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Analysis of the Growth and Carrageenan Content of *Kappaphycus Alvarezii* Seaweed at Different Locations Using a Net Bag

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ABSTRACT: *Kappaphycus alvarezii* seaweed is a type of seaweed that has high economic potential in the food, pharmaceutical and cosmetics industries. The carrageenan content, a natural compound found in seaweed, has various significant commercial benefits. However, the growth and carrageenan content of *Kappaphycus alvarezii* seaweed can be influenced by various factors, including cultivation location. This research aims to analyze the growth and carrageenan content of *Kappaphycus alvarezii* seaweed in Majane and Polewali Mandar waters, West Sulawesi using Net bags, as well as comparing the effect of different locations on the growth and content of carrageenan. Research methods include site surveys, seed bag preparation, seed collection, planting, maintenance, and testing growth parameters and water quality. The data obtained were analyzed using the independent t test. The results showed that the absolute growth of *K. alvarezii* seaweed was higher in Polewali Waters (75.667 ± 10.84) compared to Majene Waters (70.333 ± 39.77), with a significant difference. Meanwhile, the carrageenan content did not show any significant differences between the two locations. The gel strength of seaweed in Majene Waters (9.71 ± 2.23a g/cm2) was higher than that in Polewali Waters (7.73 ± 2.91a g/cm2), although not significant. Water quality parameters show that water depth, salinity, temperature and pH at both locations are suitable for seaweed cultivation.

Keywords: *Kappaphycus Alvarezii* Seaweed, Net Bag, Carrageenan Content

Introduction

Indonesia has maritime areas which are important development assets, because this area is supported by two main components which are the backbone of its development. The first is the ecophysical component, namely Indonesia's coastal and marine areas which stretch along approximately 81,000 km

of coastline and spread over around 17,508 islands with around 5.8 million km2 of water area. The potential for biological resources is abundant and of various types, where these resources have important value both in terms of the domestic market and the international market. Second, the socio-economic component: the majority of Indonesia's population (± 60%) lives in coastal areas (with an average growth of 2% per year). This is because administratively, most districts and cities are located in coastal areas. Based on these two components, mariculture has great potential to be developed with various commodities, including fish, crustaceans, Mollusca and seaweed (Dahuri et al., 2001).

One of the important commodities in Indonesia which is expected to play a role in improving the Indonesian economy in general and coastal communities in particular is seaweed cultivation. The seaweed cultivation business has a high labor absorption capacity, easy and simple cultivation technology, a short planting period, relatively small production costs and the potential to develop seaweed into processed products with high economic value with quite large market demand.

One of the seaweed production centers in West Sulawesi is Polewali Mandar Regency, whose capital is Polewali District. The area of Polman Regency is 2,022.3 km2, consisting of 16 sub-districts, 23 sub-districts and 173 villages. Of the 16 sub-districts, only five sub-districts have the potential to produce seaweed, namely, Balanipa District, Campalagian District, Wonomulyo District, Polewali District and Binuang District. The potential area for seaweed cultivation is 1,437.83 ha with a production potential of 14,716 tons/year. (BPS West Sulawesi data 2021, accessed 2023).

The growth of seaweed in West Sulawesi, especially in the Polewali and Majene areas, is influenced by various factors including environmental aspects and cultivation practices. This region, with its geographical conditions facing directly to the nutrient-rich ocean, provides optimal conditions for the growth of seaweed. Resources such as warm sea water temperatures, stable salinity, and sufficient sunlight play an important role in supporting the development of seaweed. In addition, the presence of moderate ocean currents helps distribute the nutrients and oxygen needed for optimal growth. Human factors also influence the growth of seaweed in this region, through cultivation practices such as selecting types of seaweed that suit local conditions and effective planting methods. A study by the West Sulawesi Provincial Government (2019) on the potential and development of seaweed in the area provides in-depth insight into the environmental characteristics and cultivation practices that influence seaweed growth. Additionally, scientific publications such as the "Journal of Applied Phycology" and "Aquaculture Research" often provide up-to-date research on kelp growth and cultivation, providing further understanding of the factors that influence kelp growth in this region. Overall, the combination of favorable environmental conditions and effective cultivation practices is the key to understanding and utilizing seaweed growth in Polewali and Majene, West Sulawesi.

