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Utilization of green algae *Caulerpa racemosa* as feed ingredient for tiger shrimp *Penaeus monodon*

Pemanfaatan rumput laut *Caulerpa racemosa* sebagai bahan baku pakan udang windu *Penaeus monodon*

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ABSTRACT

The study aimed to evaluate the utilization of seaweed *Caulerpa racemosa* as feed ingredient for tiger shrimp *Penaeus monodon*. This research consisted of two different stages, i.e. digestibility and growth test. Tiger shrimp with average body weight of 5.70 ± 0.42 g was reared during digestibility test. The measured parameters were total protein, calsium, magnesium, and energy digestibility. The growth test was managed by using a completely randomized design consisted of four different treatments (in triplicates) of dietary *C. racemosa* meal addition levels, i.e. 0 (control), 10, 20, and 30%. Tiger shrimp with an average body weight of 0.36 ± 0.02 g were cultured for 42 days in plastic containers (70×45×40 cm) with a stocking density of 15 shrimp/container. Apparent dry matter, protein, calcium, magnesium, and energy digestibilities of *C. racemosa* were 51.82, 88.67, 68.44, 16.39, 60.30%, respectively. The results presented that the growth performance of tiger shrimp fed with diet containing 10% of *C. racemosa* was not significantly different with the control (P>0.05). However, the growth performance of the shrimp fed with diet containing more than 20% of *C. racemosa* decreased. The enzyme activitity of superoxide dismutase (SOD) increased with the higher level of dietary addition of *C. racemosa*. It can be concluded that *C. racemosa* was possibly applied up to 10% in the feed formulation for tiger shrimp.

Keywords: *Caulerpa racemosa*, *Penaeus monodon*, digestibility, growth performance, shrimp

ABSTRAK

Penelitian ini bertujuan mengevaluasi pemanfaatan rumput laut *Caulerpa racemosa* sebagai bahan baku pakan udang windu *Penaeus monodon*. Penelitian ini dilakukan dengan dua tahap, yaitu uji kecernaan *C. racemosa* dan uji pertumbuhan udang. Udang windu yang digunakan pada uji kecernaan berbobot 5,70 ± 0,42 g. Parameter uji yang diukur meliputi kecernaan total, protein, kalsium, magnesium, dan energi. Uji pertumbuhan dilakukan menggunakan rancangan acak lengkap dengan empat perlakuan dan tiga ulangan, yaitu penggunaan tepung *C. racemosa* sebesar 0 (kontrol), 10, 20, dan 30%. Udang windu dengan bobot 0,36 ± 0,02 g dipelihara dalam wadah kontainer plastik ukuran 70×45×40 cm (volume air sebanyak 90 L) dengan kepadatan 15 ekor tiap wadah selama 42 hari. Hasil penelitian menunjukkan kecernaan total *C. racemosa* pada udang windu 51,82%, kecernaan protein 88,67%, kecernaan kalsium 68,44%, kecernaan magnesium 16,39%, dan kecernaan energi 60,30%. Penelitian tahap kedua pada kinerja pertumbuhan udang yang mengonsumsi pakan mengandung 10% *C. racemosa*, tidak memberikan nilai yang berbeda nyata dengan udang yang mengonsumsi pakan kontrol. Namun, kinerja pertumbuhan udang menurun setelah mengonsumsi pakan yang mengandung *C. racemosa* di atas 20%, sedangkan aktivitas enzim superoxide dismutase (SOD) meningkat. Dari penelitian ini dapat disimpulkan bahwa penambahan *C. racemosa* ke dalam formula pakan sampai 10% dapat digunakan sebagai bahan baku pakan udang windu.

