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Feasibility of partial replacement of discarded filamentous green seaweed (*Cladophora*) with commercial feed in spotted scat (*Scatophagus argus*) culture

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***Abstract* -** An 60-day feeding experiment was conducted to investigate the effects of partial replacement of discarded filamentous green seaweed (*Cladophora*) with commercial feed on the growth performance and feed efficiency of spotted scat (*Scatophagus argus*). Triplicate groups of fish with initial body weight of 3.31 -3.39 g were reared in the 250 L plastic tanks at salinity of 5 g L^{-1}. Results showed that growth rate of fish in the alternate feeding regime, 1 day commercial feed and 1 consecutive day dried or fresh green seaweed were not significantly different ($p>0,05$) from the control group received single commercial feed. However, significant decrease in growth performance was observed in fish fed the fresh or dried green seaweed as solely diet. Application of the combined feeding regimes, the cost of commercial feed could be reduced up to 44.63% without hindering the growth of spotted scat as well as water quality was better than using solely commercial feed. Carcass analysis revealed that the lowest and highest crude lipid contents in fish fed commercial feed and green seaweed, respectively while protein and ash contents was not affected by the feeding treatments. These findings illustrated that the discarded fresh and dried *Cladophora* can be used as a feed to partially substitute commercial feed for *S. argus* culture.

Index Terms – *Cladophora, Scatophagus argus,* growth performance, feed cost, carcass composition

I. INTRODUCTION

Seaweeds or marine macroalgae are an important component of global aquaculture, occupy approximately 20% of the total world marine aquaculture production by weight, with an annual value of US $6.7 billion in 2013 (FAO, 2017). In the Integrated Multi-Trophic Aquaculture (IMTA) system, seaweed can be used as an extractive component to remove inorganic nutrients and mitigate potentially adverse environmental impacts from aquaculture activities (Kim, *et al*., 2017). Seaweeds are rich in minerals, nutrients and bioactive compounds (Kasimala, *et al*., 2015), and the main food for many herbivorous fishes (Tolentino-Pablico *et al*., 2008; Siddik and Anh, 2015). Moreover, partial replacement of costly protein sources in animal feeds with seaweed protein could improve feed quality and reduce the feed cost (Kumar and Kaladharan, 2007).

Seaweeds are both cultivated (aquaculture) and harvest from natural populations on a year-round basis from marine environments, river mouths, lagoons and ponds. However, natural seaweed stocks have become inadequate to meet the industrial requirements; several economically important species have been cultivated and developed dramatically in Asia (Kim, *et al*., 2017). Similar to Asian countries, the seaweed in Vietnam is widely used for food, medicine and industry, obtained useful extracted substances such as agar, alginates and fucoidan, but a large amount of seaweeds from natural resources (Titlyavov, *et al*., 2012). *Cladophora* belongs to family Cladophoraceae is one of the largest and most common filamentous green algal genera, having a worldwide distribution (Leliaert and Boedeker, 2007). This genus is a good source of protein, amino acid, minerals and pigment, and essential fatty acid, which can be a suitable food for fish (Khuantrairong, and Traichaiyaporn, 2009). Field surveys revealed that *Cladophora* is abundant throughout the year in the improved-extensive shrimp farms in the Mekong delta of Vietnam. However, excessive growth of green seaweed in these farms have caused negative impacts on water quality, shrimp yield and farmer income. In response to these problems, they are removed and discarded from farms by shrimp farmers (Anh *et al*., 2016). There are over 600,000 hectares of shrimp farming in the Mekong Delta, the area under improved extensive shrimp culture is nine times that of semi-intensive/intensive shrimp (Kam *et al*., 2012). This indicates large quantities of green seaweed as discarded-product from the shrimp farms are available year round in the region. They have high nutritional values, and have been investigated as a dietary ingredient or direct food for the giant gourami fish *Osphronemus goramy* (Anh *et al*., 2013) and co-cultured with white leg shrimp *Litopenaeus vannamei* (Anh *et al*., 2014a).

