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IMPROVEMENT OF PRODUCTION PERFORMANCE OF SOFT-SHELL CRAB CULTURE THROUGH DIETARY SUPPLEMENTATION OF HIGH DOSE OF PURSLANE IN RECIRCULATING AQUACULTURE SYSTEM USING APARTMENT BOX

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ABSTRACT

The major constraints in soft-shell crab (*Scylla serrata*) culture are the irregular and low frequency of molting, which reduce production efficiency. Previous studies have shown that purslane (*Portulaca oleracea*) supplementation significantly improves molting and production performance of soft-shell crab cultured in an apartment box using a recirculating aquaculture system; however, evaluations at higher doses remain limited. This study aimed to evaluate the effectiveness of dietary supplementation with purslane stems and young leaves and to determine the optimal dose to enhance soft-shell crab growth and molting. The study used a completely randomized design (CRD) with four treatments and three replicates, namely P0 (yellowstripe scad without purslane), P60 (yellowstripe scad + 60 g kg^{-1} purslane), P70 (yellowstripe scad + 70 g kg^{-1} purslane), and P80 (yellowstripe scad + 80 g kg^{-1} purslane). The results showed that purslane supplementation significantly increased molting and improved growth performance ($P < 0.05$). Treatment P70 yielded the highest molting percentage of 76.6% and growth rate of 1.3 g day^{-1}. Meanwhile, the control treatment (P0) only achieved a molting percentage of 36.6% and a growth rate of 1.07 g day^{-1}. These findings indicate that purslane has a potential as a natural feed additive to enhance molting and growth performance in soft-shell crab culture. The dose of 70 g kg^{-1} feed can be recommended to achieve the best molting response of soft-shell crab reared in a recirculating aquaculture system using the apartment box.

KEYWORDS: feed efficiency; growth; molting; purslane; soft-shell crab

ABSTRAK: Peningkatan Kinerja Produksi pada Budidaya Kepiting Soka melalui Suplementasi Krokot Dosis Tinggi pada Pakan dalam Sistem Budidaya Resirkulasi Menggunakan Kotak Apartemen

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*Kendala utama dalam budidaya kepiting soka (**Scylla serrata**) adalah proses molting yang tidak serempak dan frekuensinya yang rendah, sehingga menurunkan efisiensi produksi. Penelitian sebelumnya menunjukkan bahwa suplementasi krokot (**Portulaca oleracea**) dapat meningkatkan molting dan kinerja produksi kepiting soka yang dibudidayakan dalam sistem kotak apartemen berbasis resirkulasi; namun, evaluasi pada dosis yang lebih tinggi masih terbatas. Penelitian ini bertujuan untuk mengevaluasi efektivitas suplementasi batang dan daun muda tanaman krokot dalam pakan serta menentukan dosis optimal untuk meningkatkan pertumbuhan dan molting kepiting soka. Penelitian ini menggunakan rancangan acak lengkap (RAL) dengan empat perlakuan dan tiga ulangan, yaitu P0 (ikan selar tanpa penambahan krokot), P60 (pakan ikan selar + 60 g kg^{-1} krokot), P70 (pakan ikan selar + 70 g kg^{-1} krokot), dan P80 (pakan ikan selar + 80 g kg^{-1} krokot). Hasil penelitian menunjukkan bahwa suplementasi krokot secara signifikan meningkatkan molting dan kinerja pertumbuhan (P < 0,05). Perlakuan P70 menghasilkan persentase molting tertinggi sebesar 76,6%, dan laju pertumbuhan 1,3 g hari^{-1}. Sementara itu, perlakuan kontrol (P0) hanya mencapai persentase molting sebesar 36,6% dan laju pertumbuhan sebesar 1,07 g. hari^{-1}. Hasil ini menunjukkan bahwa tanaman krokot berpotensi sebagai bahan tambahan pakan alami untuk meningkatkan molting dan pertumbuhan pada budidaya kepiting soka. Dosis 70 g kg^{-1} pakan dapat direkomendasikan untuk menghasilkan respons molting terbaik pada kepiting soka yang dipelihara dalam sistem resirkulasi dengan metode kotak apartemen.*

