Epiphyte Identification on *Kappaphycus alvarezii* Seaweed Farming Area in Arungkeke Waters, Jeneponto and the Effect on Carrageenan Quality

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Abstract

Kappaphycus alvarezii which is widely cultivated at sea is susceptible to other algae that drift away and attach as epiphyte. This study aims to identify epiphyte on seaweed farming K. alvarezii and its effect on carrageenan quality. The study was conducted on K. alvarezii seaweed farming area in Jeneponto, South Sulawesi. Sample of epiphyte was obtained from four stations. Epiphyte was identified in laboratory based on its morphological characteristics and calculated its density. Carrageenan yield and gel strength of healthy seaweed and those infected one were analyzed in laboratory in triplicates for each sample. Data were statistically analyzed using independent samples t-test analysis. Present study showed that there were 6 epiphytes species on the seaweed farming area, namely: Entheromorpha intestinalis, Ceramium sp., Neosiphonia apiculata, Chaetomorpha crassa, Hypnea sp., and Gracilaria sp. The average of epiphytic density in cultivation area was (24.26±9.64)%. Healthy seaweed and infected one had significantly different carrageenan yield and gel strength (P<0.05). Healthy seaweed had higher carrageenan yield (48.17±1.62)% and gel strength (1130.76±8.42) g.cm^{-2} than infected seaweed which had carrageenan yield (42.47±0.23)% and gel strength (958.22±10.85) g.cm^{-2}.

Keywords: *epiphyte, cultivation, K. alvarezii, carrageenan*

Introduction

The demand for seaweed production is increasing because of an increasing in its utilization. *K. alvarezii* is carrageenan-producing seaweed with high economic value. Carrageenan is widely used in global industries of various food, pharmaceutical, and cosmetics. Indonesia has big contribution to the production of tropical seaweed, especially *K. alvarezii*. Indonesian seaweed production continues to increase for more than 10 times, in 2005 it was less than 1 million tons increasing into 10 million tons in 2014. Indonesia contributed to the world seaweed production increasing, from 6.7% in 2005 to 36.9% in 2014 (FAO, 2016). The major mariculture commodity in Indonesia is seaweed for carrageenan production. Seaweed production accounts for 98% of total Indonesian mariculture production and 84% of value. Since 2010 until 2014, seaweed production in Indonesia increase 32% per annum (Rimmer, 2010). Seaweed production was potential to meet the sustainability of farmer's livelihood, seaweed farming has become the main income source for small-scale fishermen, particularly for some areas in South Sulawesi (Yusuf *et al*., 2018).

K. alvarezii is widely cultivated at sea. One of the obstacles in seaweed cultivation at sea is the difficulty of controlling epiphytes. The sea, as an open space, enables wide access for other algae to move along with the current and attached as competitor algae on cultivated seaweed. The aquatic environment is a factor that affects the occurrence of epiphytes, especially in tropical regions such as Indonesia. The tropical marine and coastal ecosystems are rich in biodiversity, as an archipelagic country with large areas for seaweed cultivation, Indonesia has advantages in the abundance of tropical seaweed resources. The commercial types of seaweed can be widely found in Indonesia (Mulyati and Geldermann, 2017). However, a tropical country with adequate sunlight and rich biodiversity has consequences on epiphytic problem in seaweed farming. Spore and propagule of other algae are possible to drift away and attach on cultivated seaweed, the availability of adequate sunlight will support the competitor algae to grow well on host. Epiphytes are common phenomenon in seaweed cultivation, and even become a major problem affecting the productivity of seaweed (Lüning and Pang, 2003; Critchley *et al*. 2004; Hurtado *et al*., 2006a; Vairappan, 2006).

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Several studies have reported that epiphytes could decrease the growth rate of cultivated seaweed as well as decreasing in biomass due to competition in space and nutrients with the host (Buschmann and Gómez 1993). Moreover, epiphytes also disrupt photosynthesis process and affecting the formation process of carrageenan. The decreasing of carrageenan quality in some cases causing in economic losses. To evaluate the kind of epiphyte on seaweed farming and the effect of epiphyte on carrageenan quality, we observed some epiphytes on *K. alvarezii* seaweed farming area on Arungkeke waters, Jeneponto regency, South Sulawesi and analysed carrageenan quality of cultivated seaweed.