The spotted scat (*Scatophagus argus*) is widely distributed throughout Indo Pacific basin. This species is valuable brackish water aquarium fish and an important food fish in South-east Asia (Sivan, and Radhakrishnan, 2011). This species is the omnivorous fish, as macroalgae and detritus dominated in the gut contents of the fish (Sivan, and Radhakrishnan, 2011; Gupta, 2016). In Vietnam, *S. argus* distribute along the coastal areas, is the potential species for aquaculture in the Mekong delta because they feed on a low trophic level, are easily cultured and highly adaptable to a wide range of environmental conditions and can be applied in poly-culture with other species or integrated aquaculture system (Ut and Dinh, 2016). In practice, fish feed is the most expensive operating cost item accounting for over 50% of production costs; therefore, any management interventions to reduce feed input costs will have a significant bearing on the sustainability of aquaculture operations (Rana, *et al*., 2009; Rana and Hasan, 2013). The purpose of this study was to evaluate the effect of commercial feed replacement with fresh or dried green seaweed (*Cladophora* sp.) as a food source on growth, feed utilization and carcass composition of *S. argus* in laboratory conditions. These works could provide importantly scientific information for further research to apply for field conditions that may encourage farmers using locally discarded green seaweed as food source for fish and contribute to reduce feed costs, improve their profits.

I. MATERIALS AND METHODS

Experimental feeds and fish

Fresh filamentous green seaweed, *Cladophora* (Cl) was obtained from the improved-extensive shrimp farms in Ca Mau province, Vietnam (this seaweed is ordinarily removed and discarded from these farms by shrimp farmers when it is abundant), and cleaned with seawater to eliminate dust and organisms attached to seaweed in order to maintain the quality. Dried Cl was achieved by air-drying a thin layer of biomass until reaching moisture content about 12%. Both fresh and dried *Cladophora* were stored in the fridge, and cut with scissors into small pieces (±2 mm) for feeding the spotted scat. The commercial feed (CJ F-8002), floating form with particle size of 2 mm, is produced by CJ VINA AGRI Company, Long An province, Vietnam. Proximate composition (% of dry matter) of commercial feed, fresh and dried green seaweed was analyzed by the standard methods of AOAC (2000). Nitrogen-free extract was estimated on a dry weight basis by subtracting the percentages of crude protein, lipids, crude fiber and ash from 100%. Nutritional composition of experimental feeds is presented in Table 1.

Table 1 Proximate composition (% dry matter) of experimental feeds

Composition	Moisture	Crude protein	Crude lipid	Ash	Crude fiber	NFE
Commercial feed	10.79±0.18	30.16±0.16	6.08±0.12	15.32±0.13	5.79±0.15	42.66±0.31
DCl	12.42±0.43	14.63±0.17	1.18±0.08	26.72±0.27	15.68±0.13	41.79±0.32
FCl	86.59±0.64	14.82±0.22	1.41±0.13	25.98±0.33	15.49±0.37	42.32±0.62

DCl: Dry *Cladophora*, FCl: Fresh *Cladophora*; NFE, nitrogen-free extract

Wild fingerlings of spotted scat (*Scatophagus argus*) were purchased from a reliable provider in Tien Giang province. Before starting the feeding trial, they were first reared in a 2-m^3 tank for 10 days in order to acclimate the fish to the laboratory conditions and to get them acquainted with the feeding method (alternative feeding between commercial feed and dried or fresh green seaweed).