Carrageenan, a polysaccharide found in several types of red seaweed, has a content that is influenced by a number of factors. In general, carrageenan consists of galactose bound to a sulfate group. The three main types of carrageenan, namely kappa, iota, and lambda, are distinguished by the pattern and location of sulfate groups, providing different properties such as gel stiffness and viscosity. The main factors that influence carrageenan content include seaweed species, environmental conditions, harvest age, processing methods, and cultivation practices. research published in the "Journal of Applied Phycology" by Fitriyah et al. (2016) investigated variations in carrageenan content between the seaweed species Gracilaria verrucosa and Gracilaria blodgettii in Indonesia. The results showed significant differences in carrageenan content between the two species. Additionally, a study by Hurtado et al. (2015) in "Algal Research" highlighted the influence of environmental conditions, such as temperature and light, on carrageenan production by the seaweed Eucheuma denticulatum in the Philippines. This information confirms that a deep understanding of these factors is necessary to optimize carrageenan production and ensure the desired quality in diverse industrial applications.

Seaweed cultivation business activities cannot be separated from the suitability of the waters. The main factors that become obstacles in the development of seaweed cultivation in Indonesia are unsuitable water locations and inappropriate water quality parameters, besides that determining cultivation locations is often based on feeling. Determining the suitability of waters is very important to know,

because determining the location of waters must be suitable for cultivation, so that later suitable locations can be utilized as optimally as possible. Furthermore, Hardjowigeno (2001) stated that land suitability is the suitability of land for certain purposes, through determining the value (class) of land and land use patterns which are linked to the potential of the area, so that more targeted land use can be achieved for business and sustainability.

Cultivation activities carried out in coastal areas must be in accordance with the carrying capacity of the environment. The carrying capacity of waters is something that needs to be known to find out how much water can accommodate seaweed cultivation activities. If this is ignored, it will cause various problems both for the aquatic environment, conflicts between communities and the seaweed cultivation activities carried out. Carrying capacity is the maximum intensity of land use for natural resources that occurs continuously without destroying nature or degrading the surrounding environment and ecosystem.

One method that can be used to overcome the problem of predators that interfere with seaweed growth is the use of bags in seaweed cultivation. This bag functions as a polybag which can be used as a container for seaweed seeds before they are ready to be cultivated. Syarqawi et al., (2017), stated that seaweed cultivation in Majene and Polewali Regencies can use bags in seaweed cultivation activities to increase seaweed growth.

