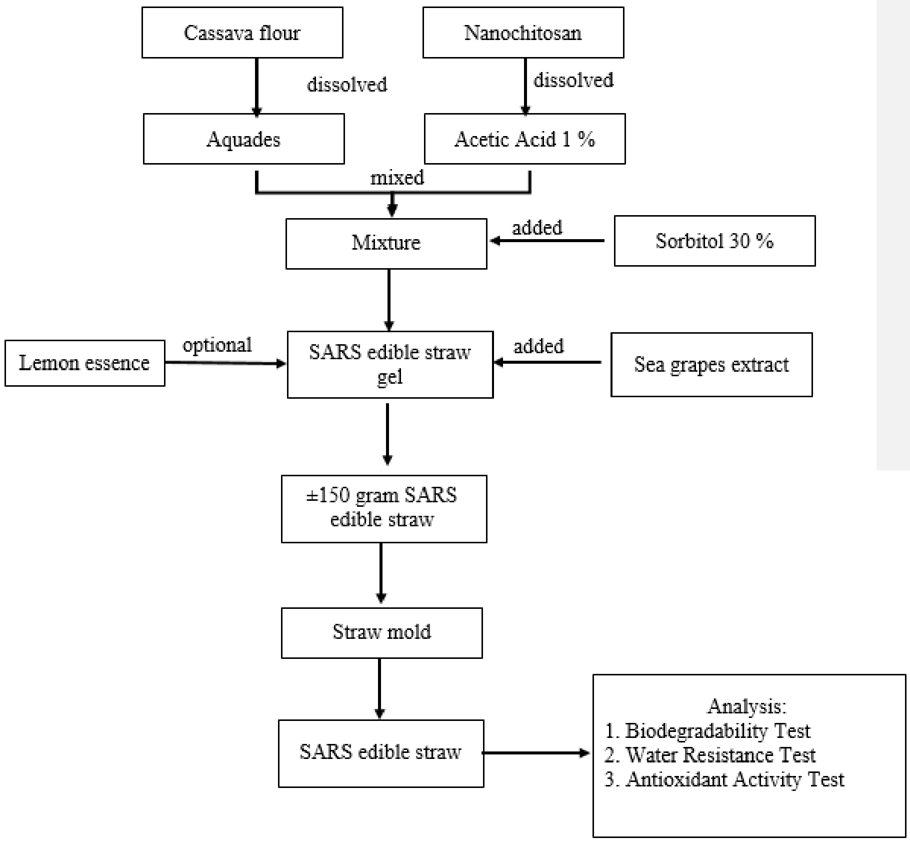

Figure 1. Flowchart of SARS Edible Straw Study

Figure 2. SARS Edible Straw non-Essence Overview

Figure 3. SARS Edible Straw Essence Overview

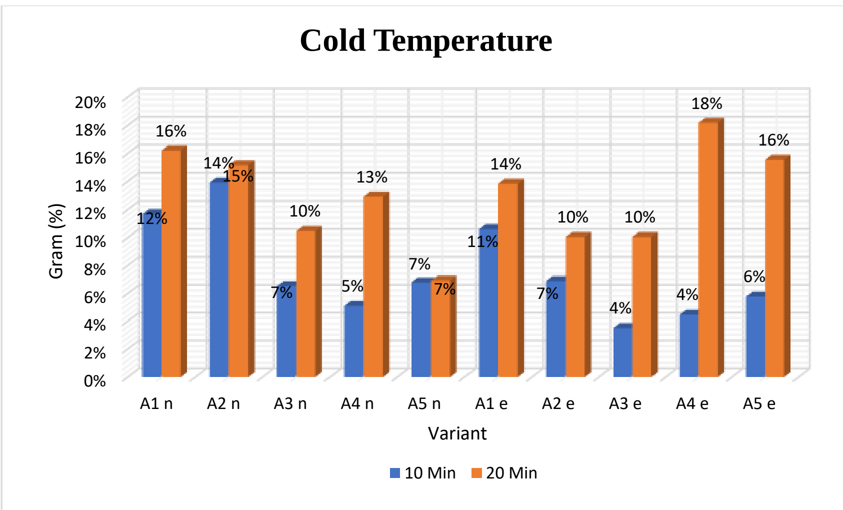

Figure 4. Cold Temperature Chart of SARS Edible Straw

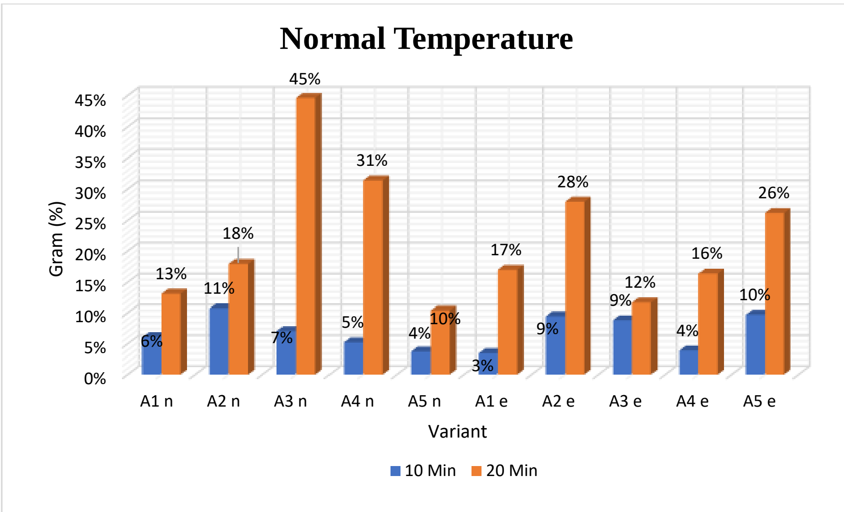

Figure 5. Normal Temperature Chart of SARS Edible Straw

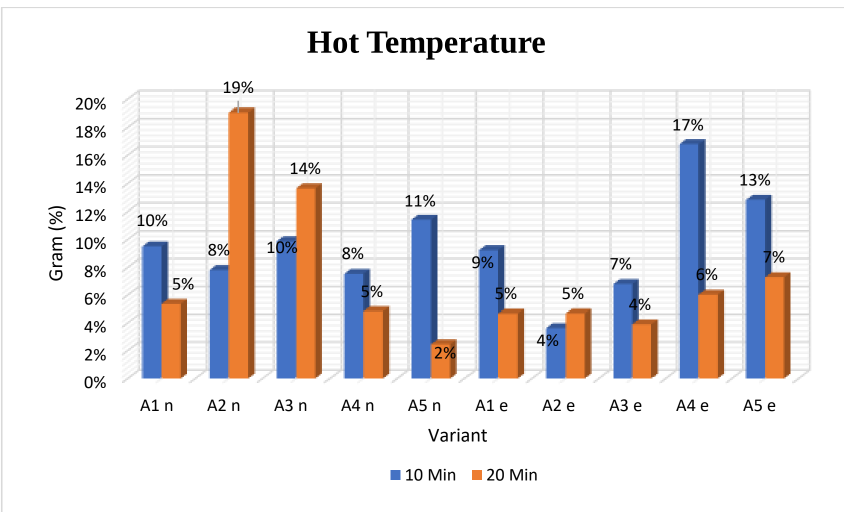

Figure 6. Hot Temperature Chart of SARS Edible Straw

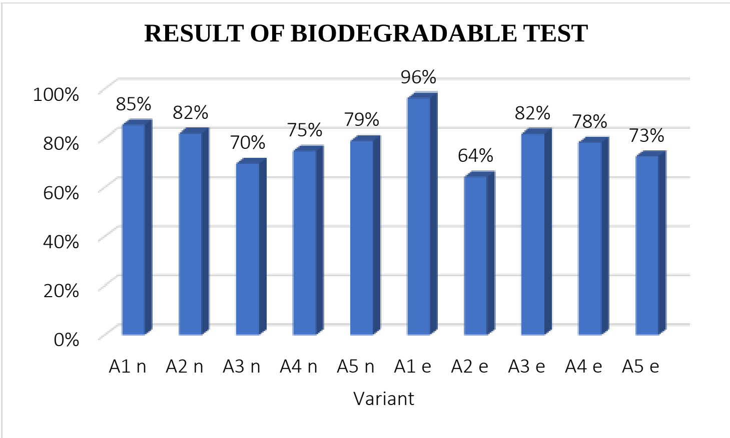

Figure 7. Biodegradable Test Chart of SARS Edible Straw

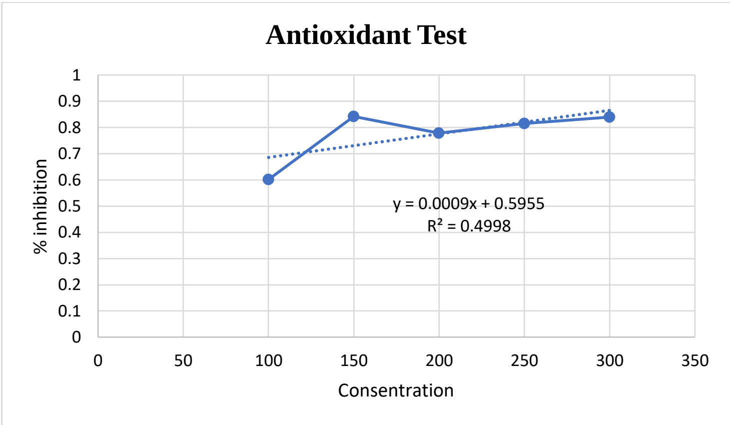

Figure 8. Antioxidant Test Chart of SARS Edible Straw

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

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Abstract

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. 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. 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. [u1]The methods of this study [u2]start from cassava flour preparation, Sea grapes extract preparation, and SARS Edible Straw preparation with biodegradability test, water resistance test, and antioxidant test. The results [u3]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 (SNI) > 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.

Keywords: Edible Straw, Caulerpa, Antioxidant, Biodegradability, Marine resources.

1. 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* (2019), 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 (Trypolska *et al*., 2022).

Plastic waste pollution, especially in the ocean, gives many impacts to the marine environment. For example, 7 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 (Katsanevakis, 2008; Tanaka *et al*., 2013; Acampora *et al*., 2014). 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. But the maintenance of the waste is difficult because it's not easy to naturally degrade. The responsibility to each individual is to reduce the use of plastic.

Sea grapes, in scientific name known as *Caulerpa racemosa*, is a green algae species which is included in the Caulerpaceae family (Pakki *et al*., 2020). The shape of *C. racemosa* is almost similar to grape, this is also the reason that make *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 (Yang *et al*., 2015; Yang *et al*., 2020).

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 (Sedayu *et al*., 2018).

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.

2. Materials and methods

2.1 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 erlenmayer, test tube, volumetric pipette, dropper pipette, blender, extractor soxhlette, hot plate, magnetic stirrer, spectrophotometer UV-Vis, vortex, termometer, 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, DPPH, methanol, ice cube, and aquades were used as materials to make edible straw.

2.2 Methods

2.2.1 Cassava Flour Preparation

About 1 kilogram 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 strainer. The result was cassava flour which can be used in the next process.