Experimental design

Feeding trial was conducted in the experimental hatchery of the College of Aquaculture and Fisheries, Can Tho University, Vietnam. The fresh and dried green seaweed *Cladophora* were used as a direct feed to replace commercial feed in an alternate feeding approach for the spotted scat (*Scatophagus argus*) juveniles for 60 days. Feeding regimes were run in triplicate tanks and each day fish were fed either commercial feed or *Cladophora*. Seven treatments included (1) single commercial feed daily as a control treatment (CF), (2 and 3) single dried or fresh *Cladophora* everyday (DCl or FCl) and 2 alternative feeding regimes where (4 and 5) 1 day commercial feed and 1 consecutive day dried or fresh *Cladophora* (1CF_1DCl and 1CF_1FCl) and (6 and 7) 2 consecutive days dried or fresh *Cladophora* (1CF_2DCl and 1CF_2FCl).

Culture system

The 250-L plastic tanks were filled with 200 L brackish water at salinity of 5 g L^{-1}. Each tank was provided a feeding tray and a continuous aeration. 20 uniformly sized fish with initial individual weight of 3.19-3.45g were placed in each tank. Fish were fed twice a day at 8:00 and 17:00 hours. The initial feed ration was 5% of the biomass, but this was adjusted daily based on the presence or absence of residual feed. Uneaten green seaweed was collected and dried in the oven until constant weight. For commercial feed, the number of pellets (per gram) was determined before the feeding and the uneaten pellets were collected and counted after 1h feeding. The water exchange rate was approximately 50% of the tank volume every week.

Water quality

Daily water temperature and pH was measured at 7:00 and 14:00 hours using a thermo-pH meter (YSI 60 Model pH meter, HANNA instruments). The concentrations of TAN (NH_3/NH_4^+) and NO_2^- were determined every week using a spectrophotometer according to American Public Health Association (APHA, 1998).

Growth performance and feed utilization

To estimate the growth performance during the experimental period, initial and final as well as intermediate samples were taken to measure average individual fish weight. Sampling was conducted at a 20-day interval. Ten fish in each tank were randomly sampled and weighed in groups using an electronic balance with an accuracy of 0.01 g and then the fish was returned to the original tanks. At the end of the feeding trial, experimental fish was individually weighed and the survival was determined.

Weight gain (WG), daily weight gain (DWG), specific growth rate (SGR), total feed intake, feeding rate, feed conversion ratio (FCR), protein efficiency ratio (PER) and survival were calculated using the following equations:

WG (g) = Final weight – Initial weight

DWG (g day^{-1}) = (final weight – initial weight)/days of culture x100

SGR (% day^{-1}) = [(ln final weight) – (ln initial weight)]/days of culture x100

$$\text{Total feed intake (g fish}^{-1}) = \frac{\text{Total feed supplied - Total feed remaining}}{\text{(Initial number of fish + Final number of fish)/2}} \times 100$$

$$\text{Feeding rate (\% BW day}^{-1}) = \frac{\text{Feed intake (g fish}^{-1}\text{ day}^{-1})}{\text{(Initial body weight + Final body weight)/2}} \times 100$$

FCR = Total feed intake (dry weight)/Weight gain (wet weight)

Protein efficiency ratio = Weight gain/Protein intake

Survival (%) = Final number of fish/Initial number of fish x 100

Proximate composition of fish carcass

At termination of experiment, 5 fish were randomly collected in each tank for the removal of viscera, bone and skin and the samples were kept at -25°C. Fish carcass samples were analyzed for moisture, crude protein, crude lipid and ash according to the methods described by the Association of Official Analytical Chemists AOAC (2000).

Statistical analysis

All percentage values were normalized through a square root arcsine transformation before statistical treatment. Data for all measured parameters were analysed using SPSS for Windows, Version 16.0. Variations from dietary treatment were compared by one-way ANOVA. The Tukey HSD post hoc analysis was used to detect differences between means, and significant differences were considered at $p<0.05$.

