

**GROWTH PERFORMANCE AND CARRAGEENAN YIELD OF *KAPPAPHYCUS ALVAREZII* (DOTY) AND *EUCHEUMA DENTICULATUM* (BURMAN) COLLINS ET HARVEY, FARMED IN BAIS BAY, NEGROS ORIENTAL AND OLINGAN, DIPOLOG CITY**

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### **Abstract**

*This study aims to determine the growth performance and carrageenan contents of the different strains of *Eucheuma* and *Kappaphycus* cultured at different depths. Thirty 50-g seedlings of each of the brown and green cultivars of *Eucheuma denticulatum* (Collins & Harvey) and *Kappaphycus alvarezii* (Doty) were cultured at different depths. Growth rates and carrageenan contents varied between species, strains and depth. The brown variety of *K. alvarezii* cultured near the water surface showed a significantly higher mean growth rate and carrageenan content. Generally, plants with higher growth rates have higher carrageenan yield.*

**Keywords:** *carrageenan content, *Eucheuma denticulatum*, *Kappaphycus alvarezii*, carrageenan yield, growth performance*

### **Introduction**

*Eucheuma denticulatum* (Collins & Hervey) and *Kappaphycus alvarezii* (Doty) have been cultivated in the Philippines since 1969-70 for carrageenan (Lim & Porse, 1981). Carrageenan exists in three main forms: kappa- carrageenan ( $\kappa$ ), iota-carrageenan ( $\iota$ ) and lambda-carrageenan ( $\lambda$ ). Different carrageenan types differ in composition and conformation, resulting in a wide range of rheological and functional properties. Kappa-carrageenan is predominantly extracted from *Kappaphycus* while iota-carrageenan from *Eucheuma*. Carrageenans are used in a variety of commercial applications as gelling, thickening, and stabilizing agents, especially in food products such as frozen desserts, chocolate milk, cottage cheese, whipped cream, instant products, yogurt, jellies, pet foods, and sauces. Aside from these functions, carrageenans are used in pharmaceutical formulations, cosmetics, and industrial applications such as mining. Carrageenan is extracted from this seaweed in two ways. Traditionally, the seaweed is made into an aqueous solution, and the residue is filtered, leaving nearly pure carrageenan. The alkaline-modified method is less expensive and easier. The seaweed is mixed in an alkali

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solution, leaving a mixture of carrageenan and cellulose that can be sold as semi-refined carrageenan.

This study investigated the growth performance and carrageenan contents of the different strains of *Eucheuma* and *Kappaphycus* cultured at different depths.

### Research Method and Design

**Study Sites.** Two experimental set-ups were established: in Bais Bay (N 9° 35.966'; E 123° 9.032') on April 22, 2005 to June 3, 2005 and in Dipolog City (N 9° 35.966'; E 123) on April 29, 2005 to May 28, 2005.

**Experimental Set-up.** The brown and green cultivars of *Eucheuma denticulatum* (Collins & Hervey) and *Kappaphycus alvarezii* (Doty) were used in the Bais set-up while the giant brown variety of *Kappaphycus alvarezii* (Doty) was used in Dipolog (Fig.1).

