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The Effect of Different Substrates on Laboratory Scale Cultivation of *Sargassum cristaefolium*

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ABSTRACT

Seaweed is an excellent aquatic commodity to be cultivated. One type is *Sargassum cristaefolium*, which contains alginate. Alginate is needed in various industrial fields for export and import. The high demand needs to be balanced by cultivation. One of the factors that affect cultivation is the substrate. The substrate as a habitat for seaweed is very diverse. This study aimed to analyze the best substrate for the growth of *S.cristaefolium* seaweed cultivated on a laboratory scale. This study was conducted for 20 days using a completely randomized design of 4 treatments and four repetitions to obtain 16 experimental units. The test treatments used were sand, coral, volcanic rock, and sand and coral substrates. The Anova test results showed that different substrates significantly affected the survival of *S. cristaefolium*. P2 with coral substrate gave the highest results for survival of 92.25%, final weight of 18.25 g, and alginate yield of 90%. This study concludes that the best substrate for the growth of *S. cristaefolium* is a coral substrate with survival reaching 91.25%, a final weight of 18.25 g, and an alginate yield of 90%.

Keywords: Alginate, Seaweed, *Sargassum cristaefolium*, Substrate, Talus

1. INTRODUCTION

Indonesia's waters support the community to conduct aquaculture activities with superior commodities. Seaweed is a commodity with high demand in domestic and foreign markets. The need for seaweed raw materials is needed by several industrial fields because of the content in seaweed, such as alginate in brown algae species for the formation of various products (Erniati et al. 2016). The high demand needs to be balanced with supply, so it is necessary to cultivate to provide seaweed in the future.

Seaweed cultivation has been widely practiced in Indonesia. One of the central sectors of seaweed cultivation that is well-known by cultivators is NTB. One type of seaweed commonly cultivated is brown algae such as *Sargassum* sp. According to Herliany et al. (2021), *Sargassum* sp and *S.cristaefolium* is a brown alga with a holdfast bladder, a bladder, and a rod-shaped stipe or talus. *S. cristaefolium* lives by attaching itself to coral substrates and dead coral fragments and is rarely found in sand substrates (Ain et al., 2014) because, according to Aulia et al. (2021), holdfasts owned by *Sargassum* sp firmly attached to the coral substrate while the sand substrate is unstable for *Sargassum* sp attach themselves and grow.

Seaweed growth can be supported by substrates suitable for the type of seaweed and water conditions. According to Ardiyanto et al. (2020), the substrate to attach seaweed is divided into soft and hard substrates, such as coral reefs, dead coral fragments, and volcanic rocks. According to Hariadi et al. (2023), with their research using different substrates to cultivate brown *Kappaphycus alvarezii* on a laboratory scale, the survival results obtained were 100% in the coral substrate treatment. Similar to the research of Jum'at et al. (2023), coral substrate is the best treatment. Cultivation in the laboratory differs from its natural habitat, so it needs to be optimized with ideal water quality.

Based on this, this study aimed to analyze the best substrate for growing *S.cristaefolium* seaweed cultivated on a laboratory scale.

2. RESEARCH METHOD

Time and Place

This research was conducted for 20 days at the Production and Reproduction Laboratory of the Aquaculture Study Program, Faculty of Agriculture, Mataram University.

Methods

The research method used was

experimental, with a completely randomized design consisting of 4 treatments and four repetitions. The treatments tested were P1 (sand substrate), P2 (coral substrate), P3 (stone substrate), and P4 (sand and coral substrate).

Procedures

Preparation of Cultivation Container

All jars (5 L) were washed thoroughly and placed on a maintenance rack with LED lights. Then, it was filled with 500 g of substrate and 4 L of seawater. Finally, all jars were aerated and covered with black plastic.

***S.cristaefolium* Seedling Preparation**

Seedlings were collected and selected at Batu Layar Beach. Seedlings were acclimatized one day before planting.

Planting and Maintenance of *S. cristaefolium*

Seedlings were weighed 20 g for each treatment. Then, the seedlings were tied with ropes on coral, volcanic rock, and coral sand substrates. On the sand substrate, the seedlings were immersed. During maintenance, a 50% water change was carried out.

Harvesting of *S.cristaefolium*

On the 20th day, harvesting was done by weighing the weight. The harvest of each treatment was collected to make alginate.