2.2.2 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 further process.

2.2.3 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 grams 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 minutes. 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 °C ± 4 hours. 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 can be seen in Figure 1.

2.3 Quality Test

2.3.1 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 (Saputro & Ovita, 2017). Biodegradable products already have a standard based on SNI (Indonesian National Standard). 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 is > 60 % degraded parts within a week

(Rohmah *et al*., 2019). Based on Pimpan *et al* (2001), 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:

$$\%\text{ weight lose} = x = \frac{W0 - W}{W0} \times 100\%$$

Notes: WO = 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:

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

Notes: WO = sample weight before buried (g)
W = sample weight after buried (g)

2.3.2 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 (Pitak & Rakshit, 2011). This study was using Gontard *et al* (1993), 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 are dissolved in water after it was soaked in 3 treatments which vary in temperature (10 °C, 25 °C, and 50 °C) for 10 minutes and 20 minutes. Samples which are not dissolved were dried at 100 °C temperature inside the oven for 30 minutes. The samples were then re-weighed in dry condition and the weight after the soaking process was obtained and determined as W1. The percentage of water resistance was calculated using the following formula:

$$S = \frac{W0 - W1}{W0} \times 100\%$$

Notes: W_O = sample weight before soaked (g)
W_1 = sample weight after soaked (g)
S = Percentage of resistance to water (%)

2.3.3 Antioxidant Test

Antioxidant content can be tested using 2.2-difenil-1-pikrilhidrazil (DPPH) (Batubara *et al*., 2015). DPPH solution was made dissolving 0.1 mg DPPH stock in 100 mL absolute methanol (Brand-Williams et al., 1995). Sea grapes extract solution sample were made in various concentrations which are 10 μg/mL, 15 μg/mL, 20 μg/mL, 25 μg/mL, 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 minutes. Then the absorbance of each sample was measured at a wavelength of 517nm with 3 times repetitions (Brand-Williams *et al*., 1995). The antioxidant test was calculated using the following formula:

$$\%\text{inhibition} = \frac{\text{A control} - \text{A sample}}{\text{A control}} \text{ x } 100\%$$

The concentration values of 5 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_{50} value (inhibitor concentration 50%) of each sample by stating the y value of 50 and the x value to be obtained from IC_{50}. The IC_{50} value represents the concentration of the sample solution needed to reduce DPPH free radicals by 50% (Rahmayani, 2013).

3. Results and discussion[u4]

3.1 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.

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 Figure 2. and Figure 3, respectively.