Kata kunci: *Caulerpa racemosa*, *Penaeus monodon*, kecernaan, kinerja pertumbuhan, udang

INTRODUCTION

For many years, the main source of vegetable protein for shrimp feed was obtained from terrestrial plant, such as soybean meal (Cruz-Suarez *et al.*, 2009; Suárez *et al.*, 2009; Derby *et al.*, 2016; Sharawy *et al.*, 2016; Xie *et al.*, 2016), lupin meal (Draganovic *et al.,* 2014), garden pea *Pisum sativum,* concentrated rice protein (Oujifard *et al.,* 2012; Chen *et al.,* 2017), and canola meal *Brassica* sp. (Kou *et al.,* 2015; Suárez *et al.*, 2009; Singh *et al.,* 2014). The ingredient selection is managed according to the nutrition and the digestibility (Cruz-Suarez *et al.*, 2009; Samuelsen *et al.,* 2014). However, those main sources contend with the livestock needs, thus the sustainability is uncertainty (Dolomatov *et al.,* 2014; Schader *et al.,* 2015). Moreover, the existance of antinutrition, such as phytate acid, tannin, and anti trypsin, causes downturn in nutrition absorption (Zhou *et al.,* 2015; Difo *et al.,* 2015). Therefore, further study about the other source of vegetable protein with low anti nutrition level is necessary.

Caulerpa racemosa is one of the marine algae species which is potentially developed as the shrimp feed ingredient. Paul *et al.* (2013) stated that the application of *Caulerpa racemosa* was able to boost high growth rate (5−7%/day) (Paul *et al*., 2013). *Caulerpa racemosa* has a high nutrient content, i.e. protein 12.88−23.42%, carbohydrate 27.2–48.10%, and fat 0.3–2.64% (Kumar *et al*., 2011; Murugaiyan & Narasimman, 2013). The calcium and magnesium content is higher as well compared to the terrestrial plant (MacArtain *et al*., 2007; Kalaivanan *et al*., 2012; Paul *et al.,* 2013). *Caulerpa* sp. contains calcium and magnesium around 5.97% and 0.4−4.1%, respectively (Santoso *et al*., 2006; Kumar *et al*., 2011; Gaillande *et al*., 2016). According to Matanjun *et al.* (2009), *Caulerpa lentillifera* contains approximately 329.69 mg/100 g of calcium and 271.33 mg/100 g of magnesium. *C. racemosa* has 8.958−11.31 mg/g of carotenoids which also acts as antioxidant, regulates cell growth, modulates gene expression, and induces immunity. Vitamin C (10.10−34.70 mg/100 g of wet weight) and vitamin E (1.1−9.4 mg/100 g of wet weight) in *C. racemosa* are considered as vigorous antioxidant to increase the immunity against disease and oxidative stress (Gaillande *et al*., 2016). In spite of delivering high nutrition, *C. racemosa* also produces secondary metabolite named caulerpin (Felline *et al*., 2012; Nagappan & Vairappan, 2014). The effect of caulerpin towards aquatic species, especially shrimp, has not been reported. Hence, the study was held to evaluate *C. racemosa* as feed ingredient for tiger shrimp *Penaeus monodon.*

MATERIALS AND METHODS

Experiment I: Digestibility test

Experimental feed preparation

C. racemosa was obtained from the coastal area of Kartini Beach, Jepara. *C. racemosa* was dried using an oven in temperature of 60–80°C for 48 hours. The dry weight was used in proximate analysis. It contained 30.03% of protein, 1.76% of crude fat, 3.29% of crude fiber, 22.22% of ash, and 42.70% of nitrogen-free extract (NFE). The commercial feed was used as base feed which is destructed then repelleting. The experimental feed is the combination of base feed and *C. racemosa* meal in ration 7:3 (NRC, 2011). The detail is shown below in Table 1.

Table 1. The composition of experimental feed for digestibility test of *C. racemosa*.

