Biochemical composition of the mud crab *Scylla paramamosain* (Estampador, 1949) fatted under the recirculating water system

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ABSTRACT

The meat yield, biochemical compositions of muscles, and hepatopancreas of mud crab (*Scylla paramamosain*) fatted under a recirculating water system were compared concerning molting stages, gender, and kinds of fresh feed. In the postmolt stage, the juvenile crabs (100 - 200 g of body weight) were reared into the recirculating water system and fed with two kinds of fresh feed (bivalvia and tilapia meat). As the crab developed from the postmolt stage going to the intermolt and end at the premolt stage, it was harvested and analyzed for its biochemical components. The results showed that meat yield from the legs-claw muscle of male crabs was higher ($P < 0.05$) than that of females, and hepatopancreas of crabs in the premolt stage was also accumulated higher ($P < 0.05$) than that of crabs in the intermolt stage. In terms of molting stages, the moisture content of muscles and hepatopancreas of crabs in the premolt stage was lower ($P < 0.05$) than that of crabs in the intermolt stage. The Fe content of hepatopancreas was the same result too ($P < 0.05$). Conversely, other biochemical components such as protein and lipid contents of legs-claw and hepatopancreas, Mg content of body and legs-claw muscles, and K content of legs-claw and hepatopancreas of crab in the premolt stage were higher ($P < 0.05$) than those of crabs in the intermolt stage. For the gender aspects, lipid contents of body muscle and hepatopancreas, P content of the legs-claw and hepatopancreas, and K content of the legs-claw muscle were higher ($P < 0.05$) in females than in males. In comparison, the ash content of body muscle and the Fe content of hepatopancreas of male crabs were higher ($P < 0.05$) than those of females. Regarding feed, crabs fed by bivalvia meat accumulated ash in body muscle, Ca, Mg, and P contents in hepatopancreas higher than those of crabs feeding tilapia meat. The results illuminate the possibilities for both consumers and processors to correctly select the molting stages and gender to cater specifically to their requirements.

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1. Introduction

The mud crab *Scylla* sp. is considered as one of the most popular and expensive seafood in Asian Countries, especially in South East Asian Countries (Parvathi & Padmavathi, 2020). In Vietnam, *Scylla paramamosain* is an important species cultured in the southern coast (Le Vay et al., 2001; Lindner, 2005). Recently, crabs have increased rapidly in demand due to their unique flavor and rich nutrition. Crab meat and hepatopancreas are not only rich in protein but also in minerals that are important for human body maintenance and development (Hosseini et al., 2014).

In nature, the crab growth has to undergo through the molting process. The molt cycle was divided into 4 major stages namely: the molt stage, postmolt stage, intermolt stage and premolt stage (Drach, 1939). The newly molt cycle starts from the molt stage, goes to postmolt, intermolt and end at the premolt stage. During the molting process, nutrients and minerals obtained from food and seawater are accumulated continuously to create muscle, hepatopancreas and their shell. Hence, their biochemical components vary complicatedly among period stages. In addition, meat yield and proximate composition of mud crabs were found differently in regards to different species, sizes, sexes, body parts, molt stage, season and capturing location (Parvathi & Padmavathi, 2020; Wang et al., 2021; Islam et al., 2022). The variation of the meat yield and biochemical composition would be affected by flavor and delicacy of consumers as well as the quality and value of products.

There were many studies reported on meat yield and biochemical composition of mud crabs, however, studies about the nutritional status of mud crab of *Scylla paramamosain* species concerning gender, molt stages and feed sources is limited. Thus, the primary objectives of the study were to quantify the meat and hepatopancreatic yield, and biochemical composition of fattening crabs relative to gender, molt stages and feed sources.