Research Parameters

Survival Rate

According to Jum'at et al. (2023), the formula used is:

$$SR = Wt \,/\, Wo \times 100\%$$

Description:

SR : Survival Rate (%)
Wo : Initial weight of seaweed (g)
Wt : Seaweed final weight (g)

Final Weight

The final weight was measured at the end of rearing.

Alginate Content Analysis

Alginate yield formula Widyartini et al. (2015):

$$\text{Rendemen alginate} = \frac{\text{Final weight (g)}}{\text{Ingredients (g)}} \times 100\,\%$$

Observation of *S. cristaefolium* Talus Tissue

Tissue observations were made at the beginning and end of maintenance by thinly slicing the *S. cristaefolium* talus and then placing the slices on a glass plate to be observed under a microscope and documented.

Water Quality

Water quality was measured at the beginning and end of rearing by measuring salinity, temperature, dissolved oxygen, light intensity, pH, nitrate, and phosphate.

Data Analysis

Data from the research results according to treatment and repetition will be analyzed using analysis of variance (ANOVA) at a confidence level of 95% and a significant value of 5%. Furthermore, if the results are significantly different, Duncan's further test is carried out, and the water quality and talus tissue analysis are descriptive.

3. RESULT AND DISCUSSION

Survival Rate

The results showed that the average survival rate of *S.cristaefolium* cultivated with different substrates on a laboratory scale gave a range of values from 56.25% to 91.25%, with the highest average in the coral substrate treatment (P2), which was 91.25% and the lowest in the sand substrate treatment (P1) with a value of 56.25%. Meanwhile, according to research by Jum'at *et al*. (2023), the survival rate of green *K. alvarezii* in the laboratory reached 39%. So, from the existing data, an ANOVA test was carried out, which showed that the difference in substrates in laboratory-scale cultivation of *S.cristaefolium* had a significantly different effect ($p<0.05$), so further testing was carried out. It was found that P1 was significantly different from P2 and P4 but not significantly different from P3.

From the results obtained, it can be seen that the low survival in P1 and P3 is due to differences in substrate from the original habitat, which makes seaweed spend much energy to adapt to its new environment (Ismariani et al., 2019). This is relevant to the statement of Djalil et al. (2021) that *Sargassum* sp. is often found living on coral substrates and rarely found living on sandy or rock substrates because, according to Festi et al. (2022) on coral substrates, *Sargassum* sp can adhere well while on sand substrates it cannot adhere well because the substrate is unstable (Aulia et al., 2021) (Figure 1).

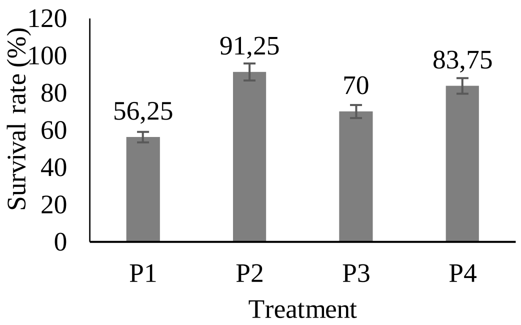


Figure 1. Survival Rate of *S. cristaefolium*

The lowest is P1, with 56.25%, followed by P3, 70%, because the talus has fallen off, which marks a decrease in seaweed growth. This is in line with the research of Amper et al. (2020) that shows that a falling talus, smooth and soft textured talus, and whiteness in the talus characterize seedlings experiencing decreased growth.

Final Weight

The results of the study on the final weight obtained during 20 days of rearing showed a range of average weight values from 11.25 to 18.25 g, with the highest average weight value in the coral substrate treatment (P2) while the lowest in the sand substrate treatment (P1) which was 11.5 g. The ANOVA test analysis results also showed a significant difference ($p < 0.05$), which stated that P1 was significantly different from P2 and P4 and not significantly different from P3 (14 g). According to previous research by Hariadi et al. (2023), the highest final weight of brown *K. alvarezii* is 20 g.

The statement shows that the average final weight of each treatment decreased from the initial seedling weight of 20 g. The low final weight in P1, followed by P3, was due to differences in the substrate from the original habitat of *Sargassum* sp, which used to live attached to the coral as in the P2 treatment. Adjusting to the new habitat makes seaweed more vulnerable to growth (Susrini et al., 2023) because it requires a lot of energy, while other energy is also needed to manufacture food reserves from photosynthesis. The considerable weight loss in P1 was also due to high phosphate from the weathering of the talus that fell off. So that the water in P1 looks cloudy and can block light entry for seaweed photosynthesis (Nikhlani & Kusumaningrum, 2021). When viewed, the initial seedling weight of 20 g, according to Novandi et al. (2022), is considered good enough to be maintained because the smaller the initial seedling weight, the easier it is to get nutrients due to lack of competition between talus. However, the statement is not supported by media conditions in the laboratory. According to Fajri et al. (2020), seaweed will grow more optimally in moving water because the current can distribute nutrients in the nutrients needed by seaweed to grow and develop.