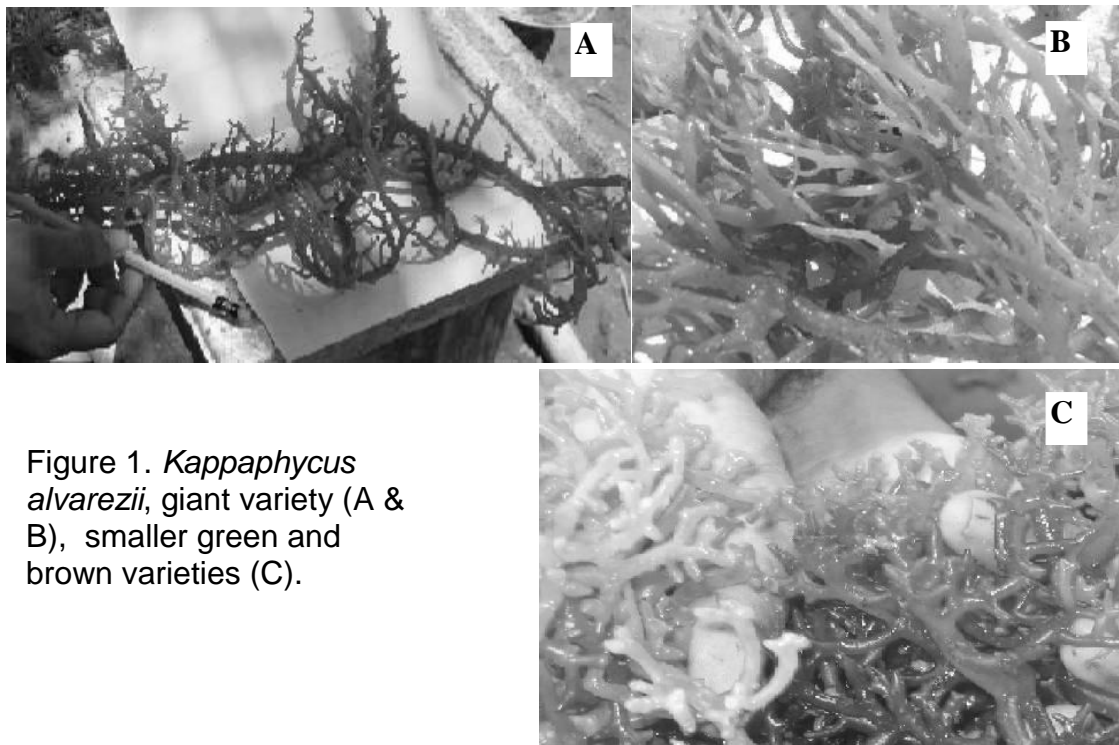
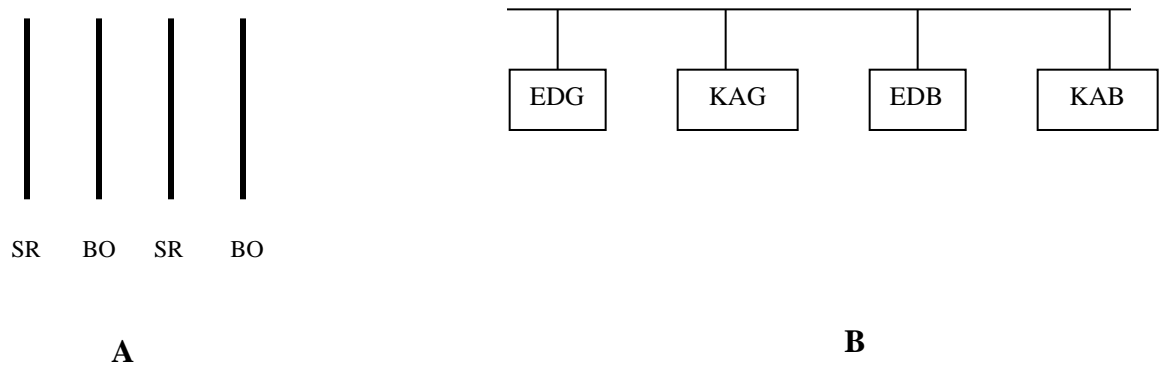


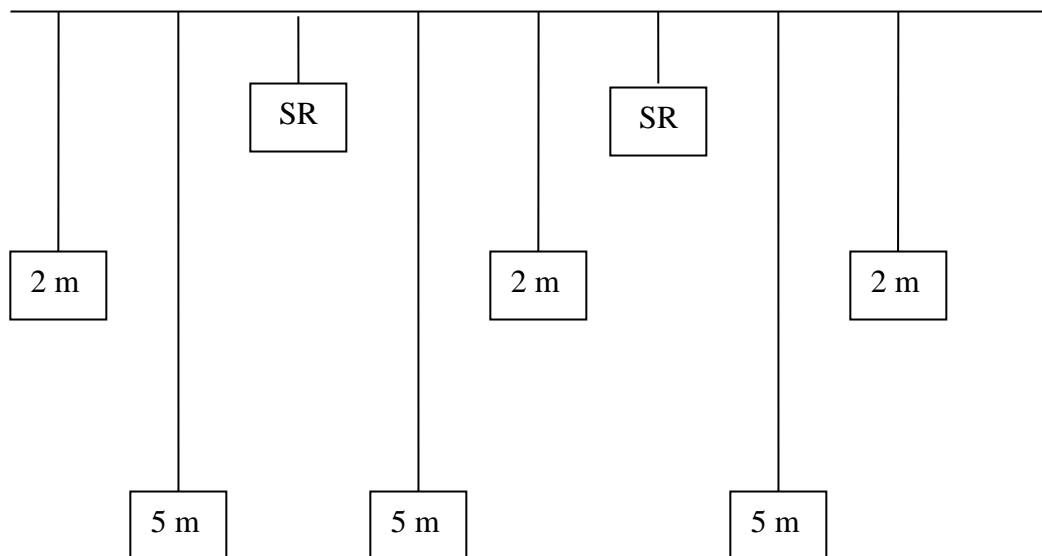
Figure 1. *Kappaphycus alvarezii*, giant variety (A & B), smaller green and brown varieties (C).

Thirty 50-g seedlings of each of the brown and green cultivars of *Eucheuma denticulatum* (Collins & Hervey) and *Kappaphycus alvarezii* (Doty) were tied randomly on a strings at 30 cm apart and cultured at two different depths: near water surface (floating method) and 2 meters below or bottom (monoline method) (Fig. 2 & 4). In Dipolog, the seedlings

were tide randomly on the string in three different lengths - 5m, 2m and surface (6 cm) at one meter apart (Figure 3). Wet weights were measured in 15 seedlings for each treatment randomly every two weeks. Final wet weights were taken during harvest and samples were dried until constant dry weight. Dried samples were used for extracting carrageenan. Carrageenan extraction was done using a modified protocol of Hurtado, Ponce & Umeski (1988), whereas, growth rates were determined following the formula from Dawes, Trono and Lluisma (1993).