Materials and Methods

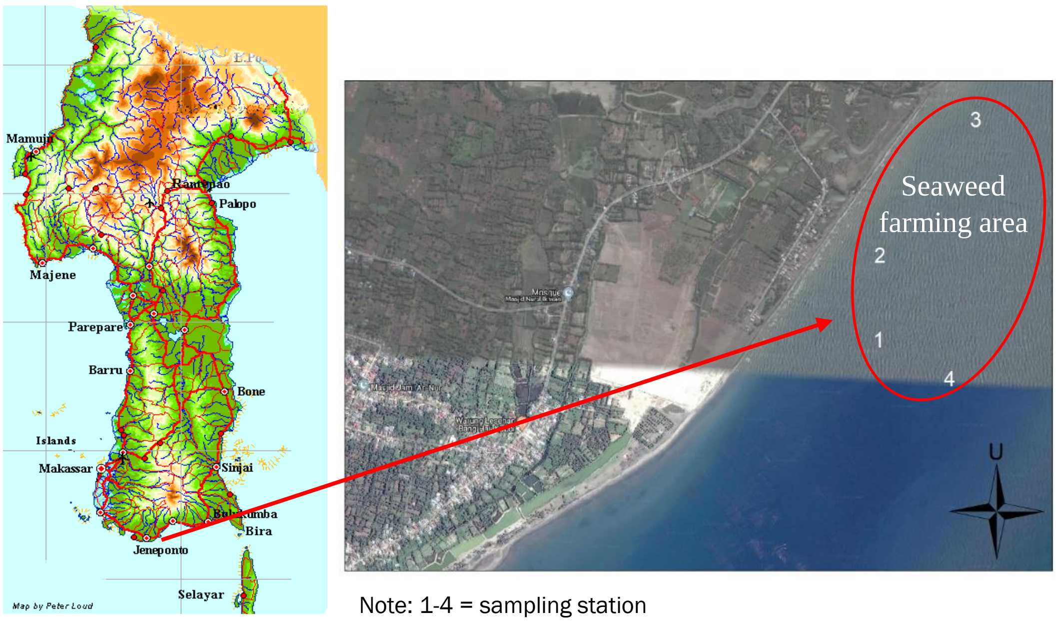
The study was conducted at seaweed farming area in Arungkeke waters, Jeneponto, Regency, South Sulawesi in June 2018 (Figure 1.). The observation was executed when there was an epiphytic occurrence at a long line-seaweed farming area. Sample of seaweed, both healthy and epiphyte infected, were taken randomly, obtained from four sampling stations then transported to laboratory for being observed. Epiphytes were separated from the host and identified based on their morphological characteristics (Hurtado *et al*., 2006b). The measurement of epiphytic density was carried out based on the method of Muñoz and Fotedar (2010). Sample obtained from four stations was rinsed using sea water, while the epiphyte was separated from the host. Both seaweed and separated epiphyte were weighed, then epiphyte load was calculated using the following formula according to Buschmann and Gómez (1993).

The quality of carrageenan was measured by analysing carrageenan yield and gel strength in healthy seaweed-free epiphytes and infected seaweed. Carrageenan yield and gel strength were analysed in laboratory in 3 replicates for each sample. Carrageenan extraction was carried out using the isopropyl alcohol precipitation (IPA) method and gel strength was analysed using the Brookfield CT3 Texture Analyser according to the Marine Colloids (1977) method. Epiphytic data was analysed descriptively, while the carrageenan yield and gel strength data were analysed statistically using independent samples t-test.

Results and Discussion

Morphological identification to competitor algae in *K. alvarezii* samples showed several species of epiphytes as presented in (Figure 2.). The distribution of competitor algae species at each station was shown in Table 1. Generally, all stations had the same species of epiphytes, it were: *Entheromorpha intestinalis*, *Ceramium* sp., *Hypnea musciformis*, *Neosiphonia apiculate*, *Gracilaria* sp., and *Chaetomorpha crassa*.