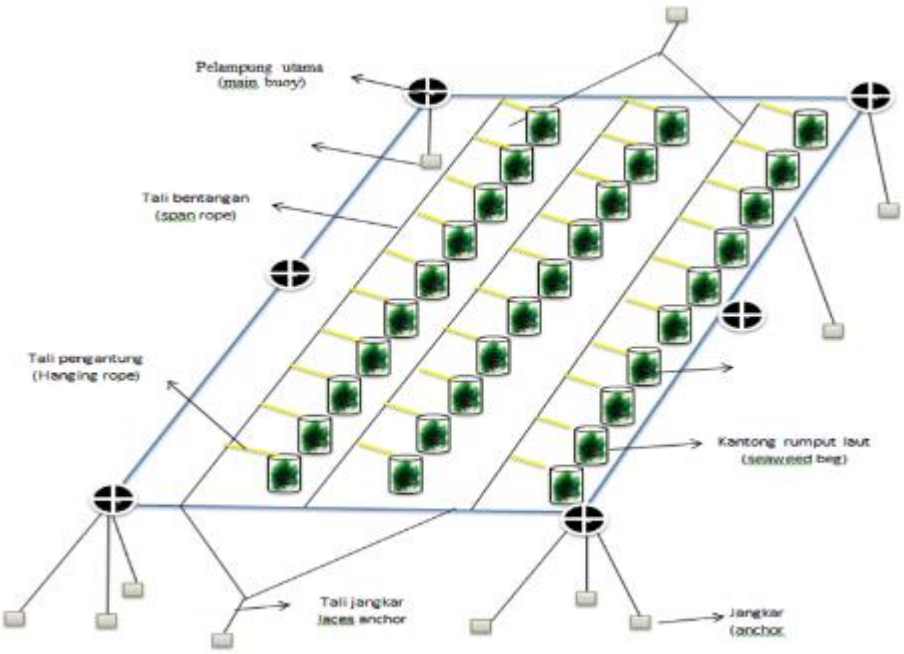
Methods

Time and Place of Research

The research was conducted in Polewali Mandar Regency and Majene Regency, West Sulawesi, in October – November 2023

Experimental Design

This research used 2 treatments and each treatment consisted of 3 replications as the treatments were different rearing locations, namely Majene and Polewali.



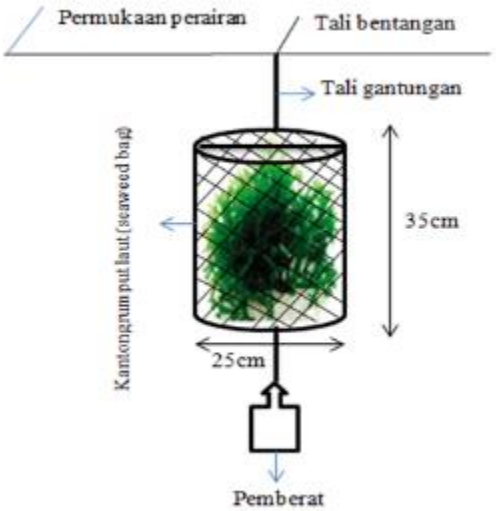
Research Procedure

Location Survey

Location survey activities are a pre-research stage to determine the research location. Survey activities consider several water quality parameters such as salinity, pH, temperature, water depth, brightness, turbidity and current speed.

Seed Bag Preparation Stage

The tool used to make seaweed seed bags is Jringan Gae, which is cut in a square shape and then shaped into a bag with a frame made of rattan with a diameter of 35 x 15 cm and a net hole size of 1 cm (square) tied using nylon rope. The number of bags to be used is 30 in one location.



Seaweed Seeds

Seaweed seeds were taken from the cultivation unit of Polewali Mandar district, West Sulawesi. The transportation process is carried out by placing the seaweed seeds into a closed stereofoam box. Seaweed seeds that have arrived at the location are first adapted.

Selection of Seaweed Seeds

In carrying out seaweed cultivation, the selection of seaweed seeds greatly influences the quality of the seaweed produced, because these are the characteristics of selecting good seaweed seeds and good seed handling methods, including the following reasons: (a) Elastic or flexible thallus , has many branches, uniform seed shape. (b) The base is larger than the tip of the branch and the tip of the thallus is straight. (c) Clean from pests, disturbing plants, dirt, has a bright color and smells fresh. (d) Try to use seeds from your own cultivation or seeds that come from a nearby location because the seeds are suitable for that location and the time required for transportation is not long (less than 4 hours).

Planting and Maintaining Seaweed Seeds

Planting seaweed seeds is carried out using the long-line method using nylon rope to tie the seaweed seed bags provided. The rope containing the seaweed seed bags is then stretched from one point to another with a length of 10-20 m in the form of a loose strip or strung together with the help of float bottles and weights.