**Figure 2.** Experimental Design in Bais Bay. A. Depth: SR – surface; BO – bottom (2 m). B. Cultivar: EDG - *Eucheuma denticulatum*, green; EDB - *E. denticulatum*, brown; KAG - *Kappaphycus alvarezii*, green; KAB – *K. alvarezii*, brown.



**Figure 3.** Experimental Design in Olingan, Dipolog City. SR – surface.



## Results and Discussion

**Carrageenan contents.** Carrageenan content varied between strain, species and depth. In Bais Bay, *Kappaphycus alvarezii* brown strain cultured at the surface has the highest (81.74 %) carrageenan content (Table 1). Generally, *K. alvarezii* has higher carrageenan content compared to *Euचेuma denticulatum* (Tables 1 & 2).

One-way analysis of variance revealed a significant difference between and within species [(F (7,16) = 10.586, p = 0.000)]. Post hoc comparisons using Tukey HSD test indicated the significant difference between and within group of species as drawn in table below :

Ka.Br.Sr = *K. alvarezii* brown surface ; Ka.Br.Btm = *K. alvarezii* brown bottom  
 Ka.Gr.Sr = *K. alvarezii* green surface ; Ka.Gr.Btm = *K. alvarezii* green bottom  
 Ed.Br.Sr = *E. denticulatum* brown surface ; Ed.Br.Btm = *E. denticulatum* brown bottom  
 Ed.Gr.Sr = *E. denticulatum* green surface ; Ed.Gr.Btm = *E. denticulatum* green bottom

In the case of *Euचेuma denticulatum*, the brown strain farmed at the surface waters has the highest carrageenan content ( mean =72.40 %), while the green strain grown in the bottom has the lowest carrageenan (mean= 63.79%).

**Table 1.** Mean carrageenan content in percent (%) of different strains of *Kappaphycus alvarezii* cultured at two different depths in Okiot, Bais Bay

No.	Species	(Mean ±)
1.	<i>K. alvarezii</i> brown surface (Ka.Br.Sr)	81.74 ± 4.15
2.	<i>K. alvarezii</i> brown bottom (Ka.Br.Btm)	77.51 ± 2.67
3.	<i>K. alvarezii</i> green surface (Ka.Gr.Sr)	78.34 ± 1.08
4.	<i>K. alvarezii</i> green bottom (Ka.Gr.Btm)	77.83 ± 3.62
	Average %	78.86%

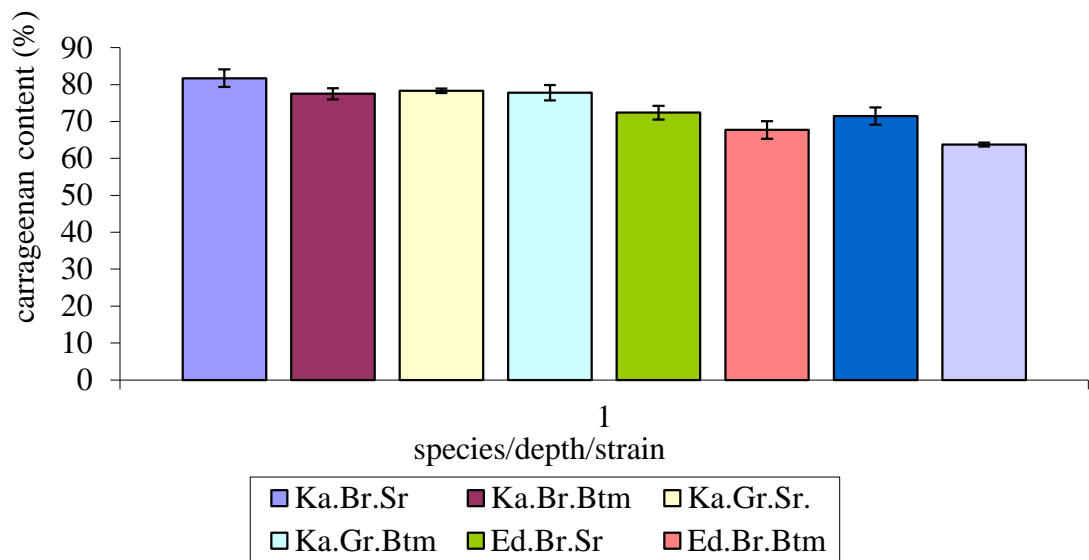
**Table 2.** Mean carrageenan content in percent (%) of different strains of *Euचेuma denticulatum* cultured at two different depths in Okiot, Bais Bay

No.	Species	(Mean ±)
1.	<i>E. denticulatum</i> brown surface (Ed.Br.Sr)	72.40 ± 3.23
2.	<i>E. denticulatum</i> brown bottom (Ed.Br.Btm)	67.71 ± 4.16
3.	<i>E. denticulatum</i> green surface (Ed.Gr.Sr)	71.49 ± 4.05
4.	<i>E. denticulatum</i> green bottom (Ed.Gr.Btm)	63.79 ± 0.89
	Average %	68.84%

In terms of species, *K. alvarezii* has a significantly higher mean than *E. denticulatum* [(F (1,6) = 20.748, p = 0.004)]. In terms of strain, there is no significant difference between brown strain and green strain, even brown strain has a higher mean (74.84 % ± 6.10) than green one (72.86 % ± 6.80), which means carrageenan content does not vary with strain. But there is significant difference between depth [(F (1,6) = 0.993, p = 0.357)]. Algae at the surface area has a higher mean (75.99 ± 4.89) than those at the bottom area (71.71 ± 7.07). Thus, carrageenan content decreased with decreasing depth (Fig. 6).