2. Materials and Methods

2.1. Source of mud crabs

Eighty juvenile male and female mud crabs (weight of 150 ± 50 g/crab) were collected from the extensive shrimp farm in the Ca Mau province, Vietnam (8°46’00”N; 105°01’40”E). These crabs were exactly selected in the postmolt stage following the description of Freeman & Perry (1985) and Drach (1939). All the crabs were transported quickly to Experimental farm for Aquaculture in Nong Lam University, Ho Chi Minh City, where the crabs were acclimated for three days before stocking into the Recirculating Water System (RWS) such as Figure 1. Plastic tubes of the RWS were divided into five private chambers with length x diameter (25 cm x 110 cm) by the bulkhead. Each crab was stocked individually in each chamber and arranged for genders and kinds of feeds. In Part A, twenty male crabs stocked in lines 1, 2, 3 and 4, and twenty female crabs stocked in lines 5, 6, 7 and 8 would be fed by tilapia meat. Similarly, the other male and female crabs were stocked in Part B and fed bivalvia meat. So, a 2 × 2 factorial experimental design with four various combinations of male or female crabs (gender factor) fed one of two kinds of feed (feed factor) was tested.

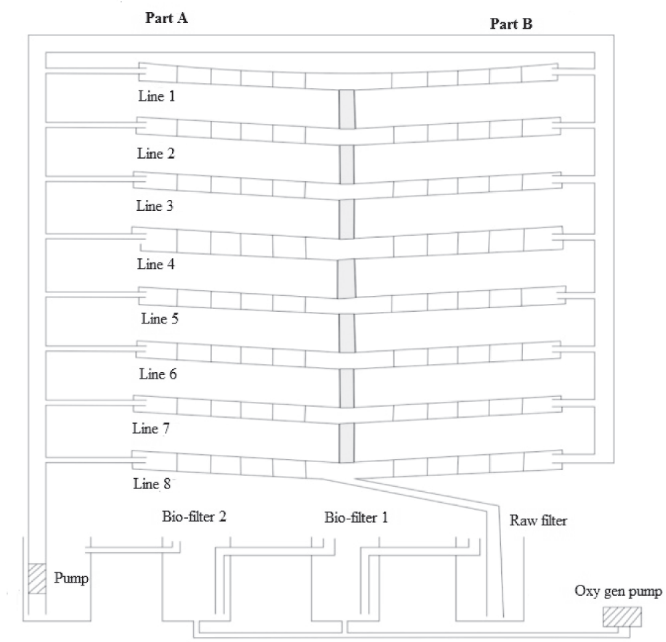

Figure 1. Diagram of the recirculating water system.

These crabs were fattened from the postmolt stage going to the intermolt stage and the end of the premolt stage. When these crabs developed into the intermolt stage, twenty-four crabs (including 6 males and 6 females fed tilapia meat and 6 males and 6 females fed bivalvia meat) were taken out, put individually crab in each plastic bag with the label and preserved in a freezer at -18 ± 2°C in the Research Institute Biotechnology and Environment for further dissection. The others would continue to rear until development into the premolt stage. When they developed into the premolt stage, they were also taken out of the RWS and preserved in the freezer at -18 ± 2°C for sample analysis. Checking and selecting the intermolt and premolt stages of crabs was based on the description of Freeman & Perry (1985) and Drach (1939).

2.2. Chemical analyses of the tissue from mud crab

At the laboratory, crabs were washed carefully with cool water. Whole-body weight of each crab was measured, and then body muscle, legs-claw muscle, and hepatopancreas were thoroughly separated by using a clean stainless steel scalpel blade. Meat and hepatopancreas removal were weighed and kept in a polyethylene bag, and immediately stored in a freezer at -18 ± 2°C for further biochemical composition analysis.

Three kinds of tissues: body muscle, legs-claw muscle, and hepatopancreas of male and female crabs from the intermolt and the premolt stages were subjected to the analyses of moisture, protein, lipid, fiber and ash contents according to TCVN 3700-90 (VS, 1990), TCVN 3705-90 (VS, 1990), TCVN 3703:2009 (VS, 2009), TCVN 4329:2007 (VS, 2007), and TCVN 5105:2009 (VS, 2009). Whereas minerals of these tissues were also determined by EDTA titrations (calcium-Ca, magnesium-Mg), photometric (phosphorous-P, iron-Fe) and flame photometric (potassium-K, sodium-Na) methods according to TCVN 12598:2018 (VS, 2018), TCVN 9516:2012 (VS, 2012), TCVN 8119:2009 (VS, 2009), and 9132:2011 (VS, 2011).