K. alvarezii that has been planted in bags is routinely controlled to determine its development conditions. Maintenance is also carried out by cleaning efifits or dirt attached to the thallus or maintenance bags, regularly during research activities. The seaweed will be harvested after approximately 45 days and the weight will be weighed and after harvest it will be dried.

Test Parameters

Absolute Growth

Absolute growth of seaweed was observed from the beginning to the end of the study, absolute growth was calculated using the absolute growth formula (Togatorop et al., 2017).

$$G=Wt-Wo$$

Description:

G = Average absolute growth (g);

wt = Seedling weight at the end of maintenance (g);

wo = Seedling weight at the start of maintenance (g).

Carrageenan yield

Carrageenan was made based on Winarno's (1990) modification. Algae flour (A gram) was weighed as much as 5 grams, extracted with 300 ml hot water (1:60), at a temperature of 85-95℃ in an alkaline atmosphere pH 8-9 for 4 hours. The extraction results obtained were filtered with a fine cloth, then the filtrate was concentrated to approximately 150 mL by heating. The filtrate was added with ethanol solution (95% alcohol) using a 200 mL measuring cup to precipitate the carrageenan. Leave it overnight and the precipitate formed is filtered again with a soft cloth and the precipitate is dried in the oven at 60℃ for 8 hours. Dried carrageenan was weighed (B grams) to determine its weight. To get the percentage of carrageenan, a formula is used:

Gel Strength

Gel strength measurements were carried out using the CZAPKE Gel Strength method (1979), which was simplified by Hatta and Hermiati (1992). The 2% carrageenan solution was heated with a KC1 solution with a concentration of 0.3%. The filtrate obtained was poured into 3 15 mL test tubes. Then the test tube was attached to the gel strength measuring device. After that, the load (M) is placed on the upper piston plate and a light load is started. Open the piston lock carefully, let the piston plate at the bottom (A) move slowly downwards until it hits the gel surface and leave it for a while. If the surface does not penetrate, then the load is added carefully. With each additional load, the piston is left for a few seconds above the gel surface, its movement is observed. The noodle treatment continues until the load is heavy enough and the bottom piston is able to penetrate the gel surface.

Samples of *K. Alvarezii* seaweed from each research station were taken from each wet stretch and then dried to obtain 50 grams dry. Sampling was carried out at harvest to determine the carrageenan content from different locations. The dried *K. alvarezii* seaweed is then extracted. The *K. alvarezii* seaweed to be extracted is washed and cleaned with water to remove sand, salt, lime, coral,

Data analysis

The data obtained will be analyzed statistically using the Independent T-Test on IBM SPSS 21. If the sig (2tailed) value is <0.05 then there is a significant difference between the 2 treatments. Water quality parameters in the form of salinity, temperature, pH, brightness, current speed and turbidity will be analyzed descriptively.

Results and Discussion

Absolute Growth

The absolute growth value of *Kappaphycus alvarezii* seaweed cultivated in Majene waters and Polewali waters using net bags can be seen in table 1.

Location	Absolute Growth
Majene	70.333±39.77
Polewali	75.667±10.84

* Not significantly different (>0.05)

Based on table 4.1 above, the average absolute growth value of *K. alvarezii* seaweed in Polewali waters is higher (75.667 ± 10.84), compared to the absolute growth of *K. alvarezii* in Majene waters (70.333 ± 39.77).

Agility

Based on the results of the T test, it shows that there are differences, where the results of the research analysis provide a real influence on the growth of *K. alvarezii* seaweed between Majene waters and Polewali waters. In this research, seaweed was also harvested at the age of 45 days and then carrageenan extraction was carried out to determine the quality of the carrageenan produced (Table 2).