Ingredients (%)	Base feed	Experimental feed
Commercial feed	97.50	67.50
C. racemosa meal	0.00	30.00
Cr_2O_3	0.50	0.50
Carboxymethyl cellulose (CMC)	2.00	2.00
Total	100.00	100.00

Shrimp rearing and feces collection

The shrimp was acclimated in fiber tank for 7 days. The tanks in digestibility test were 6 plastic tank sized in 77×54×45 cm filled with sea water (salinity 25–28 g/L) and equipped with aeration. The average weight of experimental shrimp was 5.73 ± 0.38 g and the stocking density was 12 individuals/tank (29 individuals/m^2). The shrimp was fed 8% of total biomass which adjusted to daily food requirement. The uneaten feed was collected. The feces was also collected three days after the experimental feed administration. The feces collection was conducted 2−3 hours after feeding. The feces was put into a film bottle and stored at -20°C until the amount sufficient for analysis.

Experiment II: Growth test

Experimental feed preparation

The experimental feed was crumble with three different level of *C. racemosa* meal addition (0, 10, 20, and 30%) according to the previous study by Putri *et al*. (2017). The experimental feed contained 42% of protein and 450 kcal/100 g of energy. The formulation and composition of the feed is presented in Table 2.

Shrimp rearing and observation

The shrimp was adapted for 7 days and fed using commercial feed. Before the study was begun, the shrimp was fasted for 24 hours. The rearing container was filled with seawater in salinity of 25−28 g/L and equipped with aerations system. The container was covered using dark tarp to prevent the shrimp escape. As many of 100 individuals were collected to measure initial nutrition content. The average weight was 0.36 ± 0.02 g and the stocking density was 15 individuals/container (48 individuals/m^2). The shrimp was fed three times a day (07.00, 12.00, and 17.00) and reared for 42 days. The amount of the feed was 8% of total biomass and it was adjusted to daily feed consumption. The body weight measurement was managed each two weeks. The uneaten feed and feces were collected using siphon, then water discharged was done approximately 30−50%.

Chemical analysis

The chemical analysis consisted of chromium analysis (feed and feces), proximate analysis (the experimental feed, initial body weight, and final body weight), and also calcium and magnesium mineral analysis (*C. racemosa* meal, feed digestibility, and feces). All the procedure was refrred to AOAC (1990).

Antioxidant activity test

C. racemosa meal presented biological activity as antioxidant (Gaillande *et al.*, 2016) and antibacterial because it contains phenol (Michalak & Chojnacka, 2015). Superoxide

Table 2. The formulation of experimental feed for tiger shrimp with different level of *C. racemosa* meal.

Ingredients	*C. racemosa* content			
	0%	10%	20%	30%
Fish meal	30.00	30.00	30.00	30.00
Soybean meal	28.00	23.00	18.00	14.00
Squid meal	5.00	5.00	5.00	5.00
Polard	20.00	17.00	14.00	8.00
Wheat flour	10.40	7.40	4.40	3.40
C. racemosa meal	0.00	10.00	20.00	30.00
Coconut oil	1.00	2.00	3.00	4.00
Squid oil	2.00	2.00	2.00	2.00
Lecythin	1.00	1.00	1.00	1.00
Premix[1]	2.00	2.00	2.00	2.00
Vitamin C	0.10	0.10	0.10	0.10
CMC	0.50	0.50	0.50	0.50
Feed proximate (%)				
Protein	42.18	43.25	42.65	42.69
Lipid	9.34	10.61	12.18	13.47
Crude fiber	2.54	2.54	2.29	2.17
Ash	9.38	10.66	12.37	13.59
NFE	36.57	32.94	30.51	28.08
Energy (kcal/100g)[2]	473.93	476.99	478.41	480.78

[1]Premix (g/kg feed): Vit A 50 IU, vit D_3 10 IU, vit B_1 100 µg, vit B_2 200 µg, vit B_6 200 µg, vit B_{12} 0.25 µg, vit E 600 µg, vit K_3 50 µg, niacin 650 µg, panthotenic acid 300 µg, biotin 5 µg, follic acid 40 µg, inositol 1.000 µg, vit C 400 µg, phosphorus 280 µg, potassium 5.600 µg, calcium 5.600 µg, magnesium 1.820 µg, sodium 8.400 µg, iodin 196 µg, copper 1.4 µg, irone 332 µg, manganese 3.5 µg, and zinc 33.6 µg.