3.2 Result of Water Resistance Test

The results of the water resistance test were carried out with 3 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 3 kinds of treatment based on temperature. The following is the test result data for each temperature treatment.

According to Tripathi *et al* (2009), 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.

3.2.1 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 10 minutes and 20 minutes can be seen 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 minutes is in the A3 essence variation of 0.0445 grams with a percentage of weight loss (S) of 4%, while at 20 minutes it is in the A5 variation non-essence of 0.07795 grams with a percentage of weight loss (S) of 7%.

3.2.2 Normal Temperature

The results of the SARS Edible Straw water resistance test (swelling test) at cold temperatures using an initial temperature of 25 ^{o}C with variants of 10 minutes and 20 minutes can be seen in table 2 and the graph in Figure 5.

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 minutes is in the variation of A1 essence of 0.06135 grams with a percentage of weight loss (S) of 3%. While at 20 minutes there is also variation A5 non-essence of 0.1678 grams with a percentage of weight loss (S) of 10%.

3.2.3 Hot Temperature

The results of the SARS Edible Straw water resistance test at cold temperatures using an initial temperature of 50 ^{o}C with variants of 10 minutes and 20 minutes can be seen in table 3 and the graph in Figure 6.

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

3.3 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, 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 (Haryati *et al*., 2017). 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 grams of cassava pulp flour, while the longest degraded was obtained by sample A2e with a composition of 7 grams of cassava pulp flour. 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.

According to Asiah (2010), 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.

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 (Rohmah *et al*., 2019). 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.

3.4 Result of Antioxidant Test

Antioxidant test was conducted to determine the antioxidant activity of SARS Edible Straw using the DPPH method. The measurement results can be seen from the acquisition of the inhibition concentration for each concentration (IC_{50}). 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 in order to obtain a linear regression equation. The results of calculations using simple linear regression analysis can be seen in Figure 4 with the IC_{50} value obtained from the equation y = 0.0009x + 0.5955. The x value is the IC_{50} value and the y value is 50.

4. Conclusion[u5]

The best formulation of SARS Edible Straw was A2 with a comparison of cassava pulp flour : chitosan : sorbitol : Sea grape extract was 7 : 5 : 5 : 2 respectively in both essence added and non-essence variation. SARS Edible Straw preparation was started with the preparation of cassava flour and Sea grape extraction using the solid-liquid soxhlet method which was then molded and analyzed with various tests. For example[u6], the water resistance test showed that SARS Edible Straw has the best resistance in three treatments which are low temperature (10°C), room temperature (27°C), and high temperature (50°C). The Biodegradability test showed that all variations were well decomposed and it considered that they had met the Indonesian National Standard (SNI) > 60 % for 1 week. The result of the antioxidant test showed that SARS Edible Straw had reached 70% inhibition against the free radical compound. The IC_{50} value of the SARS Edible Straw is 55,489 ppm. 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 economical value of Sea grapes as a natural marine resource to keep them sustain and conserved.

Conflict of interest

The authors declare no conflict of interest.

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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%

Notes:
n = Non essence; e = With Essence

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%

Notes:
n = Non essence; e = With Essence

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%

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

Notes:
n = Non essence; e = With Essence

Table 5. Antioxidant Test of SARS Edible Straw

Concentration (µg/ml)	% inhibition	IC_{50} (ppm)
100	60%	
150	84%	
200	78%	55,489
250	82%	
300	84%	