One-way analysis of variance revealed a significant difference between and within species [(F (2,6) = 0.687, p = 0.539)]. But post hoc comparisons using Tukey HSD test indicated there is no significant difference between and within group of species. Algae cultured at the surface area has a higher mean (72.50 ± 4.65) than 2 m (71.45 ± 5.93) and 5 m (67.56 ± 5.67). Hence, regardless of species, algae farmed at the surface area have higher carrageenan contents.

This result is higher than the results obtained from previous studies. Istini *et al* (1994) found 20.60 to 34.05% for *Eucheuma spinosum* and 21.80 to 35.47% for *Kappaphycus alvarezii*. While Gerung *et al* (1998) found 38.5% for *E. denticulatum* and 32.6% for *K. striatum*. Those differences cause by different method that used for those carrageenan extraction.



**Figure 5.** Mean Carrageenan content of different strains of *K. alvarezii* and *E. denticulatum* at different depth and in Bais bay.



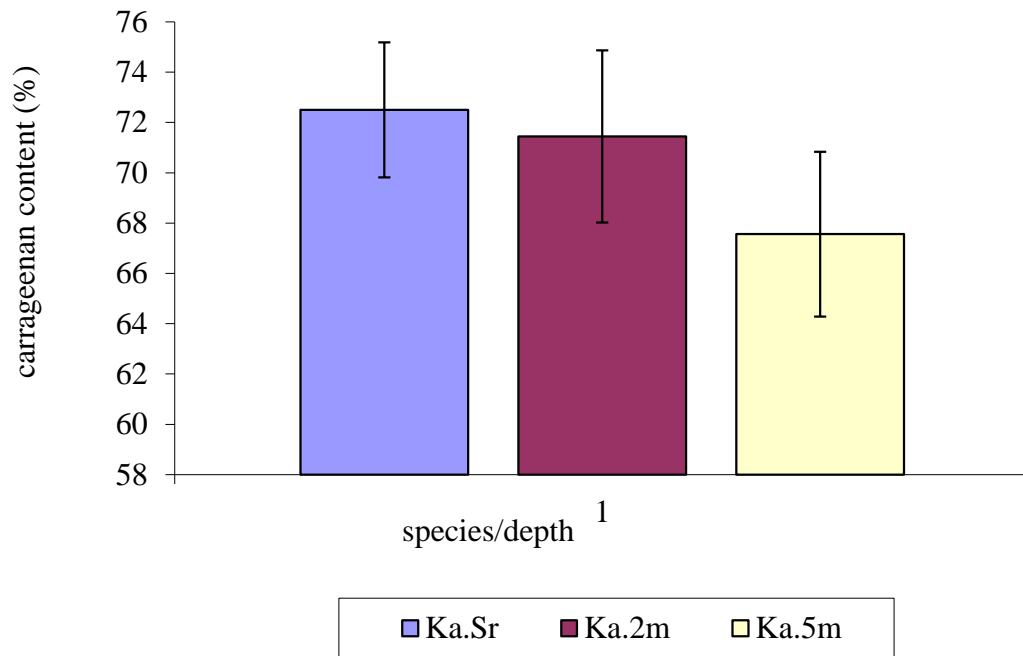
**Table 3.** Significant difference of carrageenan contents between and within group of species using Tukey HSD

No.	Species	Significant difference with :
1.	<i>K. alvarezii</i> brown surface	- <i>E. denticulatum</i> brown surface* - <i>E. denticulatum</i> brown bottom* - <i>E. denticulatum</i> green surface* - <i>E. denticulatum</i> green bottom*
2.	<i>K. alvarezii</i> brown bottom	- <i>E. denticulatum</i> brown bottom* - <i>E. denticulatum</i> green bottom*
3.	<i>K. alvarezii</i> green surface	- <i>E. denticulatum</i> brown bottom* - <i>E. denticulatum</i> green bottom*
4.	<i>K. alvarezii</i> green bottom	- <i>E. denticulatum</i> brown bottom* - <i>E. denticulatum</i> green bottom*
5.	<i>E. denticulatum</i> brown surface	- <i>K. alvarezii</i> brown surface*
6.	<i>E. denticulatum</i> brown bottom	- <i>K. alvarezii</i> brown surface* - <i>K. alvarezii</i> brown bottom* - <i>K. alvarezii</i> green surface* - <i>K. alvarezii</i> green bottom*
7.	<i>E. denticulatum</i> green surface	- <i>K. alvarezii</i> brown surface*
8.	<i>E. denticulatum</i> green bottom	- <i>K. alvarezii</i> brown surface* - <i>K. alvarezii</i> brown bottom* - <i>K. alvarezii</i> green surface* - <i>K. alvarezii</i> green bottom*