[2]Protein 5.6 kcal GE, lipid 9.5 kcal GE, carbohydrate 4.1 kcal GE (NRC, 2011). NFE = Nitrogen-free extract

dismutase (SOD) enzyme is an indicator to measure antioxidant activity. SOD enzyme is the major antioxidant enzyme to prevent reactive oxygen species (ROS) and convert superoxide free-radical to peroxide (H_2O_2) (Taylor & Savin, 2011). The SOD enzyme test was begun with blood collection (hemolymph) at the end of the study, presicely 24 hours after feeding.

Data collection

The digestibility of *C. racemosa* was calculated through base feed and experimental feed digestibility. The method referred to Bureau & Hua (2006). Growth performance was monitored through feed consumption, feed efficiency, protein efficiency ratio, feed conversion ratio (Takeuchi, 1988), specific growth rate (Halver, 1989), and survival rate.

Statistical analysis

All of the data were tabulated using Microsoft Excel 2013. Furthermore, the digestibility of *C. racemosa* meal was analyzed descriptively. On the contrary, growth parameter consisted of feed consumption, nutrition proximate of the shrimp, and SOD enzyme activity was analyzed statistically through parametric test (analysis of variance) using SPSS 16.0 and Duncan posthoc test in 95% of confidence level.

RESULTS AND DISCUSSIONS

Results

The digestibility of C. racemosa

The digestibility of *C. racemosa* meal was calculated from both base feed and experimental feed which measured through total digestibility, protein, calcium, magnesium, and energy. Those results are presented below in Table 3.

Table 3. The digestibility of *C. racemosa* meal in tiger shrimp

Experimental parameter	Digestibility (%)
Total digestibility	51.82 ± 2.15
Protein digestibility	88.67 ± 1.27
Calcium digestibility	68.44 ± 2.51
Magnesium digestibility	16.39 ± 3.99
Energy digestibility	60.30 ± 1.29

Growth performance

C. racemosa meal addition until 10% resulted similar amount of feed consumption with the control treatment. However, *C. racemosa* meal addition exceeded 20%, decreased feed consumption. Identical case was also found in specific growth rate, protein efficiency ratio, protein retention, feed conversion, and feed efficiency which followed similar result with control. Whereas, *C. racemosa* meal addition until 30% did not significantly affect survival rate (Table 4).

SOD enzyme activity

SOD enzyme activity test towards hemolymph showed that there was a rising level of SOD enzyme along with the increase of *C. racemosa* addition. The 30% of *C. racemosa* meal additition delivered higher result and significantly different with other treatments (P<0.05) (Figure 1).

Discussion

Total digestibility of *C. racemosa* is 51.82% (Table 3). The digestibility of *C. racemosa*

Table 4. Growth performance of tiger shrimp fed with different level of *C. racemosa* meal addition (control, 10%, 20%, 30%).

Parameter	*C. racemosa* addition			
	0%	10%	20%	30%
W_{42} (g)	1.25 ± 0.04[a]	1.22 ± 0.03[a]	1.03 ± 0.07[b]	0.95 ± 0.05[b]
Feed consumption (g/individual)	1.90 ± 0.06[a]	1.87 ± 0.10[a]	1.77 ± 0.07[ab]	1.67 ± 0.08[b]
SGR (%/day)	3.10 ± 0.08[a]	3.04 ± 0.06[a]	2.59 ± 0.13[b]	2.40 ± 0.14[b]
PER	1.11 ± 0.02[a]	1.06 ± 0.03[a]	0.88 ± 0.04[b]	0.82 ± 0.04[b]
PR (%)	16.74 ± 0.83[a]	16.15 ± 0.35[a]	12.46 ± 0.15[b]	11.64 ± 1.00[b]
FCR	2.14 ± 0.04[a]	2.18 ± 0.07[a]	2.66 ± 0.13[b]	2.86 ± 0.12[b]
FE (%)	46.80 ± 0.94[a]	45.90 ± 1.47[a]	37.63 ± 1.75[b]	35.02 ± 1.55[b]
SR (%)	93.33 ± 0.00[a]	95.56 ± 3.85[a]	93.33 ± 0.00[a]	95.56 ± 3.85[a]