2.3. Statistical analysis

The data were checked for normality and homogeneity of variance. Data was subjected to three-way ANOVA and mean comparison was carried out using Tukey's test. A *P*-value < 0.05 was regarded as a statistically significant difference. A few indicators appeared interactions (interaction among two or three factors) but it was not much, so interactions among these factors would be ignored in the current study. All statistical analyses were conducted using the IBM SPSS Statistics for Windows, Version 22.0 (Armonk, NY: IBM Corp). All data were expressed as the mean ± standard deviation (SD).

3. Results

3.1. Meat yield of crab with regard to gender, molting stage and kinds of fresh feed

Meat yield (% of total body weight) from body muscle, legs-claw muscle, and hepatopancreas of fattening male and female mud crabs in the RWS is shown in Table 1. As for the body parts, meat yield from legs-claw muscle was the highest (15.22% - 20.67%) followed by body muscle (15.43% - 16.78%) and hepatopancreas (6.94% - 10.97%) (Table 1). Both fresh feeds (tilapia and bivalvia meat) used to fatten crabs were not affected ($P > 0.05$) by to meat yield of any body parts of the crab. Meat yield of the body and legs-claw muscle was also not significantly different between the intermolt and the premolt stage, whereas meat yield of the legs-claw muscle depended on gender ($P < 0.05$). The legs-claw muscles of male crabs had a high value compared to female crabs.

Gender and fresh feed used to fatten crabs did not influence ($P > 0.05$) hepatopancreas yield, however, the molting stage affected ($P < 0.05$) this yield. The Hepatopancreas yield of crabs in the premolt stage was higher than that of crabs in the intermolt stage.

Table 1. Meat yield (% of total body weight) from body muscle, legs-claw muscle, and hepatopancreas of male and female mud crabs

Tissue	Molting stages	Male Crab		Female Crab	
		Tilapia meat	Bivalvia meat	Tilapia meat	Bivalvia meat
Body muscle	Intermolt	15.43 ± 2.38	15.86 ± 1.43	15.73 ± 1.68	15.73 ± 1.68
	Premolt	16.72 ± 1.80	15.74 ± 2.04	15.56 ± 2.30	16.78 ± 1.58
Legs-claw muscle	Intermolt	^{1}19.85 ± 1.26	^{1}21.20 ± 2.26	^{2}19.01 ± 2.31	^{2}15.22 ± 1.91
	Premolt	^{1}20.67 ± 1.65	^{1}20.27 ± 2.03	^{2}18.75 ± 2.03	^{2}18.03 ± 1.93
Hepatopancreas	Intermolt^{A}	7.01 ± 1.05	7.22 ± 1.44	8.60 ± 1.82	6.94 ± 1.32
	Premolt^{B}	10.97 ± 3.28	7.92 ± 1.60	10.28 ± 2.79	10.32 ± 1.28

Significant differences were found between the intermolt and the premolt stages with different superscript capital letters (P < 0.05) in the molting stage column for each tissue.

Significant differences were also found between male and female for each tissue with different superscript numbers (P < 0.05) in the same row.

Significant differences were also found between crabs fed tilapia meat and those fed bivalvia meat for each tissue with different superscript letters (P < 0.05) in the same row.

No superscript (capital letters, letters and numbers) in the same row or column in the same section shows no significant difference (P > 0.05).

3.2. Biochemical composition

The biochemical composition of the body muscle of a fattening mud crab in the intermolt and the premolt stages is shown in Table 2. Protein, fiber, Ca, Fe, P, K and Na content of body muscle crab in the intermolt and the premolt stage was not significantly different ($P > 0.05$), regardless of gender and kinds of fresh feed. Conversely, the moisture and Mg content of crab in the intermolt and the premolt stage was significantly different ($P < 0.05$), regardless of gender and fresh feed. The moisture content of the crab in the intermolt stage was higher than that of the crab in the premolt stage, while the Mg content of the crab in the intermolt was lower than that of the crab in the premolt stage. Additionally, the lipid and ash content of body female and male crabs were significantly different ($P < 0.05$), regardless of the molting stage. The lipid content of female crabs was higher than that of male crabs, whereas the ash content of female crabs was lower than that of male crabs. Furthermore, the ash content of crab fed by tilapia meat was lower ($P < 0.05$) than that fed bivalvia meat, irrespective of gender and molting stage.

