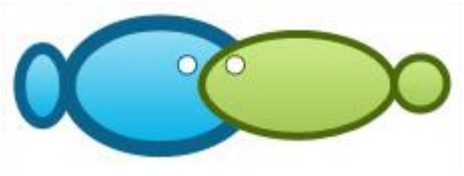

The impact of the transportation of dry systems on the growth and carrageenan content of seaweed (*Kappaphycus alvarezii*) in Batu Bao Water, Kupang District, East Nusa Tenggara, Indonesia

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Abstract. The current article refers to seaweed transportation techniques only using plastic bags and therefore being a suitable solution for archipelago areas such as East Nusa Tenggara Province. The research, dating from 2017, aimed to determine how the transportation duration influenced the variability of the mass, nutrient and carrageen content of *Kappaphycus alvarezii*, corresponding to different transportation durations, at Batu Bao Waters, Tesabela village, Kupang regency. The results were analyzed using the ANOVA statistical method. The average growth of *K. alvarezii* which was cultivated for 45 days in the waters of Batu Bao using seedlings with 6-36 hours of transportation time. The highest carrageenan content (47.17%) was produced at 6 hours transportation and the lowest result (5.02%) was found at a transportation of 36 hours. Likewise, the highest growth during a 6 hours transportation time was 627±14.03 g and the lowest growth was recorded after 36 hours of transportation, namely 95±2.17g. The highest ash content was measured for a 6 hours duration and the lowest for 36 hours of transport time.
Key Words: nutrient content, ash content, dry system, resistance, plastic sac.

Introduction. Seaweeds are plant species growing in coastal waters which not only support the ecosystem of coastal life, but also generate benefits for the community, providing occupational opportunities which come with their significant economic value. One type of red seaweed is *Kappaphycus alvarezii*, a carrageenan-producing seaweed with a large potential for cultivation development. *K. alavarezii* plays an important role, since the carrageenan extract is an international trade commodity. Carrageenan levels in each *Eucheuma* species range between 54% and 73%, depending on the seedlings condition, type and cultures location (Syamsuar 2006). Carrageenan is used as a raw material for the pharmaceutical, cosmetics, food industry and other industries (Mubarak et al 1990).

East Nusa Tenggara Province is an archipelago of 1,192 islands (Industry and Trade Service 2015). Seeds are moved from one area to another and the long transportation duration has an impact on the plant biological processes. To keep seaweed fresh, certain treatments are needed. The transport of seeds from the source location to the cultivation location can be carried out by packing. Seaweed seeds are disposed in plastic bags with a dry system. In order to avoid seeds damaging, they should not be compacted. The top of the filled plastic sack is tied. Finally, the seeds are ready to be transported by land. There are still many obstacles and challenges related to the seaweed cultivation in the archipelago, especially regarding the low productivity of the nurseries and the low yield of carrageenan resulting from the seaweed processing. Productivity of seaweed cultivation requires good and quality seeds. The various conditions of the island region will affect the quality of seaweed

seeds, their impact on growth, nutrient content and carrageenan content (Putra et al 2015).

The current study was intended to optimize the seaweed seeds transportation by making it safer, cheaper and easier, through a dry system realized by adjusting the temperature of the transport medium to the environmental conditions, in order to be able to reach remote locations. The purpose of this study was to increase the resistance of the seaweed delivered from one area to another, in such a way that the seaweed productivity, mass growth, nutrient content and carrageenan content will be improved, in order to facilitate the government program for seaweed distribution by shipping to the cultures locations.

Material and Method

Description of the study sites. This research was carried out in March-May 2017. The study consisted of two phases: the field research continued with the laboratory analysis. The field research was carried out in Batu Bao waters, Tesabele Village, West Kupang Regency. The tools used in this study are scales, white plastic sacks, para-para, rope, thermometer, stop watch, bucket, knife. The method of seaweed cultivation used is the long line method, with a rope length of 50 m and 3 stretches. The distance between the stretch of 1 m. The plant spacing applied was 15 cm, with a seedling initial weight of 50 g. The type of seaweed plant is *K. alvarezii* which is obtained from the community cultures around the waters of the village of Onansila, Semau Island, Kupang Regency. The distance from Onansila to Batu Boa, Tesabela is around 50 km, 5-8 hours by ferry (Figure 1).