**Table 4.** Mean of carrageenan contents in percent (%) of *Kappaphycus alvarezii* different depth farmed in Olingan

No.	Species	(Mean $\pm$ )
1.	<i>K. alvarezii</i> in surface	72.50 $\pm$ 4.65
2.	<i>K. alvarezii</i> in 2 m	71.45 $\pm$ 5.93
3.	<i>K. alvarezii</i> in 5 m	67.56 $\pm$ 5.67

The quality and yield of phycocolloids from seaweeds are influenced by biological and environmental factors (Santos, 1980). Zertuche-Gonzales et al (1993), found that the best carrageenan yields happened in summer, meaning there is influence of light to carrageenan yield. This study found that alga grown at the surface area has the highest carrageenan content than in the middle and bottom. Algae which get more light intensity (in certain limit) has high rate of photosynthesis and in turn high carrageenan content, although other factors are also important like temperature, nutrients and current. Several studies have demonstrated the influence of nutrients, temperature, and light on carrageenan from several species (DeBoer, 1978; DeBoer et al., 1976; Dawes et al., 1974; Ekman & Pedersen, 1990; Chopin et al., 1990).



Ka.Sr = *K. alvarezii* in surface      Ka.2m = *K. alvarezii* in 2 m depth      Ka.5m = *K. alvarezii* in 5 m depth

**Figure 6.** Carrageenan contents of *K. alvarezii* from Olingan - Dipolog City.

This study also proved that carrageenan contents vary between species. In this study, *Kappaphycus alvarezii* has a more high carrageenan contents than *Eucheuma denticulatum*.

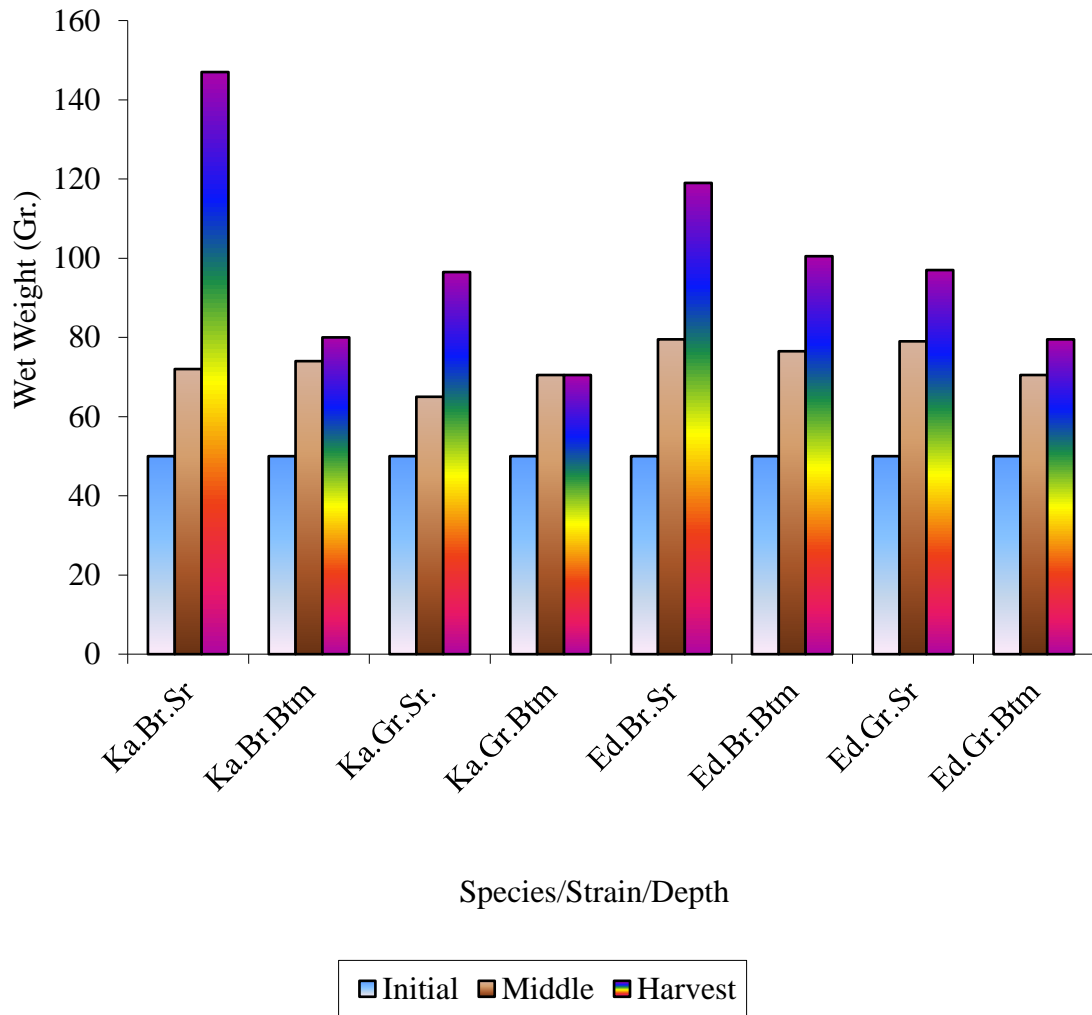
**Growth Rates.** Growth rates varied between strain, species, depth, and also between different farming site. In Bais Bay, *Kappaphycus alvarezii* brown strain surface has a higher growth (wet weight). It has increased 22 grams in 14 days and 75 grams in 25 days, followed by *Eucheuma denticulatum* brown strain surface, it has increased 29.5 grams in 14 days and 39.5 grams in 25 days.