III. RESULTS AND DISCUSSION

Water quality

Water quality parameters in the experimental tanks are given in Table 2. Daily water temperatures ranged from 26.8 to 28.8°C, and water pH remained within the range of 7.4–8.0. Generally, water temperature and pH were similar among feeding treatments. According to Macahilig *et al*. (1988), the spotted scat is highly tolerant of changes in temperature, salinity and pH. Hence, these parameters are within the suitable range for development of *S. argus* juveniles. The mean concentrations of TAN and NO_2^- in all feeding treatments varied in the ranges of 0.41-0.95 mg L^{-1} and 0.48-1.15 mg L^{-1}, respectively.

These parameters tended to increase with the culture period in which the highest values were found in the control group, received single commercial feed (CF) everyday, followed by the group fed alternative 1 day commercial feed and 1 consecutive day dried or fresh seaweed (1CF_1DCl and 1CF_1FCl) and 2 consecutive days dried or fresh seaweed (1CF_2DCl and 1CF_2FCl), while the lowest levels of TAN and NO_2^- were observed in the group fed solely dried or fresh seaweed (DCl or FCl). Statistical analysis indicated that the contents of TAN and NO_2^- in the control treatment were significantly higher than in other treatments ($p<0.05$). These results showed that the water quality in the culture tanks was much better with solely Cl feeding regimes than in the tanks with only CF. Moreover, the contents of TAN and NO_2^- in the culture tanks was increased with increasing the amount of commercial feeds used. This indicated that the rearing tanks could be maintained better water quality in case of combined feeding of commercial feed with green seaweed than single commercial feed.

Table 2 Water quality parameters in experimental tanks

Treatment	Temperature (°C)		pH		TAN (mg L^{-1})	NO_2^- (mg L^{-1})
	7:00 am	2:00 pm	7:00 am	2:00 pm		
CF	26.8±0.4	28.7±0.5	7.4±0.4	7.9±0.5	0.95±0.53^{e}	1.15±0.65^{d}
DCl	26.8±0.4	28.8±0.4	7.5±0.3	8.0±0.3	0.44±0.18^{ab}	0.48±0.24^{a}
FCl	26.8±0.4	28.7±0.3	7.5±0.4	8.0±0.4	0.41±0.20^{a}	0.52±0.25^{a}
1CF_1DCl	26.9±0.5	28.8±0.5	7.5±0.3	7.9±0.3	0.69±0.26^{d}	0.81±0.38^{c}
1CF_1FCl	26.9±0.5	28.8±0.4	7.5±0.3	7.9±0.4	0.63±0.29^{cd}	0.83±0.37^{c}
1CF_2DCl	26.8±0.4	28.7±0.6	7.5±0.3	7.9±0.3	0.59±0.23^{bcd}	0.76±0.32^{bc}
1CF_2FCl	26.8±0.4	28.8±0.6	7.5±0.2	8.0±0.4	0.51±0.20^{abc}	0.74±0.33^{b}

Means in the same column with different superscripts are significantly different ($p<0.05$).

The present observations are consistent with previous researchers. They found that significant decrease in TAN and NO_2^- levels in the culture tanks received single gut weed (*Enteromorpha* sp.) as direct feed or alternate feeding with gut weed and pellet feed compared to the tanks received only pellet feed in Tilapia culture (Siddik *et al*., 2014) or in herbivorous fish (Anh *et al*., 2013; Siddik and Anh, 2015). Although the contents of TAN and NO_2^- in the CF treatment was much higher than in other treatments, these factors are still in the tolerable range for growth of *S. argus* juveniles because this species is highly adaptable to a wide range of environmental conditions (Gupta, 2016).

Survival and growth

Table 3 showed that the survival of experimental fish was not significantly different among treatments ($p>0.05$), varying in the range of 88.3-93.3%. This result is in a agreement with the study of Siddik, *et al*. (2014) who used gut weed (*Enteromorpha* sp.) as a feed for tilapia (*Oreochromis niloticus*) or for herbivorous fish (Siddik and Anh, 2015), and Anh *et al*. (2013) utilized green seaweed as a feed for the giant gourami (*Osphronemus gourami*), they found that survival of fish was not affected by the feeding treatments.