Note: The stated value is average ± deviation standard. Different superscript letter in the same row indicates significant difference (P<0.05); W_{42}= individual final weight (day-42); SGR= specific growth rate; PER= protein efficiency ratio; PR= protein ratio; FCR= feed conversion ratio; FE= feed efficiency; SR= survival rate.

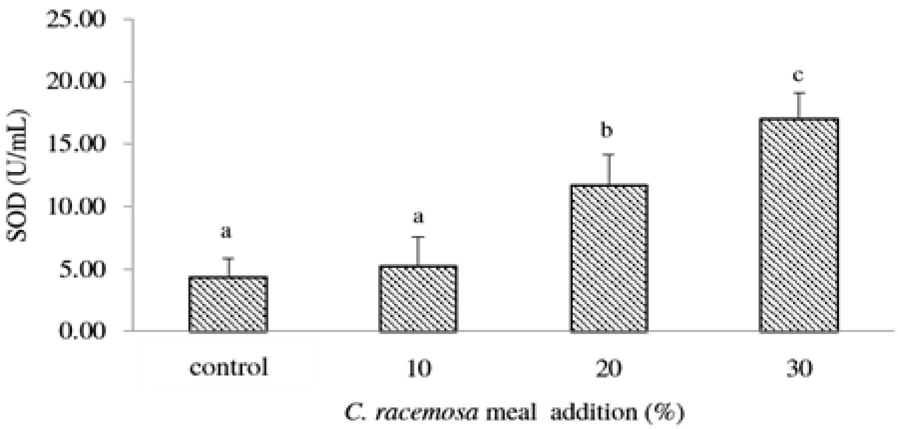

Figure 1. SOD enzyme activity in different level of *C. racemosa* meal addition (control, 10%, 20%, 30%). Different letter in the graph indicates significant difference (P<0.05).

was considerably lower than soybean meal (60.1−73%) and fish meal (74%) (Smith *et al*., 2000). However, the digestibility of *C. racemosa* was noticeably higher than poultry by-product meal (PBM) (47.9%) (Luo *et al*., 2012), meat meal (43%), canola (49%), and lupin (39%) (Smith *et al*., 2000). Total digestibility represents total quantity of the digested material (Luo *et al*., 2012). A material can not be entirely digested, so that there is a variable named total digestibility to represent the digested and undigested material (Sookying *et al.,* 2013)

A high protein content of *C. racemosa* (30%) was highly digested by the tiger shrimp around 87.42% (Table 3). According to NRC (2011), the protein digestibility of shrimp ranges from 75−95%. The digestibility of *C. racemosa* was noticeably higher than canola meal (80%), cottonseed meal (83%), and blood meal (66%) (Smith *et al*., 2000; NRC, 2011). However, the digestibility of *C. racemosa* meal was lower than soybean meal (92.1%) (Hertrampf & Pascual, 2000; Smith *et al*., 2000). The protein content of *C. racemosa* was considerably higher than the other species of green algae, such as *Enteromorpha intestinalis* (24.52%) and *Ulva lactuca* (21.06%) (Ratana-arporn & Chirapart, 2006). A decent level of digestibility is crucial in a high density aquaculture. The accumulation of uneaten feed potentially interrupts water quality, expands maintenance cost, and causes death (Lin *et al.,* 2006; Hasan *et al*., 2012; Mohanty *et al*., 2014).