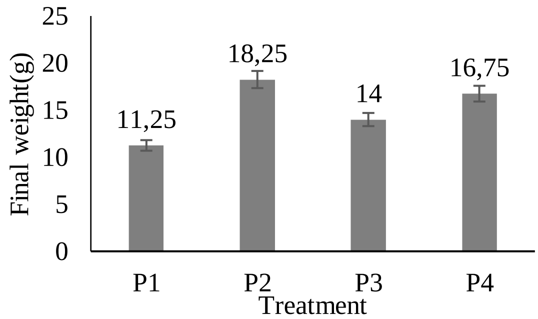


Figure 2. Final Weight of *S. cristaefolium*

Alginate Yield

The results showed a different range of alginate at the beginning of maintenance (P0) was 40%, and then at the end of maintenance, the range of values obtained was P1 (50%), P2 (90%), P3 (60%) and P4 (70%) according to research by Fitriani et al. (2023) the highest alginate yield obtained amounted to 56.5%.

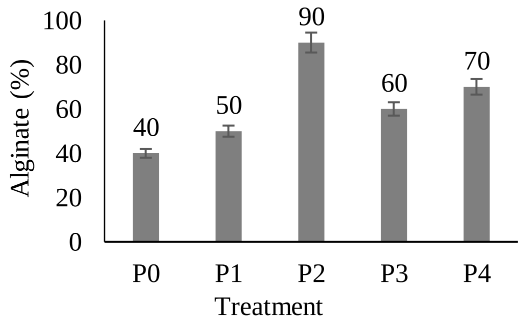


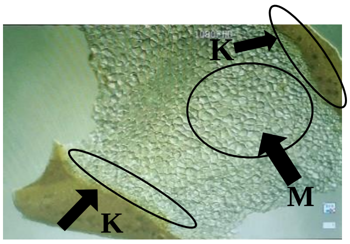
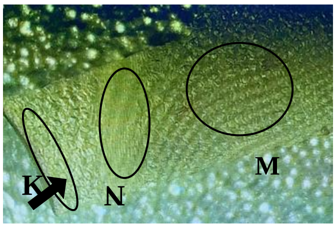
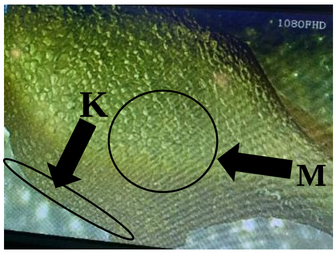
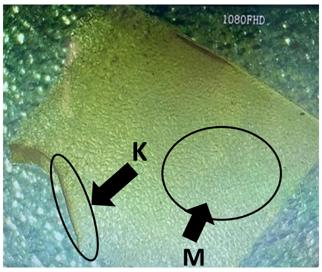
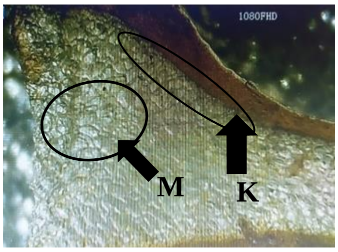
Figure 3. Alginate Yield of *S. cristaefolium*

The high and low indicate that the substrate of each treatment can be one of the factors of alginate yield because, according to Ode & Wasahua (2014), alginate can also be influenced by the conditions of the growing environment, namely the better the quality of the waters, the alginate produced will be high.

Observation of *S.cristaefolium* Talus Tissue

The histological observations of *S. cristaefolium* seaweed talus tissue in Table 1 show that in the early and late treatment talus, there are cortical cells, medular, and necrosis in P1, which indicates cell death. According to the research results by Yatin et al. (2023), *E. spinosum* seaweed cells indicate the presence of cortical, medular, and necrosis.