KATA KUNCI: efisiensi pakan; kepiting soka; krokot; molting; pertumbuhan

INTRODUCTION

The soft-shell crab (*Scylla serrata*), also known as the mangrove crab, is a highly valuable fishery commodity. The term soft-shell crab is not used to refer to a specific type of crab, but rather to describe crabs that have just completed the molting process, in which their exoskeleton has not yet hardened because it is still soft and has not undergone calcification (Gao *et al.,* 2023). Soft-shell crabs have advantages over hard-shell mangrove crabs because their entire body can be consumed without peeling, they have a distinctive and delicate taste, low calcium content, high water content, and are more expensive (Hungria *et al.*, 2017; Tavares *et al.*, 2021).

According to Muahiddah *et al.* (2024), Indonesia contributes only about 1.66% to the total value of global crab exports, indicating enormous potential for development. The selling price of soft-shell crab in the international market also varies. According to the report by Agustiyana *et al.* (2024), the United States is the primary export destination, accounting for 21.84% of Indonesia's total exports. The export price of soft-shell crab to this country ranges from USD 4.19 to USD 4.52 per kg. Meanwhile, the export price to China ranges from USD 4.52 to USD 5.55 per kg, and in Japan it reaches up to USD 6.00 per kg.

Soft-shell crab farming can be implemented in an apartment system. Although this system is generally better known for grow-out practices, several research centers and crab farmers have attempted to adapt it as a means to trigger molting in mangrove crabs (Aulia & Diamahesa, 2024; Hidayat *et al.*, 2024). This system makes it easier to monitor the crab molting process. This monitoring is crucial for the quality of soft-shell crab harvested after molting. If the crabs are harvested too late, their shells will harden again, reducing their quality (Baharuddin *et al.*, 2023).

Economically, the soft-shell crab business has high profit potential. However, many businesses in this sector are unable to maintain sustainable production. The main reasons are the uneven and low frequency of molting, which pose major obstacles in soft-shell crab farming (Biag & Mendoza, 2023; Herlinah *et al.*, 2015). In addition, crabs are naturally predatory, often leading to cannibalism that can reduce farmed populations. Furthermore, Djunaedi (2016) stated that the molting phase is a very vulnerable period, during which the mortality rate can reach 18%. If both factors occur simultaneously, the potential for total population loss can increase to 80%. Therefore, to reduce high mortality rates and maintain the availability of soft-shell crab in the market, the adoption of modern aquaculture techniques based on innovative fisheries technology is crucial. Currently, the main focus of soft-shell crab farmers is on how to stimulate the molting process after the crabs are stocked. The faster the molting occurs, the shorter the required rearing period. This condition not only reduces feed costs but also lowers other input expenses (Rahman *et al.*, 2020).

Natural compounds can be used as molting stimulants to accelerate the molting process in crabs. One compound with potential for use is the hormone ecdysterone, which occurs naturally in several plant species as phyto-ecdysteroids. The use of this compound is relatively safe because it does not cause death in organisms and can increase crabs' resistance to stress and enhance metabolic energy (Waiho *et al.*, 2021). The molting process can be controlled by adding the hormone 20-hydroxyecdysterone (20E) to the hemolymph, thereby manipulating the pre-molting phase according to production needs (Tamsil & Hasnidar, 2018). Ecdysterone hormone can be administered practically through feed. A study conducted by Sihombing *et al.* (2020) showed that the use of spinach as a natural source of ecdysterone had a significant effect in accelerating the molting of soft-shell crab. The optimal concentration of 60 g mixed with fish waste accelerated the molting duration to 13 days. In addition to spinach, purslane has potential as a natural source of ecdysterone that can be used to accelerate the molting process in mud crabs (Zhou *et al.,* 2015).

