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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

Kendala utama dalam budidaya keping 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 keping 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 keping 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 keping soka. Dosis 70 g kg⁻¹ pakan dapat direkomendasikan untuk menghasilkan respons molting terbaik pada keping soka yang dipelihara dalam sistem resirkulasi dengan metode kotak apartemen.

KATA KUNCI: efisiensi pakan; keping 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.

110 This condition not only reduces feed costs but also lowers other input expenses (Rahman
111 *et al.*, 2020).

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

126 Research results by Ihsan *et al.* (2024) show that an injection of 24 µg ecdysterone
127 hormone derived from purslane per crab can accelerate the molting rate of mangrove
128 crabs and achieve a survival rate of 100%. Furthermore, Rosmiati *et al.* (2016) reported
129 that purslane plants contain 0.43% ecdysteroid and can accelerate the molting period of
130 shrimp by 5 days compared to the control group, with a survival rate of up to 86%.
131 Additionally, Hidayat (2024) revealed that feeding a diet containing 60 g kg⁻¹ of purslane
132 plant yielded the best results for growth performance and economic benefits in soft-shell
133 farming. At this dose, the molting success rate reached 63.33% with a survival rate of

134 80%, and feed efficiency increased with a feed conversion ratio (FCR) of 1.16. Although
135 60 g kg⁻¹ was identified as the most effective dose in the previous research, the authors
136 noted that this concentration had not yet reached its optimal level and recommended
137 further evaluation with higher doses. Therefore, this research was designed to assess the
138 effectiveness of incorporating higher doses of purslane stems and young leaves into the
139 diet to identify the optimal concentration for enhancing the growth and molting
140 performance of soft-shell crabs.

141

142 ¹⁹ MATERIALS AND METHODS

143 Time and Location

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

149

150 Animals and Test Materials

151 This study used mangrove crab (*S. serrata*) seeds weighing approximately 80-100
152 g as the main test material. The crab seeds were obtained from fishermen and crab
153 collectors operating in the coastal area of Muara Gembong District, Bekasi Regency,
154 West Java, Indonesia. The test material used was fresh purslane, obtained from a flower
155 shop in Sunter Agung, Tanjung Priok District, North Jakarta, Jakarta, Indonesia. The parts
156 of the plant used were the stems and young leaves, which were then washed thoroughly
157 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.

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

Container Preparation, Recirculating Aquaculture System Preparation, and Crab

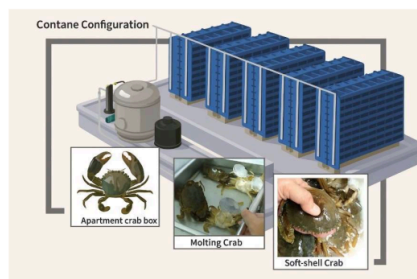
Seed Acclimatization

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

181 conditions before the crabs were introduced. The filtration system used consisted of three
182 types of filtration, namely physical, chemical, and biological, with a configuration of four
183 filter chambers that included a physical filter, a biological filter, an aeration chamber, and
184 a chemical filter equipped with a protein skimmer and sand filter. The media used in the
185 filtration system included *Dacron* (synthetic cotton), ginger coral, *Japmat*, bioballs,
186 *Kaldnes*, and ultraviolet (UV) lamps.

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

194



195

196 Figure 1. Design of a crab culture system using an apartment box integrated with a
197 recirculating aquaculture system (RAS), accompanied by illustrations of the
198 molting stages leading to soft-shell crab
199

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 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 $\pm$ 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).

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 <i>et al.</i> , 2022)
<i>In-situ</i>			
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
<i>In-situ</i>			
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

Test Parameters

Survival Rate

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

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

Description:

SR = Survival rate (%)

N_t = Number of crabs at the end of the rearing period (individuals)

N₀ = 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):

$$AGR = W_t - W_0 \dots\dots\dots (2)$$

Description:

AGR = Absolute growth rate (g day⁻¹)

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):

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

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)

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.