Notes:
n = Non essence; e = With Essence

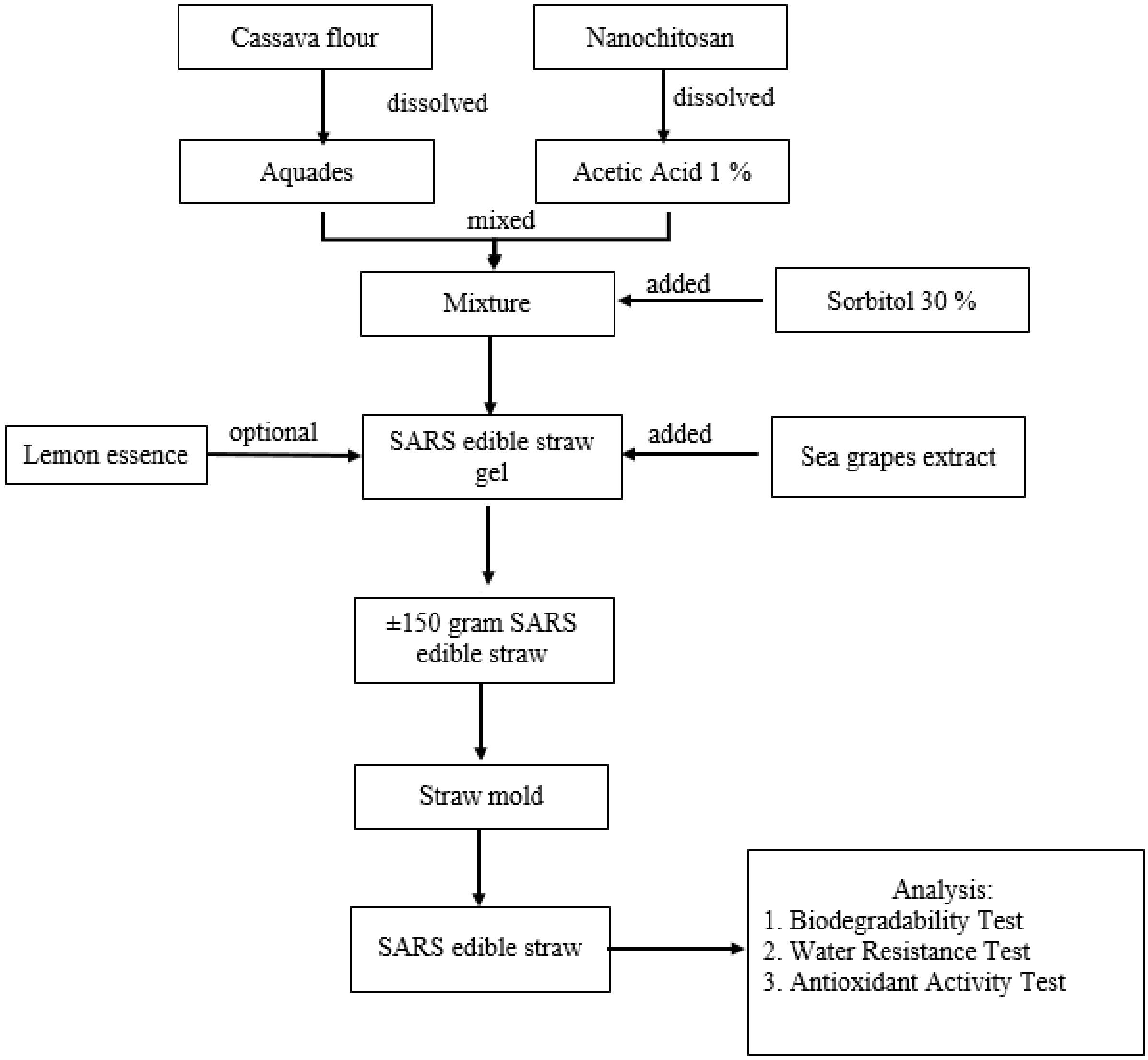

Figure 1. Flowchart of SARS Edible Straw Study

Figure 2. SARS Edible Straw non-Essence Overview

Figure 3. SARS Edible Straw Essence Overview

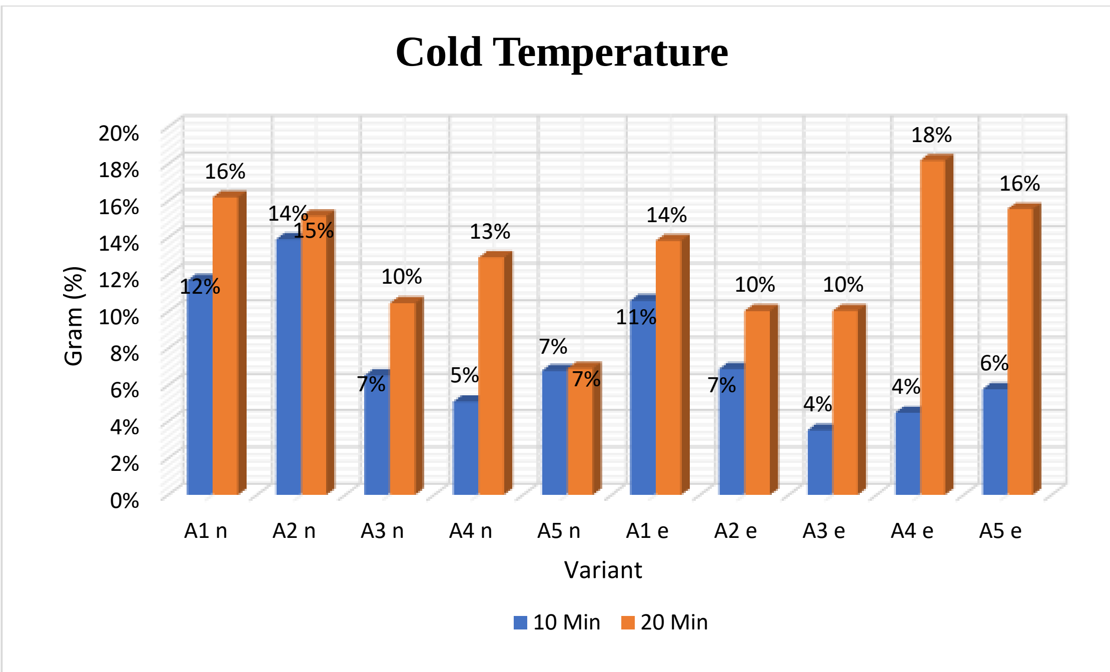

Figure 4. Cold Temperature Chart of SARS Edible Straw

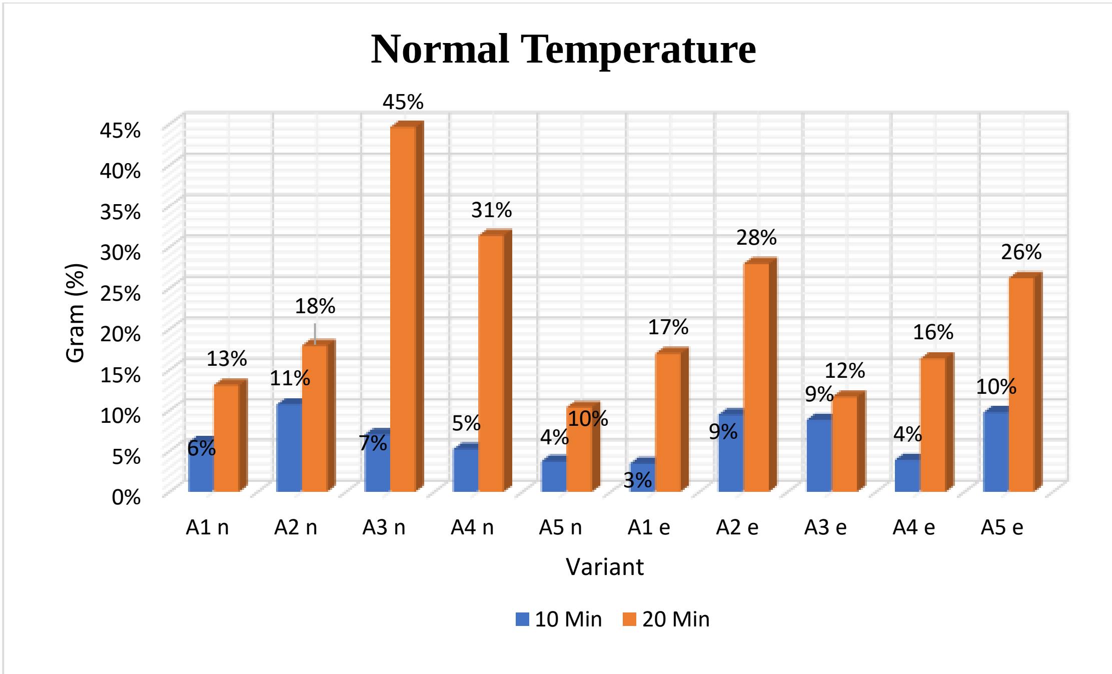

Figure 5. Normal Temperature Chart of SARS Edible Straw

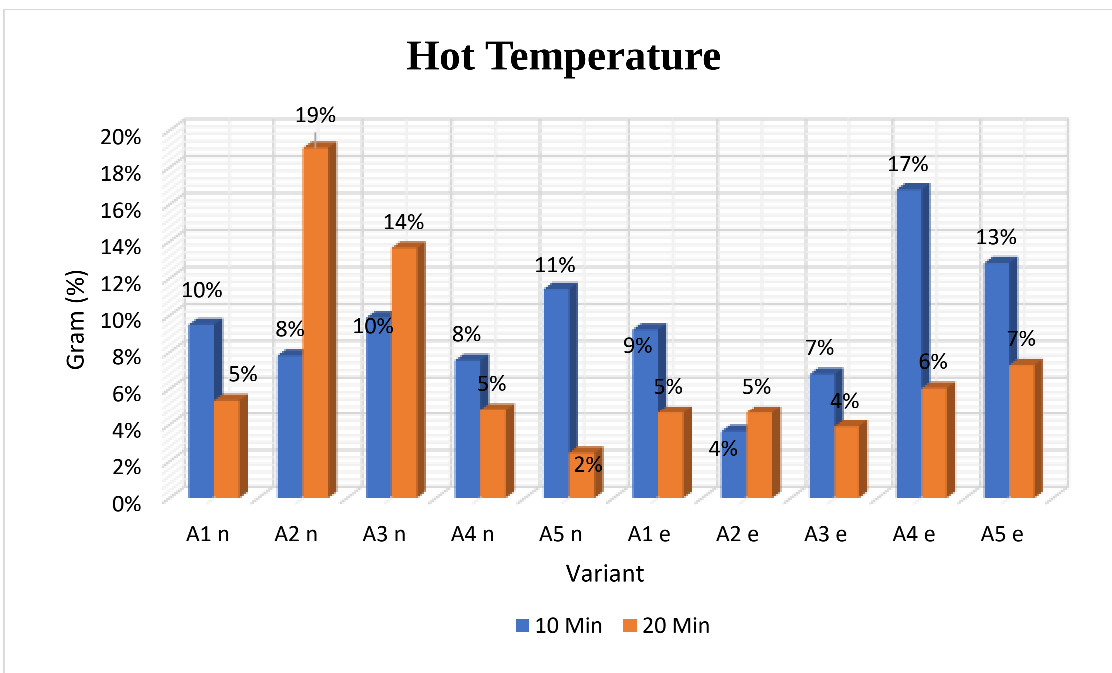

Figure 6. Hot Temperature Chart of SARS Edible Straw

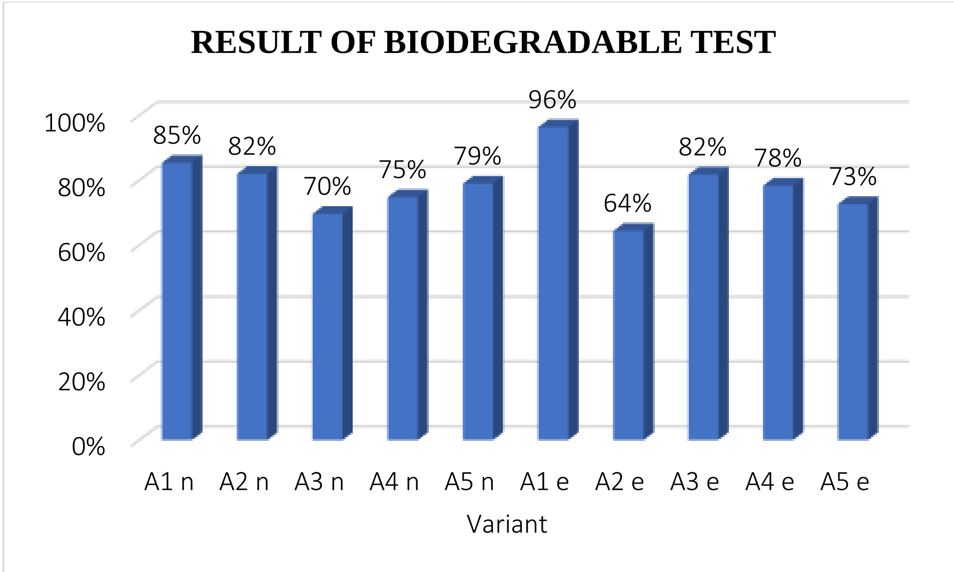

Figure 7. Biodegradable Test Chart of SARS Edible Straw

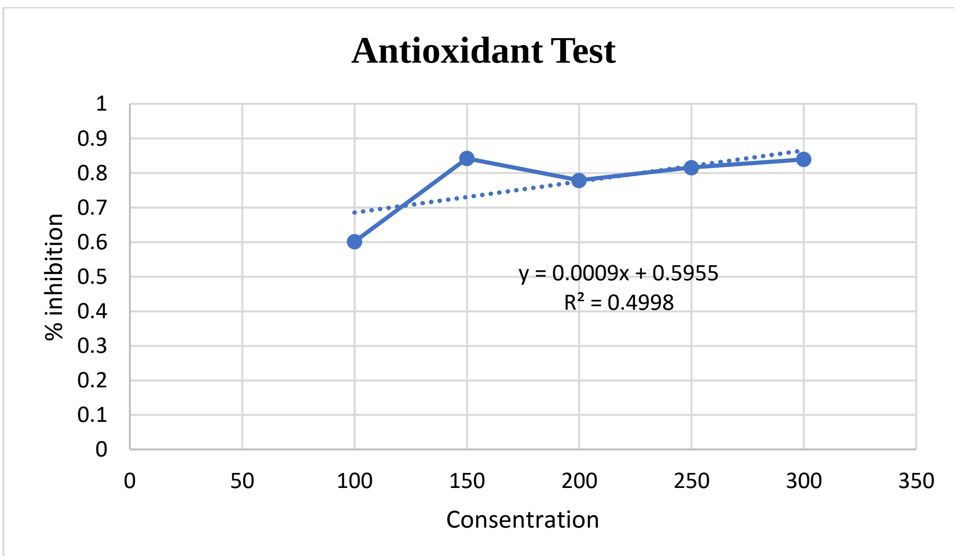

Figure 8. Antioxidant Test Chart of SARS Edible Straw

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

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Abstract

BANCKGROUND:[s1][FN2] 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. 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. 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.

MATERIAL AND METHODS: [s3][FN4]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: [s5][FN6] The best formulation of SARS Edible Straw was A2 with a comparison of cassava pulp flour : chitosan : sorbitol : Sea grape extract 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 (SNI) > 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.

Keywords: Edible Straw, Caulerpa, Antioxidant, Biodegradability, Marine resources.

1. 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* (2019), 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 (Trypolska *et al*., 2022).