Research results by Ihsan *et al.* (2024) show that an injection of 24 μg ecdysterone hormone derived from purslane per crab can accelerate the molting rate of mangrove crabs and achieve a survival rate of 100%. Furthermore, Rosmiati *et al.* (2016) reported that purslane plants contain 0.43% ecdysteroid and can accelerate the molting period of shrimp by 5 days compared to the control group, with a survival rate of up to 86%. Additionally, Hidayat (2024) revealed that feeding a diet containing 60 g kg^{-1} of purslane plant yielded the best results for growth performance and economic benefits in soft-shell farming. At this dose, the molting success rate reached 63.33% with a survival rate of 80%, and feed efficiency increased with a feed conversion ratio (FCR) of 1.16. Although 60 g kg^{-1} was identified as the most effective dose in the previous research, the authors noted that this concentration had not yet reached its optimal level and recommended further evaluation with higher doses. Therefore, this research was designed to assess the effectiveness of incorporating higher doses of purslane stems and young leaves into the diet to identify the optimal concentration for enhancing the growth and molting performance of soft-shell crabs.

MATERIALS AND METHODS

Time and Location

This research was conducted from May to July 2025 at the IPB Fisheries and Marine Observation Station (IFMOS) located in Ancol, North Jakarta, Jakarta, Indonesia. Furthermore, water quality analysis was carried out at the Aquaculture Environment Laboratory, Department of Aquaculture, Faculty of Fisheries and Marine Sciences, IPB University, Indonesia.

Animals and Test Materials

This study used mangrove crab (*S. serrata*) seeds weighing approximately 80-100 g as the main test material. The crab seeds were obtained from fishermen and crab collectors operating in the coastal area of Muara Gembong District, Bekasi Regency, West Java, Indonesia. The test material used was fresh purslane, obtained from a flower shop in Sunter Agung, Tanjung Priok District, North Jakarta, Jakarta, Indonesia. The parts of the plant used were the stems and young leaves, which were then washed thoroughly and cut into small pieces.

Research Design

This study used a completely randomized design (CRD) consisting of four treatments with three replicates. Each experimental unit consisted of 10 crabs, each maintained separately in an individual box. In total, 120 boxes were prepared to accommodate all crabs used across the treatments and replicates. Each treatment group received yellowstripe scad (*Selariodes leptolepis*) as the feed supplemented with purslane at different concentrations. The doses for each treatment are presented in Table 1.

Container Preparation, Recirculating Aquaculture System Preparation, and Crab Seed Acclimatization

This study used polyethylene boxes measuring 30 × 33 × 15 cm as containers for maintaining soft-shell crab, which were arranged vertically to resemble an apartment system (Figure 1). A total of 120 boxes were used in the study. The container preparation stages included cleaning the boxes, installing and cleaning the RAS filters, filling the water, and checking the functionality of all system components. The soft-shell crab was maintained using a fiber RAS measuring 400 × 135 × 100 cm. Before the system was used, all RAS filter components were thoroughly cleaned, dried in the sun, and then reinstalled in the system container. After that, the RAS was filled with seawater at 25 ppt salinity. The water in the system was left for 3-7 days to stabilize the environmental conditions before the crabs were introduced. The filtration system used consisted of three types of filtration, namely physical, chemical, and biological, with a configuration of four filter chambers that included a physical filter, a biological filter, an aeration chamber, and a chemical filter equipped with a protein skimmer and sand filter. The media used in the filtration system included *Dacron* (synthetic cotton), ginger coral, *Japmat*, bioballs, *Kaldnes*, and ultraviolet (UV) lamps.

The acclimatization process was carried out immediately upon the crabs' arrival at the research site to allow adjustment to the water conditions in the system, with temperatures ranging from 27-30°C. The stocking density applied was one crab per box. Acclimatization was conducted by immersion in culture water for 15 minutes in a plastic container measuring 41 × 28 × 15.5 cm. The acclimation container was filled with seawater at a salinity of 25 ppt, which falls within the optimal salinity range for soft-shell crabs of 15–35 ppt (Hastuti *et al.*, 2015).