Kasim *et al*. (2017) reported there were 7 *macro epiphytes* species in *Eucheuma spinosum* seaweed cultivation in Bau-bau, Southeast Sulawesi, namely: *Acanthophora spicifera, Chondrophycus papillosus, Chaetomorpha crassa, Jania longifurca,*



Note: 1-4 = sampling station

Figure 1. Study site on seaweed farming *K. alvarezii* in Arungkeke waters, Jeneponto regency, South Sulawesi

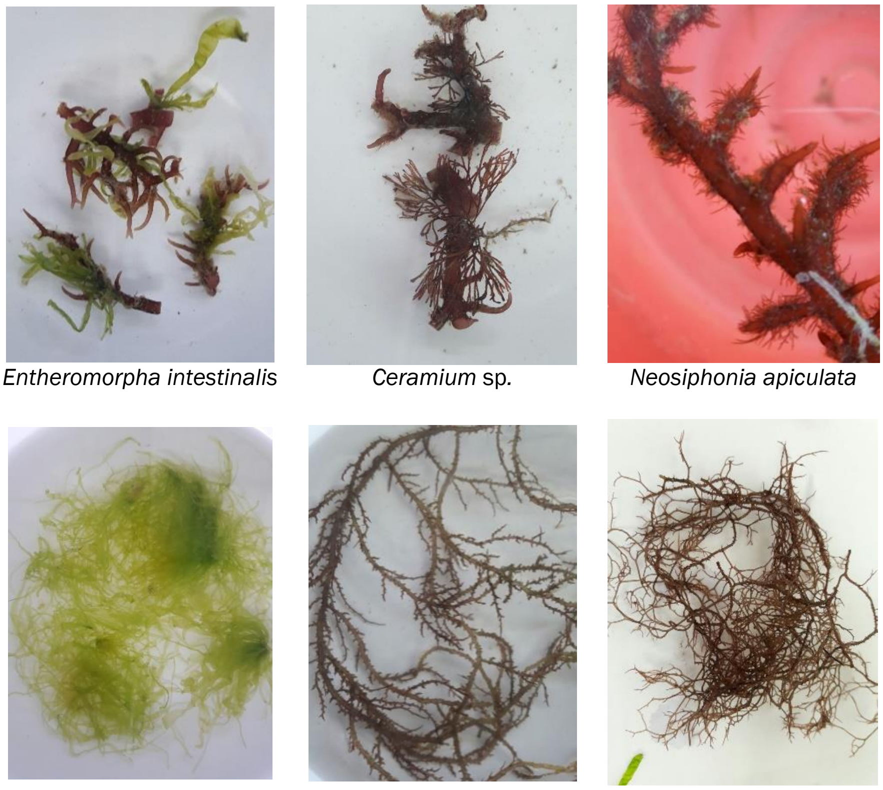


Figure 2. Some epiphytes found on *K. alvarezii* seaweed farming area

Pomatoceros triqueter, *Ulva lactuca* and *Turbunaria ornata*. Radulovich *et al*. (2015) reported filamentous species *Chaetomorpha* sp., was ubiquitous and grew abundantly on the surface of floating objects such as logs, ropes, fish cages and cultivated seaweeds and considered as fouling pest.

Hayashi *et al*. (2010), mentioned several types of epiphytes in seaweed: epiphytes which attaching weakly to the surface of seaweed and does not cause any damage host tissue; epiphytes which attaching firmly to the surface of seaweed and does not damage the host tissue; epiphyte which spreading on the surface of the outer layer of the host cell wall and does not damage cortical cells; epiphyte which spreading to the outer layer of the host cell wall and associated with damage to the host cortical cell and epiphyte which attacking the host tissue and growing intercellular, being associated with cortical destruction and medullary cells. *Hypnea* sp. and *Gracilaria* sp. were classified as first type of epiphyte. *C. crassa, E. intestinalis* and *Ceramium* sp. were second type of epiphyte, while *N. apiculata* was classified as fifth type of epiphyte. Arisandi *et al*. (2013) reported epiphytes in *Eucheuma cottonii* were dominated by the *C. crassa* which had resembles yarn shape and clot, covered thallus surface, thus blocking the penetration of light and became a competitor of *E. cottonii* in absorbing nutrient. *C. crassa* was also a suitable habitat for bacterial life. *Neosiphonia* sp. infection could decreased biomass and carrageenan quality. *Neosiphonia* sp. was known as epiphytic filamentous algae (EFA) which attached to *K. alvarezii* by forming primary rhizoid and secondary rhizoid in host (Hurtado *et al*., 2006a; Vairappan *et al*. 2014). Vairappan, *et al*. (2007) reported the early of *N. apiculata* infection was marked by a black stain on the cuticle surface cells which indicated the presence of epiphytic spores then developed, corresponding to the condition of the water temperature and salinity. Several epiphytes caused damage on host's thallus by attaching its spores on its host, made weakening of cultured seaweed, and made its exposure to bacteria population (Tampangallo *et al*., 2018).