Table 2. Biochemical composition of body muscle of fattening mud crab between the intermolt and the premolt stages (% of wet weight)

Biochemical composition	Molting stages	Male Crab		Female Crab	
		Tilapia meat	Bivalvia meat	Tilapia meat	Bivalvia meat
Moisture (%)	Intermolt^{A}	81.69 ± 0.84	82.45 ± 1.72	81.10 ± 1.42	82.50 ± 1.42
	Premolt^{B}	79.89 ± 0.67	80.65 ± 0.06	78.85 ± 2.35	77.92 ± 2.55
Crude Protein (%)	Intermolt	12.72 ± 1.34	12.10 ± 0.94	13.76 ± 1.34	12.50 ± 0.97
	Premolt	14.40 ± 4.09	11.03 ± 0.89	14.86 ± 1.53	14.90 ± 1.36
Lipid (%)	Intermolt	^{1}8.09 ± 0.34	^{1}7.37 ± 1.76	^{2}8.74 ± 1.14	^{2}8.16 ± 1.11
	Premolt	^{1}7.37 ± 1.85	^{1}7.65 ± 0.80	^{2}9.10 ± 0.16	^{2}9.24 ± 0.31
Crude Fiber (%)	Intermolt	0.59 ± 0.18	0.48 ± 0.17	0.61 ± 0.42	0.89 ± 0.08
	Premolt	0.55 ± 0.07	0.73 ± 0.34	0.58 ± 0.27	0.66 ± 0.32
Ash (%)	Intermolt	^{1}2.27 ± 0.04^{a}	^{1}2.49 ± 0.24^{b}	^{2}2.15 ± 0.23^{a}	^{2}2.24 ± 0.09^{b}
	Premolt	^{1}2.18 ± 0.24^{a}	^{1}2.44 ± 0.13^{b}	^{2}1.90 ± 0.37^{a}	^{2}2.11 ± 0.13^{b}
Ca (mg/100g)	Intermolt	161.54 ± 18.99	212.16 ± 38.16	131.25 ± 27.26	156.26 ± 35.45
	Premolt	147.13 ± 32.12	138.80 ± 10.00	145.47 ± 13.79	155.70 ± 38.39
Mg (mg/100g)	Intermolt^{A}	32.92 ± 7.90	29.89 ± 5.42	39.41 ± 9.38	36.22 ± 12.39
	Premolt^{B}	40.80 ± 3.60	47.67 ± 5.31	37.26 ± 3.65	45.15 ± 8.61
Fe (mg/100g)	Intermolt	9.72 ± 0.99	8.83 ± 1.30	9.41 ± 1.06	9.18 ± 1.56
	Premolt	8.60 ± 1.43	9.78 ± 0.52	8.28 ± 1.89	7.86 ± 2.49
P (mg/100g)	Intermolt	126.12 ± 7.60	121.42 ± 23.40	183.85 ± 73.30	123.20 ± 8.76
	Premolt	207.63 ± 64.74	160.30 ± 49.98	125.17 ± 12.52	125.35 ± 34.74
K (mg/100g)	Intermolt	181.37 ± 7.98	176.22 ± 31.39	191.27 ± 22.53	158.79 ± 21.65
	Premolt	193.45 ± 49.31	157.23 ± 10.38	220.60 ± 43.90	204.23 ± 34.52
Na (mg/100g)	Intermolt	540.81 ± 34.69	513.63 ± 32.66	489.26 ± 30.32	548.96 ± 22.00
	Premolt	482.76 ± 80.73	584.91 ± 37.88	454.61 ± 73.83	472.84 ± 67.16

Significant differences were found between the intermolt and the premolt stages with different superscript capital letters ($P < 0.05$) in the molting stage column for each tissue.