Preparation and Administration of Test Feed

In this study, the main feed used was yellowstripe scad, which contained 4.67% ash, 19.98% protein, and 2.29% fat. Purslane plant

Table 1. The doses of purslane combined with yellowstripe scad administered to the test mangrove crab

Treatment	Description
P0	Yellowstripe scad + purslane 0 g kg^{-1}
P60	Yellowstripe scad + purslane 60 g kg^{-1}
P70	Yellowstripe scad + purslane 70 g kg^{-1}
P80	Yellowstripe scad + purslane 80 g kg^{-1}

pieces were then added as a molting stimulus in accordance with the treatment dose. The feed ingredients were mixed in a blender until a well-mixed dough formed, then shaped into small balls, approximately 2-2.5 cm in diameter. The amount of feed given to the test crabs was 5% of each crab's body weight, once daily at 04:00 p.m., during the 30-day maintenance period. The prepared feed was stored at -18°C in a freezer. Before being given to the crabs, the frozen feed was defrosted at room temperature for ± 15 minutes to allow easier consumption by the crabs.

Water Quality Management and Monitoring

Water quality management was carried out through routine siphoning. The siphoned waste was drained into the filtration system without removing water from the system, allowing the used water to be processed and reused. Water recycling was carried out through filtration, sedimentation, and bioremediation stages in a controlled closed system, supported by physical, chemical, and biological filters. The filtered water was then pumped using a submersible pump (Elestar, China) to an ultraviolet (UV) unit for sterilization before being returned to the crab rearing tanks. The filters were cleaned weekly with seawater to maintain the efficiency of the system. Feed residue was cleaned by siphoning a fraction of the water and removing and washing all installed equipment. The equipment was then reinstalled to maintain optimal rearing media conditions.

Water quality monitoring was carried out *in-situ* twice a day, in the morning (08:00 a.m.) and in the afternoon (at 04:00 p.m.), with parameters measured including temperature, pH, salinity, and dissolved oxygen (DO) (AZ instrument AZ86031, Taiwan) (Cilenti *et al*., 2024). Meanwhile, chemical parameters such as total ammonia nitrogen (TAN), nitrite, nitrate, and alkalinity are analyzed every seven days using a spectrophotometric method with Photometer type PL02B-6P (Germany) (Tavares *et al*., 2018).