269
270 **Feed Conversion Ratio**

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

274
$$FCR = \left(\frac{P_a}{(B_t + B_m) - B_0} \right) \dots \dots \dots (4)$$

275 **Description:**

276 **FCR = Feed conversion ratio**

277 **P_a = Total feed provided (g)**

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

279 **B₀ = Crab biomass at the beginning of rearing period (g)**

280 **B_m = Biomass of dead crabs (g)**

281
282 **Data Analysis**

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

287
288 **RESULTS AND DISCUSSION**

289 **Survival Rate, Absolute Growth Rate, Feed Consumption, and Feed Conversion**
290 **Ratio**

291 The survival rate (SR) ranged from 73.3 ± 4.71% to 83.3 ± 4.71%, with the highest
292 value observed in P70, followed by P80, P60, and P0. However, statistical analysis

293 showed no significant differences among treatments ($P > 0.05$), indicating that the
294 addition of purslane did not affect crab survival. In contrast, the absolute growth rate
295 (AGR) was significantly influenced by treatment ($P < 0.05$). The highest AGR was
296 recorded in P70 (1.30 ± 0.40 g), followed by P80 and P60 (1.20 ± 0.60 g and 1.20 ± 0.20
297 g, respectively), while the lowest value was observed in P0 (1.02 ± 0.20 g) (Table 3).

298 The results indicate that purslane supplementation is safe for mangrove crabs and
299 does not negatively affect survival. ¹² Similar findings were reported by Hildayanti *et al.*
300 (2016), who found no significant differences in the survival of common carp (*Cyprinus*
301 *carpio*) fed diets containing purslane seed oil, despite variations in growth and nutrient
302 retention. The improved growth performance observed in this study may be associated
303 with the presence of 20-hydroxyecdysone in purslane, which acts similarly to ecdysone
304 hormones ⁵ in arthropods and plays a role in regulating growth and metabolism (Lafont *et*
305 *al.*, 2021; Subpiramanyam, 2021; Yu *et al.*, 2023). In addition, Aina *et al.* (2024) ³⁴ reported
306 that the addition of purslane extracts significantly enhanced the growth of betta fish. The
307 high nutritional value ⁵³ of purslane, particularly its omega-3 fatty acids, also contributes to
308 improved growth performance (Srivastava *et al.*, 2023). Furthermore, ³⁷ bioactive
309 compounds such as flavonoids, polysaccharides, and phenolic acids exert antioxidant and
310 immunostimulatory effects, enhancing ⁵² resistance to environmental stress (Ghorani *et al.*,
311 2023; Rozirwan *et al.*, 2025).

312 Feed consumption ranged from 0.89 ± 0.10 kg to 1.10 ± 0.07 kg, with the highest ³³
313 value in P70 and the lowest in P0. However, ³⁰ no significant differences were observed
314 among treatments ($P > 0.05$). Similarly, the ²⁸ feed conversion ratio (FCR) was not
315 significantly affected by treatment ($P > 0.05$), although the lowest FCR value was found
316 in P70 (2.48 ± 0.15), indicating better feed efficiency (Table 3).

⁴⁹ 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 ³⁹ 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).

Table 3. Survival rate, absolute ⁴⁰ growth rate, feed consumption, and feed conversion ⁴¹ 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

¹ 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.

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 ⁴² of purslane at a

343 concentration of 60 g kg⁻¹ of feed accelerated the molting process, with up to 19 crabs
344 undergoing exuviation. This finding supports the potential role of purslane as a natural
345 molting stimulant.

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

352 Crabs naturally produce ecdysteroid hormones; however, the synthesis occurs
353 gradually and is strongly influenced by internal factors (e.g., physiological condition and
354 age) and external factors (e.g., temperature, salinity, and nutrition). The concentration of
355 ecdysteroids varies across molting stage. According to Herlinah *et al.* (2015), the highest
356 concentration required during the premolt phase reached up to 175.2 mg L⁻¹, to effectively
357 initiate molting. Therefore, supplementation with exogenous ecdysteroids may be a
358 potential approach to support endogenous hormone activity and promote molting.

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

365

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

Purslane Dosage (g.kg ⁻¹ feed)	Day																														Total Molting
	parameter in a remaining sequence of 30 days using experiment codes																														
	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	0	0	0	0	0	0	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	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	4	
P0 (C)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	4	
P60 (A)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2	0	0	0	0	0	0	0	0	6	
P60 (B)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	7	
P60 (C)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	7	
P70 (A)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	8	
P70 (B)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	
P70 (C)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	7	
P80 (A)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	1	0	0	0	0	0	0	0	7	
P80 (B)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	6	
P80 (C)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	8	

368 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-
369 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:
370 Yellowstripe scad + purslane 80 g.kg⁻¹.

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 ($76.6 \pm 5.8\%$), followed by P80 ($70.0 \pm 10.0\%$) and P60 ($63.3 \pm 5.8\%$). 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 $36.6 \pm 5.8\%$. 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.

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.

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.

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,

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validation, writing – review, and editing; MAM: supervision, validation, writing – review
and editing; BAT and TC: writing – review, and editing.

1

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
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the authors, who take full responsibility for the accuracy and integrity of the final
publication.

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