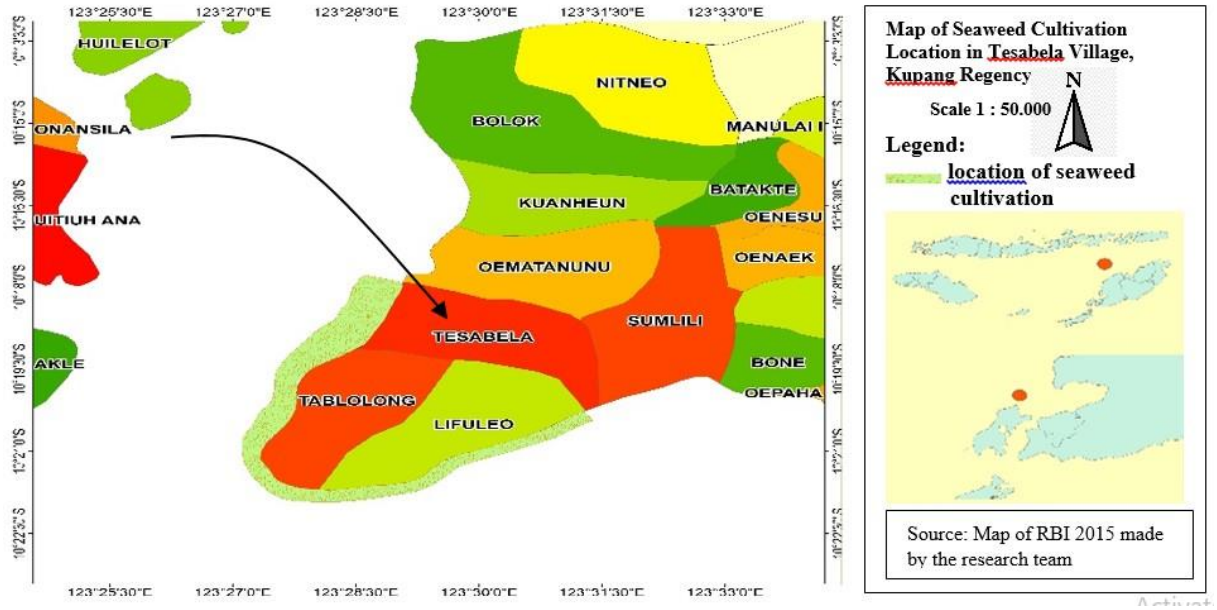

Figure 1. From Onansila Water Semau Island to Tesabela Village.

Seaweed monitoring and observations. The number of stretches observed was 3. Every 7 days a random sample was taken for a proximate analysis (water, protein, carbohydrate, fiber, and ash content), so that the planting period of 45 days was divided into 6, 12, 18, 24, 30 and 36 hours. Every 6 hours a plastic sac was opened, the seaweed seedling were observed and measured, and then the seeds were tied and planted at the cultivation site.

Statistical analysis. This research was based on descriptive and quantitative analysis methods used to determine growth, carrageenan content, water and ash (Table 1). Data resulting from observations of *K. alvarezii* seaweed transport method with dry systems in Batubao waters, Tesabela Village, Kupang Regency are shown in Table 1 and Figure 2

Table 1
Data from observations of the survival rate of seaweed seeds *Kappaphycus alvarezii* with dry system transportation

No	Number of sacks	Opened in hours						Seed condition	7 days after planting
		6	12	18	24	30	36		
1	1 sack	xx						Fresh	Survive
2	1 sack		xx					Fresh	Survive
3	1 sack			xx				Fresh	Survive
4	1 sack				xx			Fresh	Survive
5	1 sack					xx		Less fresh	Some were dying
6	1 sack						xx	Not fresh	Some were dying

Figure 2. Seaweed transportation material (original).

Results. Based on the data in Table 1 above, it can be seen that between 6 and 30 hours of transporting dried dry seaweed seedlings, all the seeds (plants) look fresh, due to the basic principle of packing and transporting dry seaweed systems in order to reduce the temperature of the living media of the commodity during the transport process, because a low temperature will reduce the metabolic process in the commodity being transported. Dry system transportation, in general, uses the principle of hibernation which suppresses the metabolism of organisms in minimum environmental conditions so that the organism is able to survive (Ikasari et al 2008). Thus, the energy owned is not much drained and will be used to maintain the survival of the commodity for longer. In addition, seaweed is resistant to heat and not easily biodegradable (Hughes et al 2013).

Conversely, in the 4 sacks that were opened after 30 and 36 hours, it appeared that the plants were not fresh anymore, moreover 50-80% of the plants showed wilt and many died. This happened because at the time the four sacks were opened, the entire seaweed in the sack was white and soft and felt a little warmer. In addition to visual observation, monitoring was carried out on plants after two days of planting. In the sacks that are opened between 6 and 24 hours of life, plants remain alive and show development, whereas in the sacks opened between 30 and 36 hours all died. Observations reveal that if a relocated plant can resist two days, the plant can grow and develop. Conversely, if the plant is not healthy and if it doesn't recover in the first two days, it will die. The values of growth, moisture content, ash content and *K. alvarezii* carrageenan levels recorded during the study are presented in Table 2 and the process stages are illustrated in Figure 3.

Figure 3: Cultivation of *Kappaphycus alvarezii* at Batu Bao Water (original).