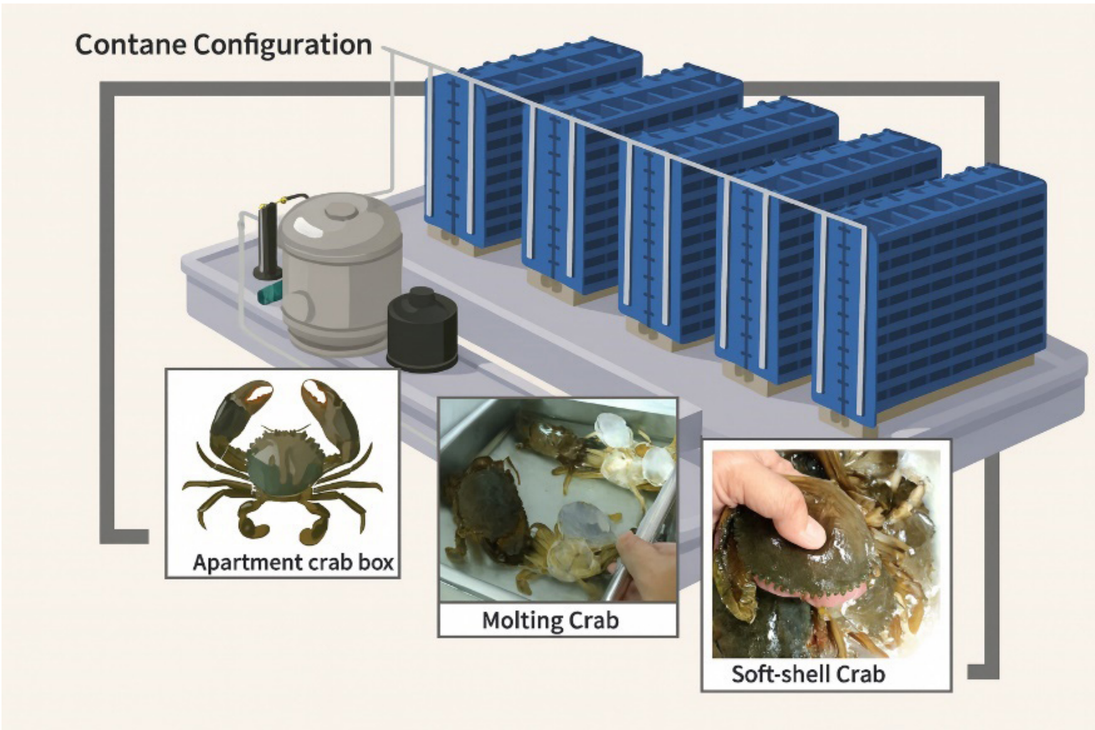

Figure 1. Design of a crab culture system using an apartment box integrated with a recirculating aquaculture system (RAS), accompanied by illustrations of the molting stages leading to soft-shell crab

Test Parameters

Survival Rate

According to Ihsanudin *et al.* (2014), the survival rate of aquatic organisms can be calculated using equation (1):

$$SR = \left(\frac{N_t}{N_0}\right) \times 100 \quad \text{.....................................(1)}$$

Description:
SR = Survival rate (%)
N_t = Number of crabs at the end of the rearing period (individuals)
N_0 = Number of crabs at the beginning of the rearing period (individuals)

Absolute Growth Rate

The absolute growth rate represents the increase in individual body mass during the rearing period. The value of the absolute growth rate is calculated using equation (2) proposed by Ihsanudin *et al.* (2014):

$$AGR = W_t - W_0 \quad \text{...(2)}$$

Description:
AGR = Absolute growth rate (g)
W_t = Final body weight of the crab at the end of rearing period (g)
W_0 = Initial body weight of the crab at the beginning of rearing period (g)

Molting Percentage

Molting percentage shows the proportion of individuals that underwent molting during the rearing period. The calculation of molting percentage refers to Rosmiati *et al.* (2016) using equation (3):

$$M = \left(\frac{N_t}{N_0}\right) \times 100 \quad \text{.....................................(3)}$$

Description:
M = Molting percentage (%)
N_t = Number of crabs that molted at the end of the rearing period (individuals)
N_0 = Number of crabs at the beginning of the rearing period (individuals)

Table 2. Water quality characteristics in the soft-shell crab culture using recirculating aquaculture system with apartment boxes and supplementation of purslane at high doses during the 30-day rearing period

Parameter	Morning	Afternoon	Optimum value (Dutta *et al.*, 2022)
In-situ			
Temperature (°C)	26.4-28.7	26.4-29.0	19-32
pH	7.6-7.9	6.8-8.2	7.0-9.0
Dissolved oxygen (mg L^{-1})	5.2-8.9	5.0-9.5	≥5
Salinity (ppt)	22-27	22-27	25
Ex-situ			
Total ammonia nitrogen (mg L^{-1})	0.38-0.45		<3
Nitrite (mg L^{-1})	0.07-0.19		<10
Nitrate (mg L^{-1})	1.39-2.35		<10
Alkalinity (mg L^{-1})	44-120		≥80

Feed Consumption

Feed consumption is defined as the total amount of feed ingested by the crabs during the rearing period. It is determined by the difference between the total feed provided and the uneaten feed remaining.

Feed Conversion Ratio

Feed conversion ratio is a measure of feed utilization efficiency, expressed as the ratio of total feed given to biomass gain achieved. The equation (4) used refers to Ihsanudin *et al.* (2014):

$$FCR = \left(\frac{P_a}{(B_t + B_m) - B_0} \right) \quad ....(4)$$

Description:

FCR = Feed conversion ratio

P_a = Total feed provided (g)

B_t = Crab biomass at the end of rearing period (g)

B_0 = Crab biomass at the beginning of rearing period (g)

B_m = Biomass of dead crabs (g)

Data Analysis

The research data were tabulated using Microsoft Excel 2019 and further analyzed using IBM SPSS Statistics version 27.0. The differences among treatments were analyzed using ANOVA with a 95% confidence level. If the test results showed a significant effect, a further test was performed using Duncan's test.