Plastic waste pollution, especially in the ocean, gives many impacts to the marine environment. For example, 7 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 (Katsanevakis, 2008; Tanaka *et al*., 2013; Acampora *et al*., 2014). 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. But the maintenance of the waste is difficult because it's not easy to naturally degrade (Acampora *et al*., 2014). The responsibility to each individual is to reduce the use of plastic. [s7][FN8]

Sea grapes, in scientific name known as *Caulerpa racemosa*, is a green algae species which is included in the Caulerpaceae family (Pakki *et al*., 2020). The shape of *C. racemosa* is almost similar to grape, this is also the reason that make *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 (Yang *et al*., 2015; Yang *et al*., 2020; Kuswari *et al*., 2021; Permatasari *et al*., 2021).

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 (Sedayu *et al*., 2018).

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.

2. Materials and methods

2.1 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 erlenmayer, test tube, volumetric pipette, dropper pipette, blender, extractor soxhlette, hot plate, magnetic stirrer, spectrophotometer UV-Vis, vortex, termometer, 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, DPPH, methanol, ice cube, and aquades were used as materials to make edible straw.

2.2 Methods

2.2.1 Cassava Flour Preparation

About 1 kilogram 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 strainer. The result was cassava flour which can be used in the next process.

2.2.2 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 further process.

2.2.3 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 grams 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 minutes. 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 °C ± 4 hours. 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 can be seen in Figure 1.