Table 3: Survival and growth rate of the spotted scat received different feeding regime for 60 days

Treatment	Initial weight (g)	Final weight (g)	Weight gain (g)	DWG (g day^{-1})	SGR (%day^{-1})	Survival (%)
CF	3.37±0.05^{a}	12.18±1.71^{d}	8.82±1.72^{d}	0.139±0.043^{c}	2.13±0.24^{c}	90.0±5.0^{a}
DCl	3.35±0.05^{a}	8.05±1.16^{a}	4.70±1.16^{a}	0.069±0.031^{a}	1.44±0.25^{a}	88.3±7.6^{a}
FCl	3.36±0.04^{a}	8.51±1.19^{a}	5.15±1.19^{a}	0.086±0.020^{a}	1.53±0.24^{a}	91.7±2.9^{a}
1CF_1DCl	3.32±0.05^{a}	11.22±1.72^{bcd}	7.90±1.72^{bcd}	0.132±0.029^{bc}	2.01±0.26d^{bc}	91.7±2.9^{a}
1CF_1FCl	3.35±0.06^{a}	11.71±1.60^{cd}	8.35±1.60^{cd}	0.139±0.027^{c}	2.07±0.22^{c}	93.3±7.6^{a}
1CF_2DCl	3.34±0.07^{a}	10.34±1.43^{b}	7.00±1.43^{b}	0.117±0.024^{b}	1.87±0.23^{b}	90.0±8.7^{a}
1CF_2FCl	3.36±0.02^{a}	10.78±1.62^{bc}	7.41±1.62^{bc}	0.124±0.027^{bc}	1.92±0.25^{b}	90.0±8.7^{a}

Mean values in each column with different letter are significantly different from each other (P<0.05).

Figure 1 indicated that individual weight of experimental fish was affected by the feeding regimes from day 20 onwards. At day 20, the mean weight of fish was 5.02-7.23 g, in which the lowest and highest values were observed in the single commercial feed and solely green seaweed treatments, respectively, while the combined feeding regimes gave intermediate values. This tendency was more pronounced at day 40 (6.44-9.63 g) and day 60 (8.05-12.18g).