RESULTS AND DISCUSSION

Survival Rate, Absolute Growth Rate, Feed Consumption, and Feed Conversion Ratio

The survival rate (SR) ranged from 73.3 ± 4.71% to 83.3 ± 4.71%, with the highest value observed in P70, followed by P80, P60, and P0. However, statistical analysis showed no significant differences among treatments ($P > 0.05$), indicating that the addition of purslane did not affect crab survival. In contrast, the absolute growth rate (AGR) was significantly influenced by treatment ($P < 0.05$). The highest AGR was recorded in P70 (1.30 ± 0.40 g), followed by P80 and P60 (1.20 ± 0.60 g and 1.20 ± 0.20 g, respectively), while the lowest value was observed in P0 (1.02 ± 0.20 g) (Table 3).

The results indicate that purslane supplementation is safe for mangrove crabs and does not negatively affect survival. Similar findings were reported by Hildayanti *et al.* (2016), who found no significant differences in the survival of common carp (*Cyprinus carpio*) fed diets containing purslane seed oil, despite variations in growth and nutrient retention. The improved growth performance observed in this study may be associated with the presence of 20-hydroxyecdysone in purslane, which acts similarly to ecdysone hormones in arthropods and plays a role in regulating growth and metabolism (Lafont *et al.*, 2021; Subpiramaniyam, 2021; Yu *et al.*, 2023). In addition, Aina *et al.* (2024) reported that the addition of purslane extracts significantly enhanced the growth of betta fish. The high nutritional value of purslane, particularly its omega-3 fatty acids, also contributes to improved growth performance (Srivastava *et al.*, 2023). Furthermore, bioactive compounds such as flavonoids, polysaccharides, and phenolic acids exert antioxidant and immunostimulatory effects, enhancing resistance to environmental stress (Ghorani *et al.*, 2023; Rozirwan *et al.*, 2025).

Feed consumption ranged from 0.89 ± 0.10 kg to 1.10 ± 0.07 kg, with the highest value in P70 and the lowest in P0. However, no significant differences were observed among treatments ($P > 0.05$). Similarly, the feed conversion ratio (FCR) was not significantly affected by treatment ($P > 0.05$), although the lowest FCR value was found in P70 (2.48

± 0.15), indicating better feed efficiency (Table 3).

The addition of purslane did not significantly affect feed consumption or FCR. This result is consistent with Hidayat *et al.* (2024), who reported no significant effects on feed intake and utilization in mud crabs supplemented with plant extracts. Purslane contains vitamins E, C, and B, which support metabolic processes (Faisal *et al.*, 2025). In addition, it is rich in bioactive compounds such as omega-3 fatty acids, flavonoids, β-carotene, and minerals, which play important roles in physiological processes, including molting regulation, antioxidant activity, and cellular protection, rather than directly improving feed utilization efficiency (Ghorani *et al.*, 2023).

Total Molting

Throughout the 30-day rearing period in the recirculating aquaculture system (RAS), the molting performance shown in Table 4 tended to increase with the addition of purslane. The control group (0 g kg^{-1}) exhibited the lowest molting activity, ranging from three to four individuals. In contrast, crabs fed diets supplemented with purslane showed higher total molting, ranging from five to seven individuals in P60 treatment, seven to eight individuals in P70 treatment, and six to eight individuals in P80 treatment. These results indicate a tendency for increased molting activity in response to purslane supplementation. The study by Hidayat (2024) reported that the addition of purslane at a concentration of 60 g kg^{-1} of feed accelerated the molting process, with up to 19 crabs undergoing exuviation. This finding supports the potential role of purslane as a natural molting stimulant.

The molting process in crabs is regulated by the endocrine system, in which ecdysteroids act as the primary regulators controlling molting (Zhao *et al.*, 2022). An increase in ecdysteroid levels in the hemolymph is essential to initiate molting, as this hormone regulates the expression of various genes involved in the process. Ecdysone, the active form of ecdysteroid, stimulates gene expression, thereby accelerating the completion of the premolt stage and triggering molting (Zhao, 2020).