2.3 Quality Test

2.3.1 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 (Saputro & Ovita, 2017). Biodegradable products already have a standard based on SNI (Indonesian National Standard). 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 is > 60 % degraded parts within a week (Rohmah *et al*., 2019). Based on Pimpan *et al* (2001), 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:

$$\% \text{ weight lose} = x = \frac{W0 - W}{W0} \times 100\%$$

Notes: WO = 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:

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

Notes: WO = sample weight before buried (g)
W = sample weight after buried (g)

2.3.2 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 (Pitak & Rakshit, 2011). This study was using Gontard *et al* (1993), 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 are dissolved in water after it was soaked in 3 treatments which vary in temperature (10 °C, 25 °C, and 50 °C) for 10 minutes and 20 minutes. Samples which are not dissolved were dried at 100 °C temperature inside the oven for 30 minutes. The samples were then re-weighed in dry condition and the weight after the soaking process was obtained and determined as W1. The percentage of water resistance was calculated using the following formula:

$$S = \frac{W0 - W1}{W0} \times 100\%$$

Notes: W_O = sample weight before soaked (g)
W_1 = sample weight after soaked (g)
S = Percentage of resistance to water (%)

2.3.3 Antioxidant Test

Antioxidant content can be tested using 2.2-difenil-1-pikrilhidrazil (DPPH) (Batubara *et al*., 2015). DPPH solution was made dissolving 0.1 mg DPPH stock in 100 mL absolute methanol (Brand-Williams et al., 1995). Sea grapes extract solution sample were made in various concentrations which are 10 µg/mL, 15 µg/mL, 20 µg/mL, 25 µg/mL, 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 minutes. Then the absorbance of each sample was measured at a wavelength of 517nm with 3 times repetitions (Brand-Williams *et al*., 1995). The antioxidant test was calculated using the following formula:

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

The concentration values of 5 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_{50} value (inhibitor concentration 50%) of each sample by stating the y value of 50 and the x value to be obtained from IC_{50}. The IC_{50} value represents the concentration of the sample solution needed to reduce DPPH free radicals by 50% (Rahmayani, 2013).

3. Results and discussion

3.1 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 (Sedayu *et al*., 2018).[s9][FN10]

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 Figure 2. and Figure 3, respectively.

3.2 Result of Water Resistance Test

The results of the water resistance test were carried out with 3 different temperature parameters including cold temperature (10 ^{o}C), normal temperature (25 ^{o}C), and hot temperature (50 ^{o}C). This test aims to determine the effectiveness of SARS Edible Straw in use in everyday life which is represented by 3 kinds of treatment based on temperature. The following is the test result data for each temperature treatment.

According to Tripathi *et al* (2009), 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.

3.2.1 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 10 minutes and 20 minutes can be seen 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 minutes is in the A3 essence variation of 0.0445 grams with a percentage of weight loss (S) of 4%, while at 20 minutes it is in the A5 variation non-essence of 0.07795 grams with a percentage of weight loss (S) of 7%.

3.2.2 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 minutes and 20 minutes can be seen in table 2 and the graph in Figure 5.

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 minutes is in the variation of A1 essence of 0.06135 grams with a percentage of weight loss (S) of 3%. While at 20 minutes there is also variation A5 non-essence of 0.1678 grams with a percentage of weight loss (S) of 10%.

3.2.3 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 minutes and 20 minutes can be seen in table 3 and the graph in Figure 6.

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

3.3 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 (Pitak & Rakshit, 2011), so that it will support the degradation process that will be carried out. [s11][FN12]The degradation test for SARS Edible Straw was carried out by testing the soil burial test (Haryati *et al.*, 2017). 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 grams of cassava pulp flour, while the longest degraded was obtained by sample A2e with a composition of 7 grams 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. [s13][FN14]

According to Asiah (2010), 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.

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 (Rohmah *et al*., 2019). 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.

3.4 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 (IC_{50}). 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 in order to obtain a linear regression equation. The results of calculations using simple linear regression analysis can be seen in Figure 84 with the IC_{50} value obtained from the equation y = 0.0009x + 0.5955. The x value is the IC_{50} value and the y value is 50.[s15][FN16]

4. Conclusion

The best formulation of SARS Edible Straw was A2 with a comparison of cassava pulp flour : chitosan : sorbitol : Sea grape extract was 7 : 5 : 5 : 2 respectively in both essences added and non-essence variation. ~~SARS Edible Straw preparation was started with the preparation of cassava flour and Sea grape extraction using the solid-liquid soxhlet method which was then molded and analyzed with various tests. For example, the water resistance test showed that SARS Edible Straw has the best resistance in three treatments which are low temperature (10°C), room temperature (27°C), and high temperature (50°C). The Biodegradability test showed that all variations were well decomposed and it considered that they had met the Indonesian National Standard (SNI) > 60 % for 1 week. The result of the antioxidant test showed that SARS Edible Straw had reached 70% inhibition against the free radical compound. The IC_{50} value of the SARS Edible Straw is 55,489 ppm.~~ 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.

Conflict of interest

The authors declare no conflict of interest.

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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%

Notes:
n = Non essence; e = With Essence

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%

Notes:
n = Non essence; e = With Essence

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%

Notes:

n = Non essence; e = With Essence

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

Notes:
n = Non essence; e = With Essence

Table 5. Antioxidant Test of SARS Edible Straw

Concentration (μg/ml)	% inhibition	IC_{50} (ppm)
100	60%	
150	84%	
200	78%	55,489
250	82%	
300	84%	