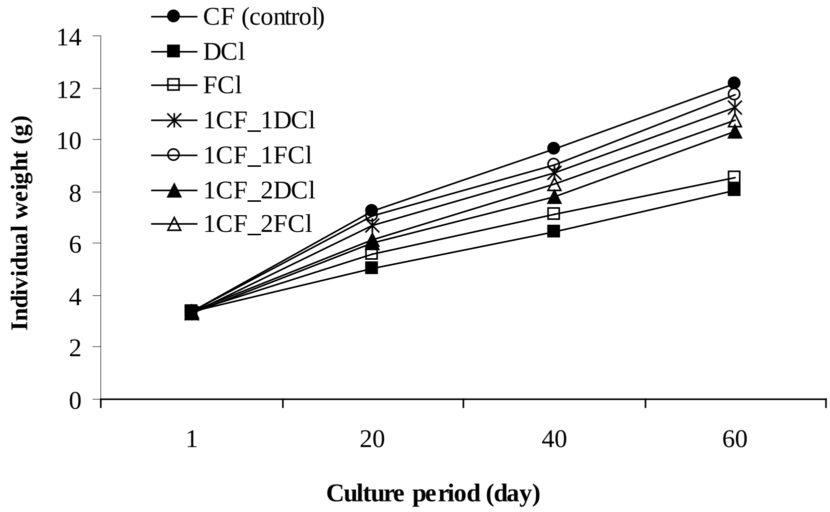

Figure 1: Growth curve of spotted scat received different feeding regimes

There was high variation in the final weight, weight gain (WG), daily weight gain (DWG) and specific growth rate (SGR) of experimental fish in the different feeding treatments. Growth rate of the fish received alternative feeding regimes of 1 day commercial feed and 1 consecutive day dried (1CF_1DCl) or fresh green seaweed (1CF_1FCl) were comparable (p>0.05) to the control group (CF). When fish received 2 consecutive days with green seaweed (1CF_2DCl and 1CF_2FCl), their growth was significantly lower (p<0.05) than the control. Additionally, the lowest growth rates were observed in the group fed only on dried or fresh green seaweed (DCl or FCl) which was significantly different from other treatments. Overall, fish fed fresh seaweed showed a better performance than the ones fed dried seaweed. However, at the same alternate feeding regime between commercial feed and green seaweed, no significant difference (p>0.05) was observed between the dried and the fresh seaweed forms (Table 3).

Previous study reported that seaweeds have been shown to be a source of minerals and nutrients in fish diets and the main food for many herbivorous fishes (Tolentino-Pablico *et al*., 2007). Moreover, efficiency of using seaweed as feed for the cultured species may be variable depending on the feeding habits, age and the species of both seaweed and fish (Cruz-Suarez, *et al*., 2008; Siddik and Anh, 2015). In the present study, difference in growth performance of the spotted scat could be related to feeding habit of the species. Gandhi (2002) found that filamentous green seaweeds (*Enteromorpha compressa* and *Ulva* spp.) dominated the gut contents in *S argus* fish of size above 100-200 mm in total length. Other studies also detected a large proportion of algae and detritus in the stomach of *S argus* indicated omnivorous fish (Sivan, and Radhakrishnan, 2011).

These results are in accordance with the study of Siddik *et al*. (2014) who reported that growth performance of Tilapia in the alternate feeding treatments, 1 day commercial feed and 1 consecutive day fresh or dried gut weed (GW) were not significantly different from the group fed solely commercial feed (CF). Whereas significantly reduced growth was observed in fish fed the fresh or dried gut weed as single diet. Similar observation was reported by Anh *et al*. (2013) for the giant gourami (*Osphronemus gourami*).

In our results, differences in growth performance of fish could be related to different nutritional value between commercial feed (CF) and green seaweed (Cl) *i.e*. CF contains 30.16% crude protein and 6.08% lipid, while DCl and FCl had average crude protein and lipid of 14.63-14.82% and 1.18-1.41%, respectively (Table 1). Generally, fish require diets containing 30 to 55% of crude protein and 5 to 10% lipid to meet the needs for optimal growth. Protein requirements usually are lower for herbivorous fish and omnivorous fish than they are for carnivorous fish (NRC, 2011). Therefore, fish received only green seaweed or 1 day commercial feed and 2 consecutive days seaweed did not meet nutrient requirements for growth.

Feed utilization

The average total feed intake was between 13.47 and 17.94 g fish^{-1} with the lowest values found in the DCl and FCl treatments, which was statistically different ($p<0.05$) from the other feeding treatments. Mean feeding rate varied from 3.86 to 4.68 %BW day^{-1}, in which significantly larger percentages were observed in the spotted scat fed the 1CF_2DCl and 1CF_2FCl diets; the other two treatments (DCl and 1CF_1DCl) showed intermediate values. The lowest feeding rate was found in the CF group but it was insignificantly different ($p>0.05$) from the FCl and 1CF_1FCl treatments.

Table 4 Feed utilization of spotted scat *S. argus* fed different feeding regimes over 60 days

Treatment	Total feed intake (g fish^{-1})	Feeding rate (%BW day^{-1})	Feed conversion ratio (FCR)	Protein efficiency ratio (PER)
CF	16.83±1.38^{b}	3.86±0.16^{a}	1.91±0.02^{a}	1.74±0.02^{a}
DCl	13.47±0.36^{a}	4.22±0.17^{bc}	2.88±0.18^{e}	2.38±0.15^{de}
FCl	13.51±0.42^{a}	4.07±0.02^{ab}	2.63±0.09^{de}	2.57±0.08^{e}
1CF_1DCl	17.36±0.13^{b}	4.27±0.08^{bc}	2.20±0.08^{bc}	1.99±0.06^{bc}
1CF_1FCl	17.05±1.26^{b}	4.04±0.23^{ab}	2.04±0.11^{ab}	2.16±0.11^{cd}
1CF_2DCl	17.94±0.45^{b}	4.68±0.11^{d}	2.56±0.06^{d}	1.88±0.03^{ab}
1CF_2FCl	17.68±0.22^{b}	4.47±0.03^{cd}	2.39±0.03^{cd}	1.99±0.02^{bc}