The digestibility of calcium and magnesium in the *C. racemosa* meal was 68.44% and 16.39%, respectively (Table 3). The calcium requirement of the shrimp is 0.5−1.25%, while the shrimp requires magnesium as many of 0.1−0.3% (Hertrampf & Pascual, 2000; Hena *et al*., 2012). Calcium held several roles in bone formation, muscle contraction, and blood vessel. On the other hand, magnesium is necessarily needed in cell respiration, enzyme activator, and also in lipid, carbohydrate, and protein metabolism (NRC, 2011; Antony *et al*., 2015; Bernard & Bolatito, 2016). Shrimp has the ability to directly absorb several minerals, such as magnesium and calcium, in the water through the gill and exoskeleton in a low concentration yet (Hertrampf & Pascual, 2000; NRC, 2011; Verma & Tomar, 2014). Hence, mineral addition is inevitably essential to fulfill shrimp requirement (Roy *et al.,* 2009; Pine & Boyd, 2010).

The energy digestibility of *C. racemosa* was 60.30% (Table 3) which was lower than the energy digestibility of soybean meal (71−76%) and poultry by-product meal (PBM) (82%) (Smith *et al,*. 2000; NRC, 2011). The value showed positive correlation with the protein digestibility of soybean meal which was higher than *C. racemosa* meal. However, the energy digestibility was nearly similar with the other plant-based ingredients, such as cottonseed meal (61%) and cornmeal (60%) (NRC, 2011) and higher than canola (53%) and lupin meal (45%) (Smith *et al*., 2000).

The diminishing level of growth performance along with the increasing level of *C. racemosa* dosage was assumed caused by the downturn of ingredients quality. The experimental feed was made isoprotein and isoenergy, thus the lower level of growth performance was supposedly caused by the low quality of the feed ingredients. According to Luis *et al.* (2010) and Sudaryono *et al.* (1999), a low quality of feed ingredients is possibly generated by low palatability which also leads to low feed consumption. Kamal and Sethuraman (2012) and Gaillande *et al.* (2016) mentioned that *C. racemosa* has a secondary metabolite compound in the methanol faction named caulerpin. This compound seemed unpalatable and it directly affected the feed attractiveness, especially in the higher dosage (>20%). Luis *et al.* (2010) also reported that *C. racemosa* released antifeeding chemical compound which also presumably decreased the feed consumption of *Thalassoma pavo*.

Feed palatability is essential to attract the shrimp to consume the feed. Being slow and rely on its chemoreceptor are the habits of the shrimp to discover the feed (Smith *et al*., 2000; Aggio *et al*., 2012; Tantikitti, 2014). Caulerpin is known to own undesirable taste for the shrimp, so that the feed consumption decreased. In addition, feed palatability is precisely affected by attractant content. Glycine and alanine amino acids are known as decent attractant for shrimp (Sudaryono *et al.*, 1999). Soybean meal contents glycine and alanine as many of 1.69% and 2.02%, respectively (Song *et al.*, 2008), compared with *C. racemosa* meal which contents glycine and alanine 1.28% dan 0.2%, respectively (Bhuiyan *et al.*, 2016). The addition of *C. racemosa* meal up to 20%, led to lower percentage of soybean meal in the feed formulation (Table 2), thus the concentration of glycine and alanine decreased as well. As a consequence, feed palatability was also declined.

The declining level of growth performance was apparently caused by caulerpin which activated after being consumed. It was shown by the increasing level of SOD enzyme (Figure 1). SOD enzyme is the major antioxidant enzyme that prevents reactive oxygen species (ROS) through counteracting free radical and phagocytosis (Matanjun *et al*., 2010; Zhang *et al*., 2013; Box *et al.,* 2008). The SOD enzyme increases along with the higher level of *C. racemosa* dosage. The 30% of *C. racemosa* treatment resulted in 16.97 U/mL of SOD enzyme and it was different significantly with the other treatments. The increase level of SOD enzyme was assumed to anticipate ROS as a result of detoxification process towards caulerpin. Liu *et al.* (2009) stated that caulerpin inhibits hypoxia-inducible factor-1 (HIF-1) which controls oxygen homeostasis. When the HIF-1 is inhibited, ROS will be produced and it will lead to hypoxia condition. Metabolism rate will increase to produce SOD enzyme to prevent ROS. The increase of metabolism rate is not followed by an adequate energy supply. Felline *et al.* (2012) reported that caulerpin was also found in body tissues of white seabream *Diplodus sargus* fed using *C. racemosa.* As a consequence, a detoxification mechanism increased and it decelerated the growth performance.