Location	Carrageenan Content
Majene	49,64±2,02
Polewali	49,76±2,62

*Not significantly different between treatments (P≤0.05)

In table 2, it can be seen that the average value of carrageenan content produced in Majene waters is around 49.64 ± 2.02 while in Polewali waters it is 49.76 ± 2.62. Analysis of variance in the cultivation of *K. alvarezii* seaweed shows that there is a real influence on the percentage of *K. alvarezii* carrageenan content, where according to Atmadja and Kadi (1998) that different planting locations will give different results on the percentage of carrageenan content.

The high levels of carrageenan are strongly influenced by ecological conditions that support the development of seaweed

Gel Strength

Gel strength, also known as breaking force, is defined as the point of the largest load area which is used to break the polymer matrix in the loaded area. Gel strength is a parameter used to indicate the quality of carrageenan in forming gels such as turning liquid into gel. Based on previous research, seaweed harvest age is a factor that greatly influences the gel strength value. (Table 3)

Location	Gel Strength
Majene	9,71±2,23
Polewali	7,73±2,91

The gel strength obtained from the results of this research in Majene waters was 9.71 ± 2.23a g/cm2 and Polewali 7.73 ± 2.91a g/cm2. The strength of the Majene and Polewali gels was not significantly different (P≥0.05). Even though it is not significantly different, the average value obtained is that the gel strength of Majene seaweed is greater than that of Polewali. The lower sulfate content in Majene seaweed increases the gel strength. Samsuari (2006) stated that the strength of the gel can be influenced by the type or type of carrageenan and the presence of ions that can inhibit the formation of hydrocolloids. The properties of carrageenan gel depend on ionic strength because ionic strength that remains constant will increase the strength of carrageenan gel.

Conclusion

Research on the cultivation of Kapppaphycus alvarezii seaweed in Majene and Polewali waters shows that there are differences in absolute growth rates. The highest average absolute growth of *K. alvarezii* seaweed was 70,333 in Majene waters and 75,667 in Polewali waters. Aquatic ecological characteristics such as water movement, temperature, salt content, nutrients and lighting are believed to influence seaweed growth.

Carrageenan, a polysaccharide extracted from red seaweed, is found in the cell walls or intracellular matrix and is the largest constituent of the dry weight of seaweed. The amount and quality of carrageenan produced by *K. alvarezii*, one type of seaweed that produces kappa carrageenan, varies based on several factors including variety, plant age, sunlight, nutrients and salinity. Research shows that the average value of carrageenan content produced in Majene waters is around 49.64 ± 2.02 while in Polewali waters it is 49.76 ± 2.62

Gel strength or breaking power indicates the quality of carrageenan in gel form. Research shows that the gel strength obtained from *K. alvarezii* seaweed in Majene waters is 9.71 ± 2.23 g/cm2 and Polewali 7.73 ± 2.91 g/cm2. The gel strength of Majene and Polewali seaweed is not significantly different (>0.05), but the average value obtained shows that the gel strength of Majene seaweed is greater than that of Polewali.

Suitability of land for seaweed cultivation in certain waters is important for the success of the cultivation business. Determining the suitability of waters includes measuring biophysical parameters, including water depth, brightness, current speed, temperature, salinity, pH, DO, and nitrate and phosphate levels. These factors greatly influence the growth and development of seaweed.

In conclusion, the growth and development of *Kappaphycus alvarezii* seaweed is influenced by various factors, including aquatic ecological characteristics, carrageenan content, gel strength, and water quality parameters. Understanding these factors can help support the success of seaweed cultivation and contribute to the sustainability of seaweed cultivation businesses.

Suggestion

Conduct further research to develop and improve cultivation methods using net bags, including adjustments to net bag designs and planting techniques.

Carry out routine monitoring of water quality at each cultivation location to better understand the environmental factors that influence growth and carrageenan content

Conduct further research on the chemical content of carrageenan, including a more in-depth analysis of the dominant types of carrageenan.

Research efficient post-harvest and processing methods to support the sustainability and added value of carrageenan products

Involve local communities in seaweed cultivation activities to encourage their participation in marine resource management and increase awareness of the importance of sustainability.

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