Notes:
n = Non essence; e = With Essence

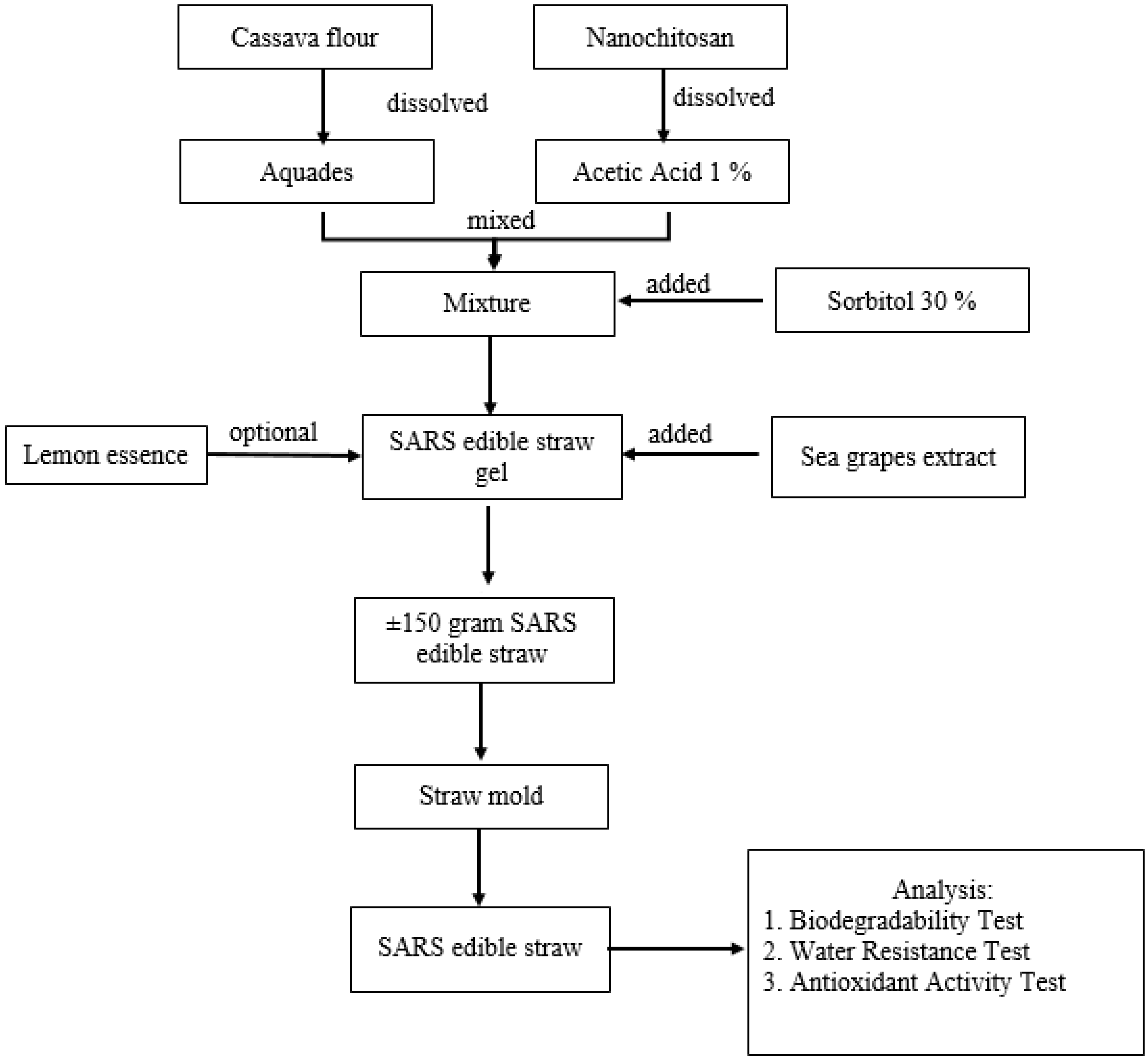

Figure 1. Flowchart of SARS Edible Straw Study

Figure 2. SARS Edible Straw non-Essence Overview

Figure 3. SARS Edible Straw Essence Overview

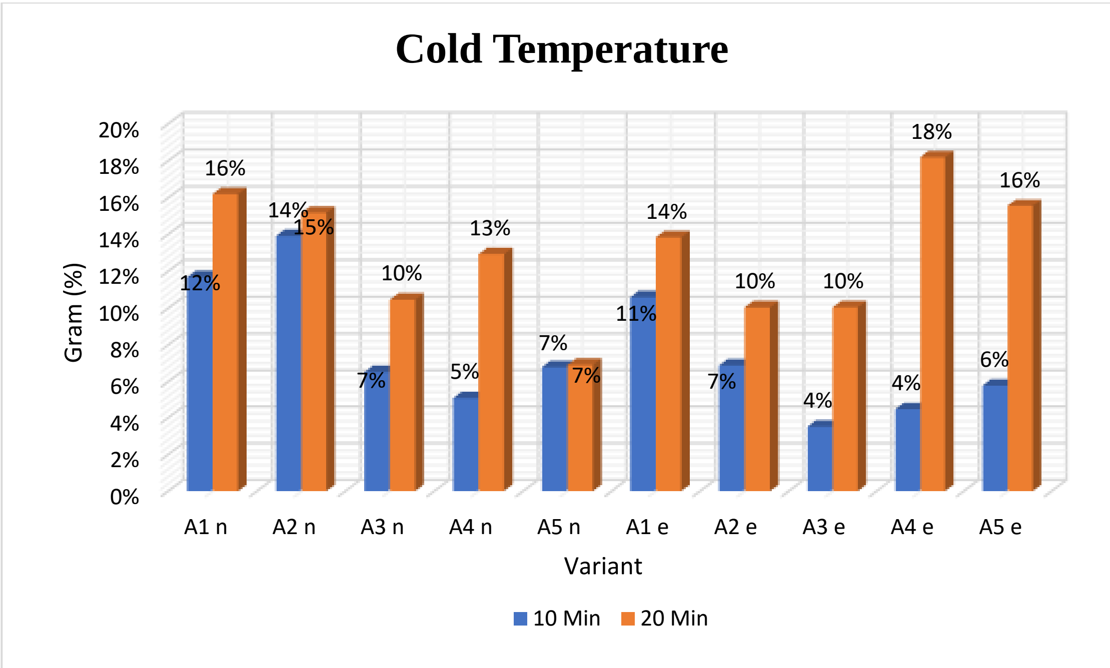

Figure 4. Cold Temperature Chart of SARS Edible Straw

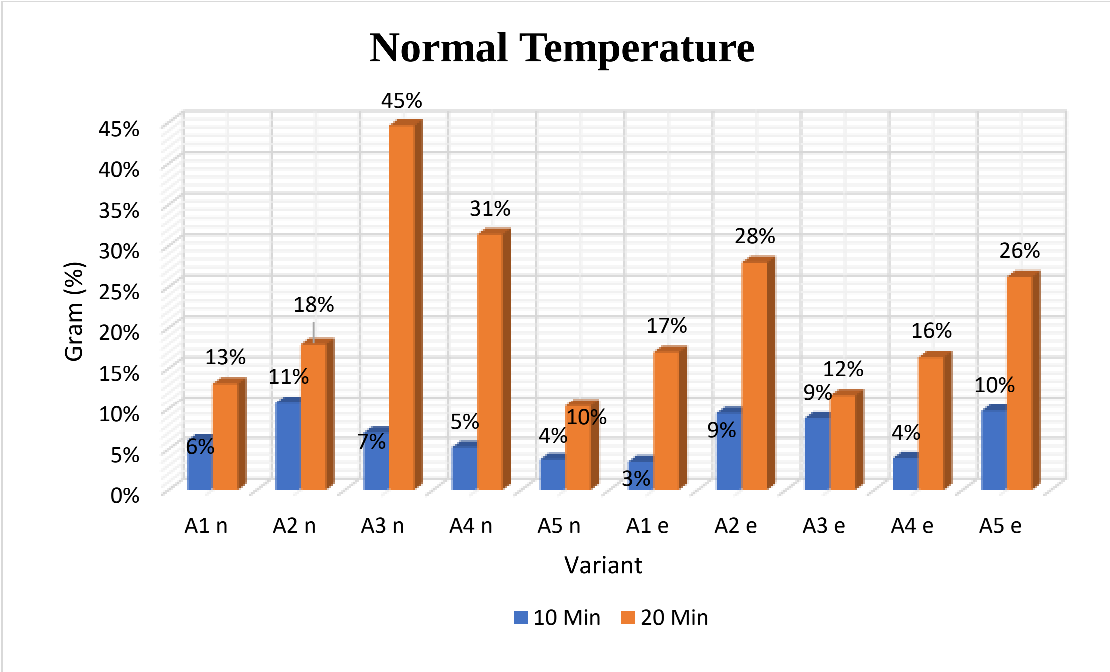