One-way analysis of variance revealed a significant difference between and within species [(F (7,72) = 7.782, p = 0.000)]. Post hoc comparisons using Tukey HSD test indicated the significant difference between and within group of species as shown in Table 5.

In terms of group of species, *E. denticulatum* has a higher mean (49.00 ± 34.16) than *K. alvarezii* (48.50 ± 37.08) but there is no significant difference (table 6). In terms of strain, revealed a significant difference between brown and green strain between species. Brown strain has a highest mean than green one (Table 6). in terms of depth, the



plants that growth in surface area has a highest mean than in bottom, for both, within and between species (table 6).



**Figure 4.** Growth (wet weight) of *K. alvarezii* and *E. denticulatum* in Bais Bay

In terms of growth rates (%), only *Kappaphycus alvarezii* brown surface showed positive rates. It has 2.607 % in 14 days than reached 2.854% in next 25 days. In the first 14 days cultured, *E. denticulatum* brown surface has a higher rates (3.312%), followed by *E. denticulatum* green surface (3.264%), while *K. alvarezii* green surface has a smallest one (1.874%). After 25 days, *K. alvarezii* brown surface has a higher rate (2.854%), while the others have smallest rates, even *K. alvarezii* green strain bottom did not show any growth (Fig. 5).



**Table 5.** Significant difference of growth (wet weight) between and within group of species in Bais bays using Tukey HSD

No.	Species	Significant difference with :
1.	<i>K. alvarezii</i> brown surface	- <i>K. alvarezii</i> brown bottom* - <i>K. alvarezii</i> green surface* - <i>K. alvarezii</i> green bottom* - <i>E. denticulatum</i> brown bottom* - <i>E. denticulatum</i> green surface* - <i>E. denticulatum</i> green bottom*
2.	<i>K. alvarezii</i> brown bottom	- <i>K. alvarezii</i> brown surface*
3.	<i>K. alvarezii</i> green surface	- <i>K. alvarezii</i> brown surface*
4.	<i>K. alvarezii</i> green bottom	- <i>K. alvarezii</i> brown surface * - <i>E. denticulatum</i> brown surface*
5.	<i>E. denticulatum</i> brown surface	- <i>K. alvarezii</i> green bottom*
6.	<i>E. denticulatum</i> brown bottom	- <i>K. alvarezii</i> brown surface
7.	<i>E. denticulatum</i> green surface	- <i>K. alvarezii</i> brown surface*
8.	<i>E. denticulatum</i> green bottom	- <i>K. alvarezii</i> brown surface* - <i>E. denticulatum</i> brown surface*

In case of Olingan – Dipolog City, *Kappaphycus alvarezii* brown strain surface has a higher growth (wet weight). It has increased 128.9355 grams in 30 days, followed by *Kappaphycus alvarezii* brown strain 2 meters (84 grams in 30 days), and *Kappaphycus alvarezii* brown strain 5 meters (74.4 grams in 30 days) (Fig. 6)

**Table 6.** T- test of growth (wet weight) between and within group of species

No.	Species/strain/depth	Mean	F	Sig.
1.	<i>K. alvarezii</i> <i>E. denticulatum</i>	48.50 ± 37.08 49.00 ± 34.16	1.406	.239
2.	<i>K. alvarezii</i> brown <i>K. alvarezii</i> green	63.50 ± 43.65 33.50 ± 21.03	7.825*	.008
3.	<i>E. denticulatum</i> brown <i>E. denticulatum</i> green	59.75 ± 38.30 38.25 ± 26.17	1.326	.257
4.	Brown species Green species	61.62 ± 40.58 35.87 ± 23.56	7.774*	.007
5.	<i>K. alvarezii</i> surface <i>K. alvarezii</i> bottom	71.75 ± 39.11 25.25 ± 12.40	11.877*	.001
6.	<i>E. denticulatum</i> surface <i>E. denticulatum</i> bottom	58.00 ± 44.23 40.00 ± 16.38	10.035*	.003
7.	Planted in surface Planted in bottom	64.87 ± 41.79 32.62 ± 16.17	24.366*	.000