Means in the same column with different superscripts are significantly different ($p<0.05$).

With respect to the use of fresh or dried green seaweed a single feed, feed conversion ratio (FCR) of DCl and FCl were significantly higher (2.63-2.88) than using solely commercial feed (1.91) and alternative feeding treatments except the 1CF_1FCl group. Additionally, application of alternative feeding regime, FCR showed in-between values, varying in the range of 2.04-2.56. However, protein efficiency ratio (PER) were best in DCl and FCl groups (2.38 and 2.57), and significantly ($P<0.05$) different form the control (1.74) and other groups except the 1CF_2DCl treatment.

The analysis of feed cost revealed that the highest quantity of commercial feed and feed cost were observed in the fish fed on single CF. When applying the alternative 1 day commercial feed and 1 consecutive day dried or fresh green seaweed (1CF_1DCl and 1CF_1FCl) diet, the feed costs are being reduced with 38.85% - 44.63%. Nevertheless, in the alternating feeding regime of 1 day commercial feed and 2 consecutive day dried or fresh green seaweed (1CF_2DCl and 1CF_2FCl), the expenditure of feed was decreased from 46.86% to 49,51% (Table 5) but the growth performance of the fish was negatively influenced (Table 3).

Table 5. The expenses of commercial feed in culture of the spotted scat received alternative feeding regime of commercial feed and green seaweed

Treatment	Quantity of commercial feed (CF) used for fish growth (kg CF/kg fish)	CF cost for fish growth (USD/kg)	Reduction ratio of CF cost compared to control treatment (%)
CF	2.14±0.03	1.46±0.02	-
1CF_1DCl	1.31±0.04	0.89±0.03	-38.85±1.73
1CF_1FCl	1.18±0.07	0.81±0.05	-44.63±3.18
1CF_2DCl	1.14±0.06	0.78±0.04	-46.86±2.95
1CF_2FCl	1.08±0.04	0.74±0.03	-49.51±1.72
DCl	-	-	-
FCl	-	-	-

Price of commercial feed was 0.68 USD kg^{-1}

Similar results were reported by Siddik *et al*. (2014), the FCR and PER values of tilapia varied in the ranges of 1.29 -4.73 and 1.44 to 2.59, respectively, and the cost of the combined feeding regimes of CF and GW could be decreased with 41% without hampering the growth of fish. Also, when alternate feeding of CF and fresh or dried GW were applied for herbivorous fish, the FCR of CF were reduced from 26.1 to 43.0% in spotted scat, from 32.7 to 44.2 % in red tilapia, and from 48.2 to 57.8 % in giant gourami, correspondingly (Siddik and Anh, 2015). Another study of Anh *et al*. (2014b) found that gut weed can be used as partial replacement with pellet feed for stocking the spotted scat that can contribute to reduce the feed cost and improve water quality.

According to Rana, *et al*. (2009), in a context of increasing feed and production costs in aquaculture, feed utilization efficiency is of utmost importance as feed expenditure is typically greater than 50% of total production cost. Hence, alternate feeding with high and low-protein commercial pellets could be effective in reducing feed conversion ratio. The growth rates of striped catfish (*Pangasianodon hypophthalmus*) fingerlings fed 30% protein pellets for 7 days and then fed on 18% protein pellets for the next 3 or 5 days were not significantly different when compared with those fed only 30% protein diets all of the time. Other investigations revealed that alternate feeding has shown promising results, and farmers who have adopted the schemes have noted a positive impact on reducing production costs (Rana and Hasan, 2013; Romana-Eguia, *et al*., 2013). Additionally, mixed feeding schedules using high and low-protein diets were proved to be useful for omnivorous and herbivorous fish, such as common carp, catla, rohu, Nile tilapia. This method obtained better FCRs and significant savings on feed costs (Bolivar, *et al*., 2006; Rana and Hasan, 2013).