Table 1. Talus slices of *S. cristaefolium*

Treatment	Talus Tissue Slice Picture	Information
Normal/first tissue		K: Cortical M: Medular
End of P1 tissue		K: Cortical M: Medular N: Necrosis
End of P2 tissue		K: Cortical M: Medular
End of P3 tissue		K: Cortical M: Medular
End of P4 tissue		K: Cortical M: Medular

At the beginning of cell maintenance, the cells appear clear and tight, indicating that the cells are in a healthy condition (Achmad, 2016). Likewise, at the end of the study, P2, P3, and P4 showed cortical cells at the edge of the cell wall, which increased in size in the center (medular) (Darmawati, 2014). Furthermore, in contrast to P1, which shows signs of unhealthy cells, according to Quere et al. (2015), it is characterized by empty spaces that indicate cell necrosis.

Water Quality

Water quality measurements during maintenance showed good results for *Sargassum cristaefolium* (Table 2).

Table 2. Water Quality

Parameter	Range	Reference
Temperature (°C)	27,7-29,7	27-30 (Ihsan et al., 2023)
Dissolved oxygen (mg/L)	6,1-6,7	3-8 (Serihollo et al., 2021)
pH	7,2-7,6	7.0-8.5 (BSNI 7572.2, 2010)
Salinity (ppt)	28-30	28-34 (BSNI 7572.2, 2010)
Light intensity (lux)	575-625	500-1000 (Sitorus et al., 2020)
Phosphate (mg/L)	0,72-4,62	0,1-0,2 (Rohman et al., 2018)
Nitrate (mg/L)	0,23-1,88	0,9-3,5 (Cyntya et al., 2018)

Based on the results of the study, the temperature at the beginning and end of maintenance is 27.7-29.7°C which is still classified as suitable for seaweed growth, following Ihsan et al. (2023) that 27-30°C is feasible for the growth of *Sargassum* sp. Water temperature is susceptible to seaweed's metabolic ability because, according to Nirmala et al. (2014), metabolism will increase with the water's increasing temperature. The photosynthesis process can also be disrupted if the temperature is too high because it will cause chlorophyll degradation (Rohmat et al., 2014) and decreased dissolved oxygen (Djalil et al., 2021).

The amount of dissolved oxygen in the waters is obtained from photosynthesis (Ihsan et al., 2023). Dissolved oxygen obtained during maintenance is 6.1-6.7 mg/L. This value is optimal for seaweed growth, which generally requires 3-8 mg/L (Serihollo et al., 2021). Waters with acidic pH < 4 and alkaline > 8 cannot be tolerated by seaweed, although each type of seaweed has a different pH tolerance limit (Yulius et al., 2017). Based on the results in Table 2, the pH range obtained at the beginning and end of the maintenance is ideal for seaweed cultivation at 7.2-7.6. SNI 7572.2 (2010) states that pH 7.0-8.5 suits seaweed.

Salinity during maintenance ranged from 28-30 ppt. Salinity is good for the growth of *S. cristaefolium*, according to BSNI 7572.2 (2010). The optimal salinity of seaweed is 28-34 ppt. The difference in results is due to differences in measurement time. According to Gultom et al. (2019), high and low salinity does not cause death, but seaweed growth will decrease due to the talus's blanching, which makes the talus easily fall off.

The maintenance of seaweed in the laboratory certainly requires ideal lighting, so a common white light LED lamp replaces sunlight for plant photosynthesis (Lulu et al. 2021). According to Hulpa et al. (2021), high and low light intensity can be a limiting factor. If it is too low, photosynthesis is inhibited; if it is too high, growth decreases due to increased respiration rates. However, this study's results were 575-625 lux, good for growth with the optimal range of 500-1000 lux (Sitorus et al., 2020).

Phosphate and nitrate are both nutrients related to water fertility. In the study, the phosphate results obtained were 0.72-4.62 ppm. These results exceed the optimal limit of 0.02 - 1 ppm (Rohman et al., 2018). The high phosphate in the study was due to the formation of sediment at the bottom due to talus that fell off and experienced weathering. According to Mansur et al. (2023), the cause of high phosphate is plant weathering.

The nitrate results in the maintenance obtained were 0.23-1.88 mg/L. The range is ideal for maintaining seaweed, with an optimal range of 0.9-3.5 mg/L for macroalgae to grow (Cyntya et al., 2018). If the N content is insufficient in the waters, the development of talus cells is inhibited because it inhibits the formation of chlorophyll.

4. CONCLUSION

The conclusion is that the best substrate for the growth of *S. cristaefolium* is coral substrate, with survival reaching 91.25%, final weight of 18.25 g, and alginate yield of 90%.

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