The average of epiphytic density on cultivation area was (24.26±9.64)%, the distribution of epiphytic density on each station was described in Figure 3. Hosnan *et al*. (2016) reported the prevalence of competitor algae on *E. cottonii* seaweed farming in Sumenep regency was 0.14-17.24%, meanwhile Munõz and Fotedar (2010) reported the epiphytes density on *Gracilaria cliftonii* seaweed farming up to 40% with 24 types of epiphytic species. Vairappan *et al*. (2008) measured the epiphytic density in *K. alvarezii* seaweed cultivation based on the number of epiphytes per centimetre square of seaweed specimen, it was reported that the epiphytic density of *K. alvarezii* from Tawi-tawi, Indonesia was 69 epiphytes cm^{-2}. Tsiresy *et al*. (2016) found the rate of epiphytes infestation varied from 42 to 78 epiphytes cm^{-2}.

Some factors that influence the onset of epiphytism among others are the intensity of sunlight and the movement of water. The emergence of epiphytes at the study site of seaweed farming was suspected due to the low currents in Arungkeke waters. Current becomes one of the determining factors of macro algae spreading. Current is an important factor influencing the transport of epiphytes. The vertical and horizontal spreading of macro algae is generally associated with the pattern and velocity of currents in certain regions and also the topography of each area (Komatsu *et al*., 2014). Epiphytism usually occurs when there was change in water temperature, wind and water movement (Johnson and Gopakumar, 2011). Munõz and Fotedar (2010) explained that the growth of epiphytes on seaweed cultivation was due to an increase of the water temperature and the occurrence of irradiation, further reported that the highest epiphytic diversity was in spring time. The availability of light in certain regions will greatly affect the algal community in waters.

Carrageenan quality

Carrageenan yield of healthy seaweed was higher (48.17±1.62)% than infected seaweed (42.47±0.23)% (Figure 4.). T-test analysis showed that carrageenan yield of healthy seaweed was significantly different from infected seaweed (P<0.05). The gel strength of healthy seaweed was higher (1130.76±8.42) g cm^{-2} than infected seaweed (958.22±10.85) g cm^{-2} (Figure 5). The result of t-test analysis showed that the gel strength of healthy seaweed was significantly different with infected seaweed (P<0.05). Previous studies reported that epiphytes in *K. alvarezii* seaweed could decrease the yield and quality of carrageenan. Vairappan *et al*. (2014) reported that infected *K. alvarezii* by *N. apiculata* had lower carrageenan yield (20.5±2.5%) than healthy seaweed (65.5±4.2%), as well as its gel strength was lower (687.9±3.5 g cm^{-2}) than healthy seaweed (1456.5±24.7 g cm^{-2}). Pang *et al*. (2011) reported, epiphytic disruption in seaweed was through two methods i.e. material exchange and energy metabolic. The condition may lead to the disruption during photosynthesis process. Photosynthesis is basic anabolism process and the only mechanism for transferring sunlight energy into chemical energy for plants. Disruption during the photosynthesis process will affect the quality of carrageenan, in which the phycocolloid is the result of photosynthesis. Mulyati and Geldermann, (2017) reported that the most critical risk in carrageenan supply was poor quality of raw dried seaweed which was contaminated with other materials during cultivation and post-harvest handling.