Crabs naturally produce ecdysteroid hormones; however, the synthesis occurs gradually and is strongly influenced by internal factors (e.g., physiological condition and age) and external factors (e.g., temperature, salinity, and nutrition). The concentration of ecdysteroids varies across molting stage. According to Herlinah *et al.* (2015), the highest concentration required during the premolt phase reached up to 175.2 mg L^{-1}, to effectively

Table 3. Survival rate, absolute growth rate, feed consumption, and feed conversion ratio of soft-shell crab reared in a recirculating aquaculture system (apartment box) and supplemented with high doses of purslane

Treatment	SR (%)	AGR (g)	FC (kg)	FCR
P0	73.3 ± 4.71[a]	1.02 ± 0.20[a]	0.89 ± 0.10[a]	3.99 ± 0.17[a]
P60	76.7 ± 9.43[a]	1.20 ± 0.20[b]	1.00 ± 0.10[a]	3.63 ± 0.31[a]
P70	83.3 ± 4.71[a]	1.30 ± 0.40[c]	1.10 ± 0.07[a]	2.48 ± 0.15[a]
P80	80.0 ± 8.16[a]	1.20 ± 0.60[b]	1.07 ± 0.12[a]	2.83 ± 0.13[a]

Note: Values with different superscript letters in the same column indicate significantly different results ($P < 0.05$). SR: survival rate, AGR: absolute growth rate, FC: feed consumption, and FCR: feed conversion ratio. P0: Yellowstripe scad + purslane 0 g kg^{-1}, P60: Yellowstripe scad + purslane 60 g kg^{-1}, P70: Yellowstripe scad + purslane 70 g kg^{-1}, P80: Yellowstripe scad + purslane 80 g kg^{-1}.

initiate molting. Therefore, supplementation with exogenous ecdysteroids may be a potential approach to support endogenous hormone activity and promote molting.

The ecdysteroid-like substances present in purslane highlight the potential of this plant to enhance molting in mud crabs (*S. serrata*), thereby supporting growth performance and production efficiency in aquaculture systems. However, as this study did not directly measure steroid concentrations, these results should be considered cautiously and are based on established theoretical frameworks, which are supported by relevant literature.

Molting Percentage

The molting percentage of soft-shell crabs was significantly affected by purslane supplementation ($P < 0.05$) (Table 5). The highest molting percentage was numerically observed in the P70 treatment (76.6 ± 5.8%), followed by P80 (70.0 ± 10.0%) and P60 (63.3 ± 5.8%). However, no significant differences were found among purslane-supplemented groups (P60, P70, and P80) ($P > 0.05$). All supplemented treatments showed significantly higher molting percentages than the control group (P0), with a value of 36.6 ± 5.8%. These results indicate that dietary supplementation of purslane increased the molting percentage of soft-shell crabs compared to the control. This pattern is consistent with the total molting data in Table 4, where higher molting counts were also found in the purslane treatments.

The improvement in molting percentage may be associated with the presence of 20-hydroxyecdysone in purslane (Ihsan *et al.*, 2024), which functions as a molting hormone by stimulating exuviation. The slightly lower value observed in P80 suggests that increasing the dose beyond a certain level may not further enhance performance. Similar findings were reported by Liu *et al.* (2022), who found that excessive doses of exogenous 20-hydroxyecdysone (20-HE) hormone can induce negative feedback, thereby reducing the effectiveness of ecdysteroid in the crab's hemolymph.