The deficiency of feed causes the nutrient deficiency, thus the nutrient retention is declining. Protein retention (PR) presents the amount of protein retented from the digested feed. The feed is basically the energy source to fulfill the basal metabolism, daily maintenance, and growth necessity (Hu *et al.,* 2008*;* Kaushik & Seiliez, 2010). The protein retention of *C. racemosa* 10% treatment was 16.15% which not significantly different with control treatment (16.74%) (Table 4). On the contrary, the protein retained in the 20% and 30% treatment decreased gradually and differ significantly with the 0% and 10% treatment. It also straightly affected the declining of protein efficiency ratio (PER). The PER result of 10% *C. racemosa* treatment was 1.06 and it was not significantly different with control (P>0.05). The *C. racemosa* addition until 10% was assumed as a proper composition as protein source for tiger shrimp feed. On the other hand, *C. racemosa* addition more than 20% generated lower value of PER. A lower value of PER indicated that protein was used to achieve energy demand. It also implied that energy demand from non-protein energy sources, such as lipid and carbohydrates, have not fulfilled yet.

The decreased growth performance was caused by feed digestibility presumably. Feed digestibility is required to discover feed quality and show the digested nutrient composition and absorbed by the shrimp to support its growth and metabolism (Luo *et al.*, 2012). The addition of *C. racemosa* exceeded 20% caused the soybean meal substitution more than 35% (Table 2). The total digestibility of soybean meal is 73% (Smith *et al.*, 2000) and the protein digestibility ranges from 92.1−94.0% (Hertrampf & Pascual, 2000; NRC, 2011). Those values is higher than *C. racemosa* meal with total digestibility 51.82% and protein 87.42% (Table 3).

The specific growth rate (SGR) resulted by 10% of *C. racemosa* treatment was 3.04%/day which not significantly different with control (3.10%/day). In contrast, *C. racemosa* addition exceeded 20% showed lower SGR. It could be generated by inefficient feed consumption, especially protein retention, which led to low growth rate. Feed conversion ratio (FCR) is an indicator to determine feed effectivity. A low feed conversion ratio indicates high feed efficiency.

The FCR value of 10% *C. racemosa* treatment was 2.18 and it did not differ significantly with control treatment (2.14). It indicated that the feed efficiency of both treatments were similar (Table 4). Conversely, the 20% and 30% of *C. racemosa* treatment demonstrated higher FCR value and low feed efficiency value (Table 4). The results explained that 10% of *C. racemosa* addition was more efficient compared with 20% or above. Feed efficiency (FE) value is applied in weight added and feed consumption ratio (Watanabe, 1988; Richard *et al.*, 2010). Consumed feed will produce a value which describes feed efficient utilized by the experimental shrimp. The FE value describes the most efficient treatment in terms of energy fulfillment and growth. The FE value in this study was higher compared to the result by Widyantoko *et al.* (2015) which used 3% of *Sargassum* sp. meal in the experimental feed (33.19%).

The survival rate of tiger shrimp presented unsignificant difference amongst treatments (P>0.05). It indicated that the addition of *C. racemosa* meal into the shrimp diet did not cause death on the experimental shrimp and it could be used as feed ingredient. A moderate toxic compound named caulerpin was able to be anticipated through SOD enzyme mechanism.

CONCLUSION

A 10% of *Caulerpa racemosa* is potentially used as tiger shrimp diet ingredient. A higher level of *Caulerpa racemosa* addition may diminish the growth rate of tiger shrimp *Penaeus monodon*.

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