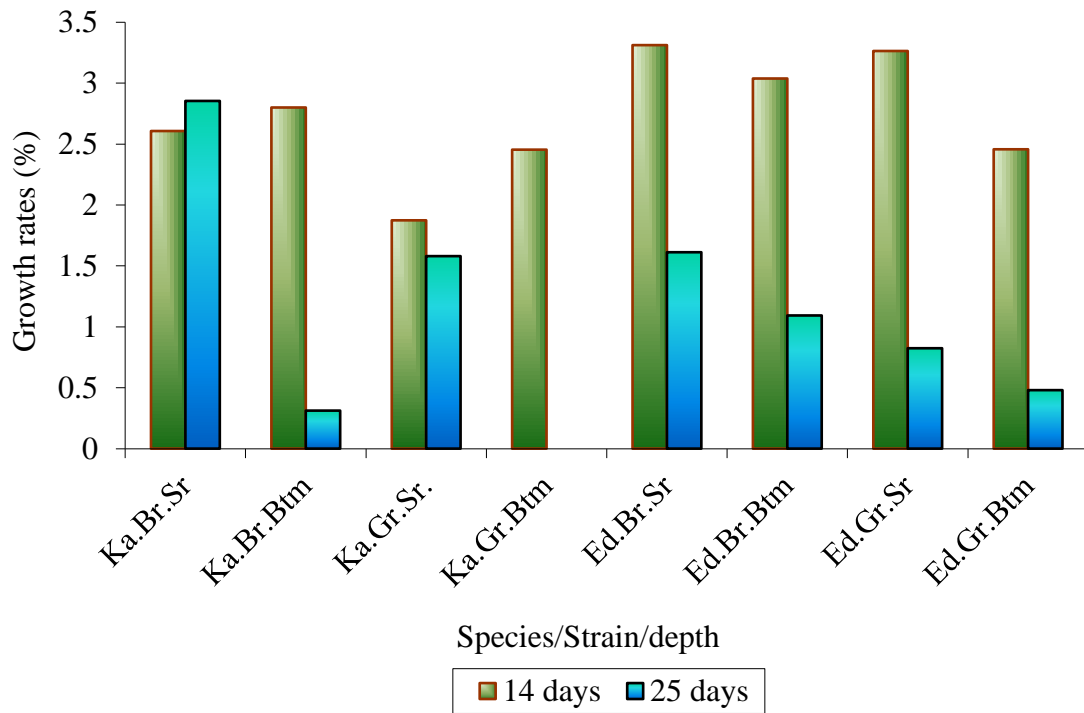
\* = significant difference



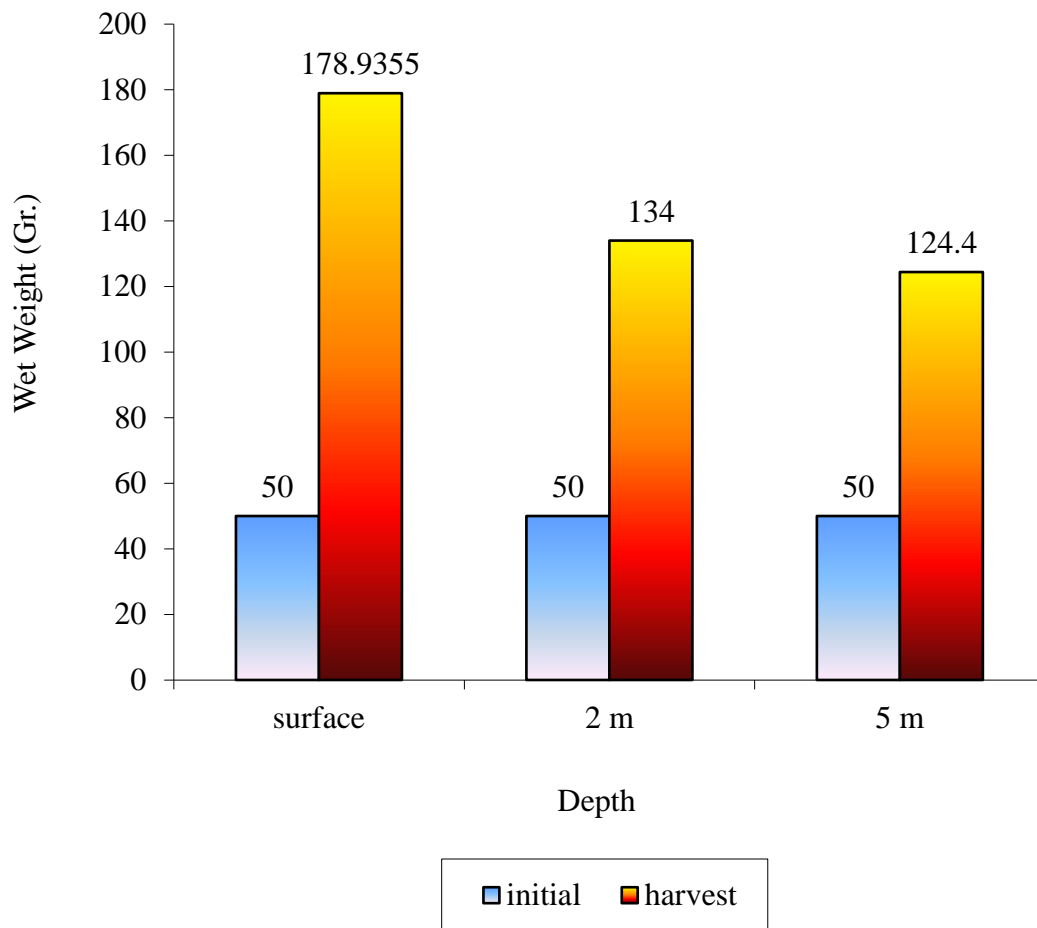
One-way analysis of variance revealed a significant difference between and within group of species [(F (2,84) = 9.146, p = 0.000)]. Algae farmed at the surface area has the highest mean growth. Post hoc comparisons using Tukey HSD test indicated the significant difference between and within group of species as drawn in Table 7.