Table 4. Daily molting frequency and total molting of soft-shell crabs during the 30-day rearing period and supplementation of high doses of purslane in a recirculating aquaculture system using apartment boxes

Purslane Dosage	Day																														Total Molting
($g.kg^{-1}$ feed)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
P0 (A)	0	0	0	0	0	0	0	[redacted]	0	0	0	0	0	[redacted]	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	3
P0 (B)	0	0	0	0	0	0	[redacted]	0	0	0	0	0	0	0	[redacted]	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	4
P0 (C)	0	0	0	0	0	0	[redacted]	0	0	0	0	0	[redacted]	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	4
P60 (A)	0	0	0	[redacted]	0	0	0	[redacted]	0	0	0	0	[redacted]	0	0	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	6
P60 (B)	0	0	[redacted]	0	0	[redacted]	0	0	0	0	0	[redacted]	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	7
P60 (C)	0	0	0	[redacted]	0	[redacted]	[redacted]	0	0	0	[redacted]	0	0	[redacted]	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	7
P70 (A)	[redacted]	0	[redacted]	0	0	[redacted]	0	0	0	[redacted]	0	0	0	0	[redacted]	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	8
P70 (B)	[redacted]	0	0	[redacted]	0	0	[redacted]	0	0	[redacted]	0	0	[redacted]	0	[redacted]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
P70 (C)	0	[redacted]	0	0	[redacted]	0	0	[redacted]	0	0	0	0	0	[redacted]		0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	7
P80 (A)	0	0	0	0	[redacted]	0	0	0	0	[redacted]	0	0	0	0	[redacted]	0	0	0	0	2	0	0	1	0	0	0	0	0	0	0	7
P80 (B)	0	0	0	0	[redacted]	0	0	0	0	0	[redacted]	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
P80 (C)	0	0	0	[redacted]	0	0	0	0	[redacted]	0	0	0	[redacted]	0	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	8

Note: Values represent the number of individuals molting per day in each replicate. Total molting indicates the cumulative number of crabs that molted during the 30-day rearing period. P0: Yellowstripe scad + purslane 0 g kg^{-1}, P60: Yellowstripe scad + purslane 60 g kg^{-1}, P70: Yellowstripe scad + purslane 70 g kg^{-1}, P80: Yellowstripe scad + purslane 80 g kg^{-1}.

Table 5. Molting percentage of soft-shell crab reared in a recirculating aquaculture system (apartment box) and supplemented with high doses of purslane

Treatment	Molting percentage (%)
P0	36.6 ± 5.8[a]
P60	63.3 ± 5.8[b]
P70	76.6 ± 5.8[b]
P80	70.0 ± 10.0[b]

Note: Values with different superscript letters in the same column indicate significantly different results ($P < 0.05$). P0: Yellowstripe scad + purslane 0 g kg^{-1}, P60: Yellowstripe scad + purslane 60 g kg^{-1}, P70: Yellowstripe scad + purslane 70 g kg^{-1}, P80: Yellowstripe scad + purslane 80 g kg^{-1}.

Ecdysteroid hormones are known to regulate molting and processes in crustaceans (Sorach *et al.*, 2013). Previous studies have also demonstrated that supplementation or administration of ecdysteroid-related compounds can accelerate molting. For instance, Rosmiati *et al.* (2016) reported that three compounds isolated from *Portulaca oleracea* and *Morus* sp. were able to shorten the molting period of shrimp broodstock by up to 4 days compared to the negative control.

CONCLUSION

Dietary supplementation with purslane enhanced molting performance and supported the growth of soft-shell crabs, with the best response observed at a dose of 70 g kg^{-1} of feed. These findings indicate that purslane has potential as a practical feed additive to improve molting efficiency in apartment-based recirculating aquaculture systems. Further studies are recommended to investigate the physiological mechanisms underlying these effects and to evaluate their consistency in larger-scale production settings, to support the application of purslane in commercial soft-shell crab farming.

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AUTHOR CONTRIBUTION

IR: conceptualization, validation, writing review, and editing; RAP: investigation, formal analysis, and writing original draft; DMW: conceptualization, supervision, validation, writing review, and editing; MAM: supervision, validation, writing review and editing; BAT: writing review, and editing; TC: writing review, and editing.

DECLARATION OF COMPETING INTEREST AND USE GENERATIVE AI

The authors declare that there are no conflicts of interest associated with this research. During the preparation of this manuscript, the authors used artificial intelligence (AI) tools (ChatGPT from OpenAI) to assist with language refinement and journal formatting. All AI-generated content was thoroughly reviewed, edited, and approved by the authors, who take full responsibility for the accuracy and integrity of the final publication.

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