Table 2

Specific growth rate (SGR), growth, moisture, ash and carrageenan of *Kappaphycus alvarezii*

Parameter	*6 hours*	*12 hours*	*18 hours*	*24 hours*	*30 hours*	*36 hours*
SGR (% day^{-1})	4.03±0.06	3.60±0.12	3.01±0.04	2.97±0.07	1.07±0.16	0.57±0.08
Growth (g)	627±14.03	613±14.02	606±13.01	456±14.11	105±4.03	95±2.17
Moisture (%)	10.53±0.15	10.97±0.13	11.07±0.13	11.97±0.13	14.08±0.13	15.10±0.13
Ash (%)	25.16±0.21	24.97±0.13	20.35±0.13	18.81±0.13	12.14±0.13	10.97±0.04
Carrageen (%)	47.17	47.03	40.14	36.12	9.17	5.02

The data shows that for a transportation with a dry system with a 6-hour-24-hour trip, the seaweed grows well, while with a 30 hours and 36 hours trip the growth decreases. The growth rate of seaweed from transportation results for 6 hours-24 hours is relatively good, from 4.03 to 2.97% day^{-1} and is comparable to the value found by Soegiarto et al (1978), ranging between 2 and 3% day^{-1}. According to Atmadja et al (1996), freshness factor of seed and the brightness of the waters support the growth of seaweed at a minimum of 1.5-2.5 m. Because of the fact that the sunlight reaches in the waters up to 2-5 m, it can be optimal to light the bottom of the waters, being needed to help the process of photosynthesis for growth (Mahrus et al 2015). The photosynthesis process reaches its optimal pace and its outcomes support the plant growth. In addition, seed selection factors also play a role in the success of a cultivation process. Aditya & Ruslan (2003) explained that the quality of seaweed seeds greatly determines growth, productivity, product quality and resistance to ice-ice.

Discussion. Moisture and ash content are important components related to the quality of seaweed. Therefore testing the water content in foodstuffs is needed to protect food from damage. According to Wenno et al (2012), the water content in carrageenan is very influential on the age and seed used. According to FAO (2014), the moisture content meets the quality standards for commercial carrageenan, with a maximum limit of 12%. The results of this study are in line with Anwar et al (2013), who stated that carrageenan water content is determined by the alkaline atmosphere of KOH solution which is able to inhibit the water increase in the carrageenan molecule. Increasing KOH concentration can also reduce the mineral salts concentration. Desiana & Hendrawati (2015) also reported that with increasing KOH concentrations, the water content decreased, depending on the seeds which were used. When the seed treatment is 30 hours-36 hours there is excess moisture content of 2.08-3.10%, compared to the reference value required by FMC Corp, since the seeds are not viable anymore. Results of the current study correlate a lower water content, with a higher carrageenan ash content), as shown in Table 2, which is in line with the study of Prasetyowati et al 2008 on *Eucheuma cottonii* seaweed. Not only the seedling is still healthy and fresh for a treatment of 6-24 hours, while for the 30 hours and 36 hours treatments it is dead, but it is suspected that 6-24 hours treated seeds are able to better react with potassium hydroxide solution (KOH). The K^+ cation element reacts with carrageenan to produce high ash content and the absorption of the K^+ cation by the young thallus. As stated by Basmal et al (2005), the increase of the ash level is due to the number of K^+ cations that react with more carrageenan. Suryaningrum et al (1991) stated that the levels of carrageenan ash are influenced by the quantity of salts and minerals, such as K, Mg, Ca, Na, and by the quantity of sugars, like the ammonium galactose and 3.6-anhydrogalactose, contained by the plant. According to the commercial carrageenan standard, establishing the range of the ash content at 15-40% on a dry weight basis, the carrageenan produced in the current study, especially by using seeds resulted from the 6 hours-24 hours treatment, meets the quality requirements. The use of fresh and supple seedlings influenced the seeds quality, determining the measured carrageenan content variability. Meristem is very important in plant growth and development, as suggested by the study of Oedjoe et al (2019), which states that the tallus growth of is influenced by the meristem tissue that contains undifferentiated cells capable of cell division. The 6 hours-24 hours treatment result is higher than the

content value obtained by Syahlun et al (2013) as the highest carrageenan levels in seaweed (44.07%). The differences in carrageenan levels are thought to be influenced by maintenance time, seaweed seeds used, extraction methods and extraction raw materials. Freile-Pelegrin (2006) identified among the factors that can affect the quality of carrageenan: the condition of seeds; the foreign objects; the season, light, nutrients, temperature and the salinity, that can reduce the quality of seaweed. Susanto (2003) suggested that the type and quality of carrageenan originating from aquaculture depends on varieties, but also on the age of plants, rays, nutrients, temperature and salinity. Lestari et al (2015) considered that carrageenan levels depend on the planting and maintenance period, which is about 45-60 days, and Hayashi et al (2007) stated that the best carrageenan conditions can be achieved if seaweed is cultivated for 45 days.

Conclusions. The results of the current research demonstrated that a dry transportation system of *K. alvarezii* between the culture locations can be a successful solution for seaweed farmers who experience a shortage of seaweed seeds in the archipelago. There was a relationship between transportation time and growth, carrageenan content and nutrient content. The highest carrageenan content (47.17%) was produced at 6 hours transportation and the lowest result (5.02%) was found at a transportation of 36 hours. Likewise, the highest growth during a 6 hours transportation time was 627±14.03 g and the lowest growth was recorded after 36 hours of transportation, namely 95±2.17g. The highest ash content was measured for a 6 hours duration and the lowest for 36 hours of transport time.

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