In terms of growth rates (% per day), *Kappaphycus alvarezii* brown surface has a highest, its 4.25% per day, while *K. alvarezii* brown 2 meters has 3.27% per day, and *K. alvarezii* brown 5 meters 3.04% per day (Fig. 7).

As observed in Fig. 6 & 7, growth rates tend to decrease with decreasing depth. Cultivar at the surface area has higher growth rate than the others. This fact indicates that nutrients, light and water movement (current) have positive effect to growth rates. At the surface area, the alga will get more light for photosynthesis. *Kappaphycus* and *Eucheuma* favor strong water current.



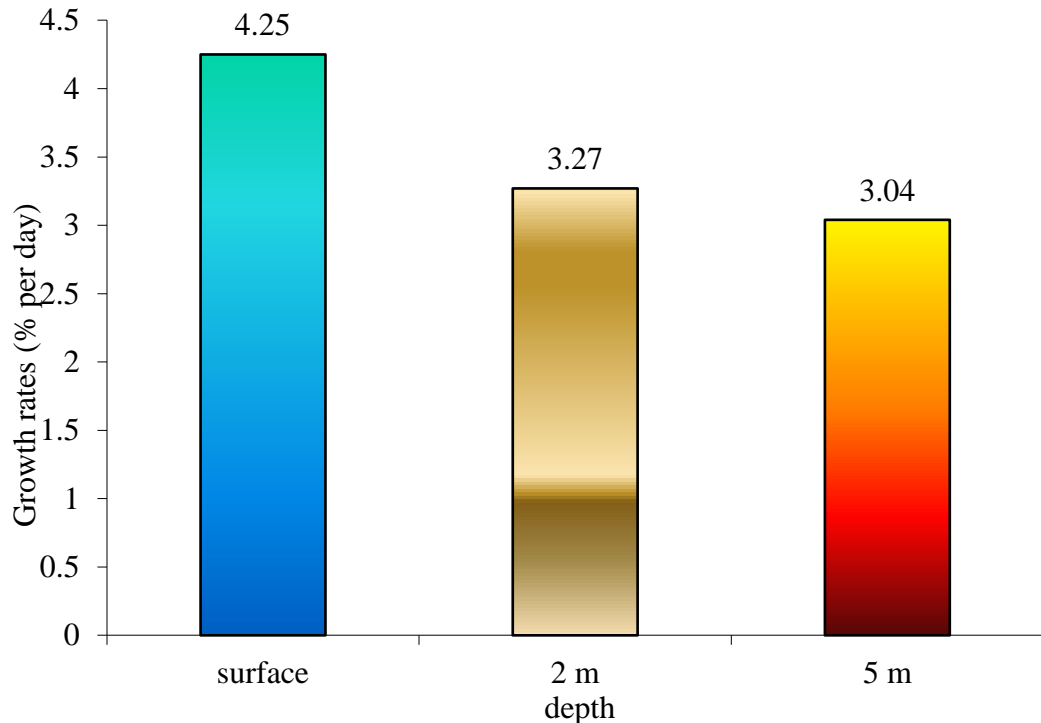
**Figure 5.** Growth rates (% per day) of *Kappaphycus alvarezii* and *Eucheuma denticulatum* in Bais Bay



**Figure 6.** Growth (wet weight) of *Kappaphycus alvarezii* in different depth farmed in Olingan – Dipolog City

**Table 7.** Significant difference of growth (wet weight) between and within group of species in Olingan, Dipolog City using Tukey HSD

No.	Species/depth	Significant difference with :
1.	<i>K. alvarezii</i> surface	- <i>K. alvarezii</i> 2 m* - <i>K. alvarezii</i> 5 m*
2.	<i>K. alvarezii</i> 2 m	- <i>K. alvarezii</i> surface*
3.	<i>K. alvarezii</i> 5 m	- <i>K. alvarezii</i> surface*



**Figure 7.** Growth rates (% per day) of *Kappaphycus alvarezii* brown strain in Olingan, Dipolog City

### Conclusion

Algae cultured at the seawater surface tend to have higher carrageenan contents than the one in bottom area. Carrageenan content decreases with decreasing depth. *Kappaphycus alvarezii* is likely to have higher carrageenan content than *Euचेuma denticulatum*. In terms of growth, the brown strain tends to have higher growth rates than the green ones. Best growth conditions coincide with best carrageenan yield.

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