Figure 5. Normal Temperature Chart of SARS Edible Straw

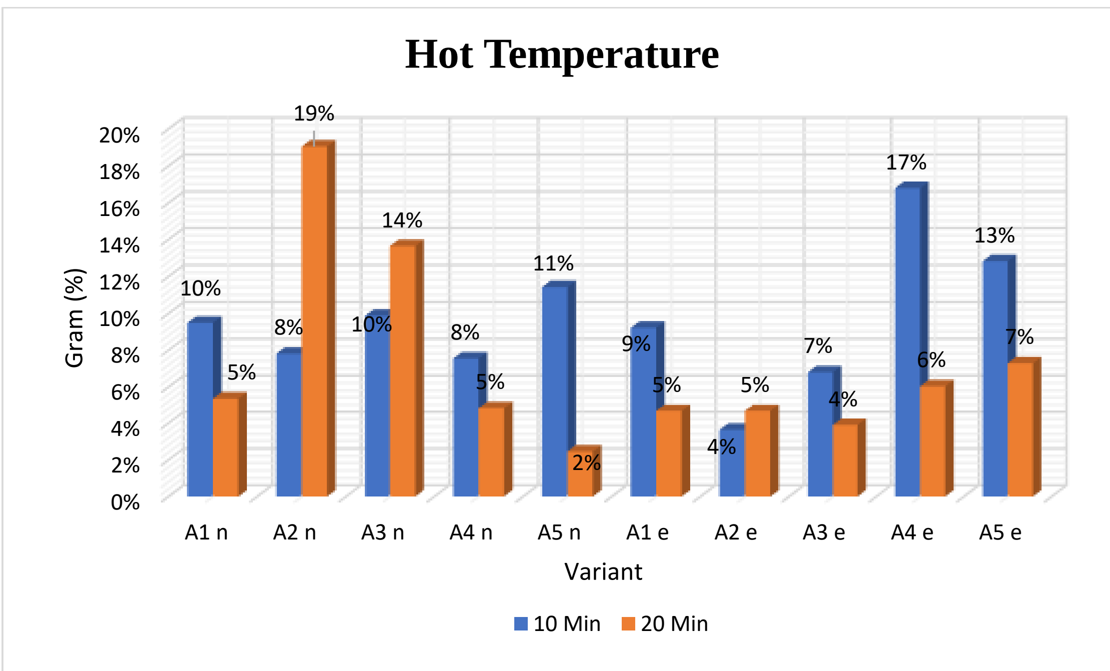

Figure 6. Hot Temperature Chart of SARS Edible Straw

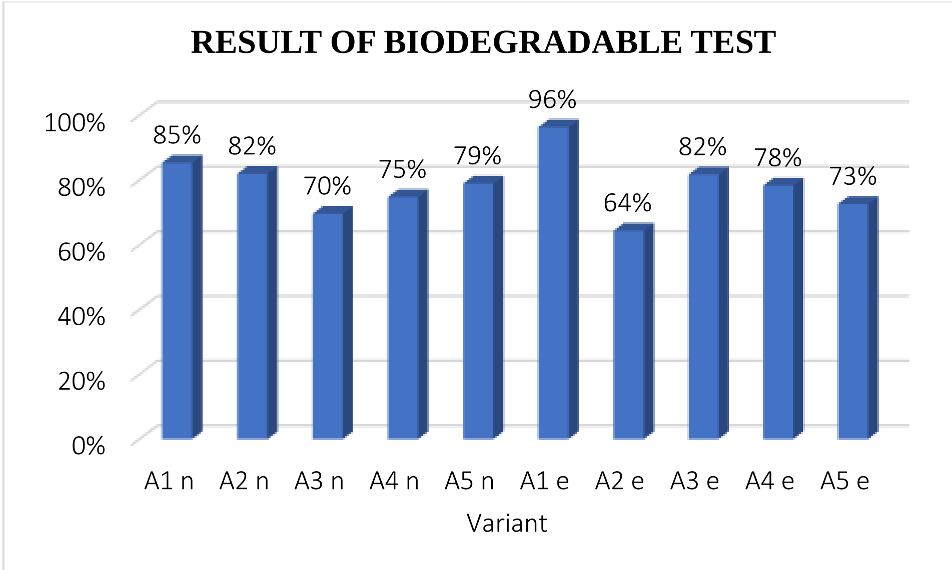

Figure 7. Biodegradable Test Chart of SARS Edible Straw

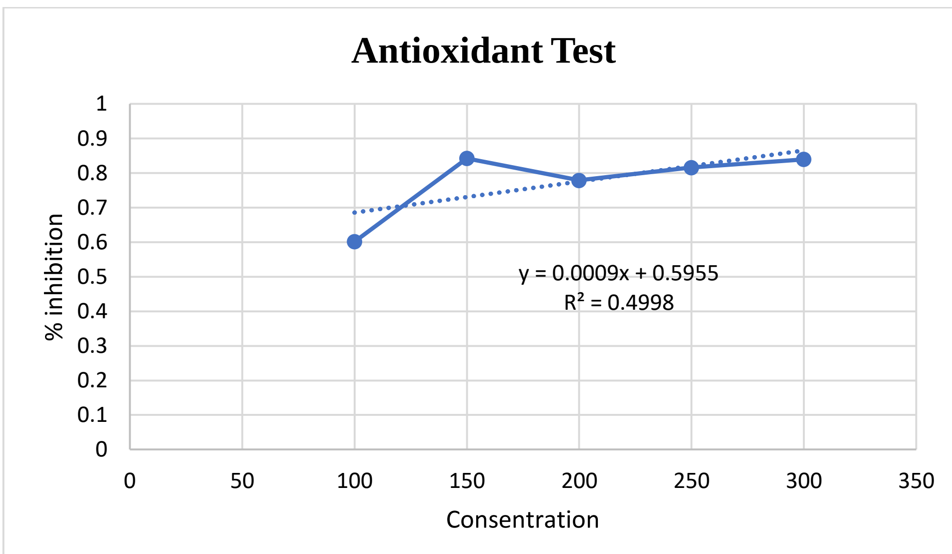

Figure 8. Antioxidant Test Chart of SARS Edible Straw