Some studies reported some efforts have been performed to overcome epiphytes. Lüning and Pang (2003) recommended high density seaweed cultivation method to overcome epiphytes. Base on the knowledge that the competitor algae is known as a fast-growing but opportunistic organism, its growth

Table 1. Distribution of epiphytes on each sampling stations

Sampling station	Epiphyte
1	*Entheromorpha intestinalis* *Ceramium* sp. *Hypnea musciformis* *Neosiphonia apiculata* *Gracilaria* sp.
2	*Entheromorpha intestinalis* *Ceramium* sp. *Hypnea musciformis* *Neosiphonia apiculata* *Gracilaria sp.*
3	*Chaetomorpha crassa* *Entheromorpha intestinalis* *Ceramium* sp. *Neosiphonia apiculata*
4	*Chaetomorpha crassa* *Entheromorpha intestinalis* *Ceramium* sp. *Neosiphonia apiculata*

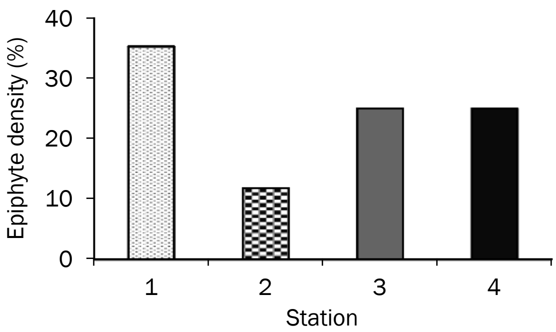


Figure 3. Epiphytic load on four sampling stations

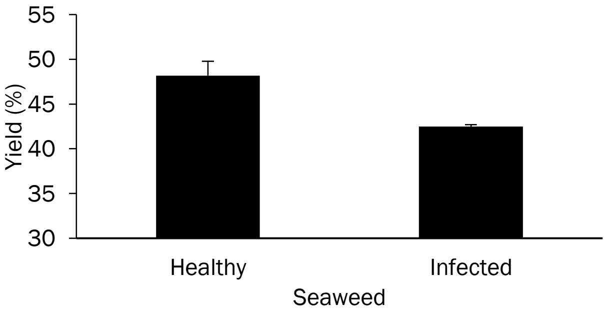


Figure 4. Carrageenan yield of healthy and epiphyte infected *K. alvarezii*

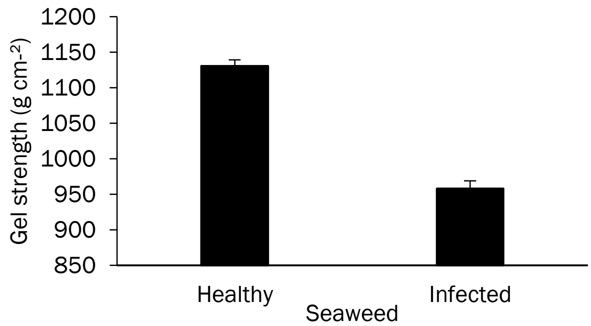


Figure 5. Gel strength of healthy and epiphyte infected *K. alvarezii*

is very dependent on the sunlight. Thus, in high-density cultivation, competitor algae will be covered by cultivated seaweed and do not get enough sunlight for its growth. Borlongan *et al*. (2011) overcome epiphytes by using AMPEP (Acadian Marine Plant Extract Powder), found that *Neosiphonia* growth was reduced up to 6-50% by AMPEP application. Hurtado and Critchley *et al.* (2013) explained that AMPEP could reduce damage on *K. alvarezii* seaweed caused by *Neosiphonia* epiphytic. The use of this *Ascophyllum nodosum* extract was claimed as an efficient and effective tool to help reduce *Neosiphonia* epiphytism (Hurtado *et al*., 2014). The other epiphytism control technique is by maintaining a certain light intensity that favours the growth of cultivated seaweed but reduces the epiphytic algae. Changing the seasonal rhythms of seaweed cultivation also helps to control epiphytism (Titlyanov and Titlyanova, 2010). Farmers have a simple way to prevent epiphytes, i.e. by shaking the rope line of seaweed frequently, so that the propagules or spores of epiphytes do not stick to cultivated seaweed and cultivation facilities. This method is effective enough to avoid epiphytic disorders in seaweed cultivation.

Conclusion

Epiphytes found on *K. alvarezii* seaweed farming area in Arungkeke waters were *Entheromorpha intestinalis, Ceramium* sp*., Neosiphonia apiculata, Chaetomorpha crassa, Hypnea* sp*.,* and *Gracilaria* sp. Epiphyte affected the quality of carrageenan, where healthy seaweed had higher carrageenan quality than infected one.

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