Carcass proximate composition of the spotted scat is presented in Table 6. There were not significant differences ($p>0.05$) in moisture, crude protein and ash contents among the experimental groups, varying in the ranges of 76.67-79.27%, 17.20-17.57% and 2.48-2.86%, respectively. However, crude lipid in their carcass showed a significant change. The lowest content was detected in treatments DCl and FCl (1.17% and 1.32%) while the highest level was observed in treatments CF (3.90). When combined feeding of CF and DCl or FCl were applied, the lipid contents showed intermediate values (1.73-2.31%). The current results coincided with the study of Ibrahim *et al.* (2007) who reported that fat content were significantly decreased with increasing *Azolla* meal percentage in the diets and commercial feed showed highest level of fat content in fish, and other components did not change compared to the control diet. Similar results were reported for tilapia (Siddik *et al.* 2014) and for the spotted scat (Anh, *et al*. 2014b). These authors confirmed that the carcass lipid contents of experimental fish were decreased with increasing in seaweed frequency while the protein and ash contents of fish carcass did not obviously change.

Table 6: Proximate composition (% of wet weight) of fish carcass fed different feeding regimes

Treatment	Moisture	Crude protein	Ash	Crude lipid
CF	76.67 ± 1.72^{a}	17.46 ± 0.58^{a}	2.61 ± 0.36^{a}	3.90 ± 0.19^{e}
DCl	78.95 ± 1.87^{a}	17.54 ± 0.53^{a}	2.86 ± 0.40^{a}	1.17 ± 0.04^{a}
FCl	79.27 ± 1.59^{a}	17.57 ± 0.64^{a}	2.56 ± 0.43^{a}	1.32 ± 0.04^{ab}
1CF_1DCl	77.85 ± 1.09^{a}	17.35 ± 0.86^{a}	2.75 ± 0.41^{a}	2.19 ± 0.19^{cd}
1CF_1FCl	77.91 ± 1.53^{a}	17.47 ± 0.63^{a}	2.48 ± 0.33^{a}	2.31 ± 0.18^{d}
1CF_2DCl	77.04 ± 1.41^{a}	17.20 ± 0.47^{a}	2.78 ± 0.46^{a}	1.68 ± 0.05^{bc}
1CF_2FCl	77.26 ± 1.04^{a}	17.38 ± 1.04^{a}	2.64 ± 0.45^{a}	1.73 ± 0.06^{bc}

Means in the same column with different superscripts are significantly different (p<0.05).

In Mekong delta of Vietnam, filamentous green seaweeds (*Cladophora* spp.) have been found abundantly in the improved-extensive shrimp farms. These seaweeds usually over grow and outbreak in the shrimp farms and they are periodically removed and discarded by farmers (Anh *et al*., 2016). The herbivorous spotted scat (*S. argus*) is mainly fed on seaweeds and aquatic plants that could contribute to minimize excessive development of green seaweeds. Furthermore, the availability and abundant year-round of green seaweeds are economical for fish culture for a maximal production/cost ratio with applying an alternate feeding regimes commercial feed and green seaweeds shows economical and environmental sustainability. The results of the present study illustrated that the discarded green seaweeds (*Cladophora* spp.) in dried and fresh forms could be used in combined feeding with commercial feed to reduce feed costs and maintain better water quality for spotted scat culture. In this way, farmers can maximize the use of on-farm resources without additional cost for feeds.

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