Significant differences were also found between male and female for each tissue with different superscript numbers ($P < 0.05$) in the same row.

Significant differences were also found between crabs fed tilapia meat and those fed bivalvia meat for each tissue with different superscript letters ($P < 0.05$) in the same row.

No superscript (capital letters, letters and numbers) in the same row or column in the same section shows no significant difference ($P > 0.05$).

The biochemical composition of the legs-claw muscle of fattening mud crab in the intermolt and the premolt stages is shown in Table 3. Similarly, the Fiber, ash, Ca, Fe and Na content of the legs-claw muscle of crab in the intermolt and the premolt stage was not significantly different ($P > 0.05$), regardless of gender and kinds of fresh feed. Meanwhile, moisture, lipid and Mg content of the legs-claw muscle of crab in the intermolt and the premolt stage were different ($P < 0.05$), regardless of gender and fresh feed. The moisture content of the legs-claw of crab in the intermolt stage was higher ($P < 0.05$) than that of crab in the premolt stage, while lipid and Mg content of crab in the intermolt was lower ($P < 0.05$) than those of crab in the premolt stage. In addition, protein and K content of crab totally depended ($P < 0.05$) on molting stage and gender, regardless of fresh feed. Protein and K content of female crabs or crabs in the premolt stage were higher than those of male crabs or crabs in the intermolt stage. Moreover, the phosphor content of the legs-claw of female crabs was higher than that of male crabs, regardless of molting stage and fresh feed.

Table 3. Biochemical composition of the legs-claw muscle of fattening mud crab between the intermolt and the premolt stages (% of wet weight)

Biochemical composition	Molting stages	Male Crab		Female Crab	
		Tilapia meat	Bivalvia meat	Tilapia meat	Bivalvia meat
Moisture (%)	$Intermolt^A$	82.36 ± 0.39	82.32 ± 2.03	80.41 ± 1.54	81.82 ± 2.12
	$Premolt^B$	78.51 ± 2.20	80.62 ± 0.19	78.93 ± 1.70	76.98 ± 2.70
Crude Protein (%)	$Intermolt^A$	^{1}12.44 ± 0.67	^{1}12.21 ± 1.90	^{2}14.71 ± 1.04	^{2}13.42 ± 1.78
	$Premolt^B$	^{1}15.61 ± 2.34	^{1}11.72 ± 0.62	^{2}15.57 ± 1.30	^{2}15.88 ± 1.67
Lipid (%)	$Intermolt^A$	5.66 ± 1.87	4.93 ± 1.18	4.71 ± 0.45	4.60 ± 1.30
	$Premolt^B$	7.93 ± 1.01	7.48 ± 0.16	8.93 ± 1.43	8.94 ± 0.41
Crude Fiber (%)	Intermolt	0.79 ± 0.24	0.66 ± 0.09	0.27 ± 0.09	1.81 ± 0.79
	Premolt	0.82 ± 0.23	0.48 ± 0.19	0.82 ± 0.24	0.77 ± 0.13
Ash (%)	Intermolt	2.15 ± 0.05	2.29 ± 0.46	2.33 ± 0.34	2.28 ± 0.64
	Premolt	2.20 ± 0.32	2.55 ± 0.09	2.37 ± 0.02	2.26 ± 0.20
Ca (mg/100g)	Intermolt	161.94 ± 43.34	188.37 ± 69.74	167.04 ± 6.73	164.62 ± 29.35
	Premolt	207.50 ± 8.69	152.33 ± 26.63	186.10 ± 16.07	201.65 ± 47.49
Mg (mg/100g)	$Intermolt^A$	30.63 ± 8.73	63.86 ± 23.56	46.16 ± 8.02	58.29 ± 5.59
	$Premolt^B$	69.51 ± 19.57	70.13 ± 3.04	68.21 ± 16.77	50.42 ± 14.61
Fe (mg/100g)	Intermolt	9.21 ± 0.35	9.85 ± 0.96	8.37 ± 1.67	8.39 ± 1.60
	Premolt	8.22 ± 2.39	7.71 ± 1.26	9.79 ± 1.68	7.59 ± 0.93
P (mg/100g)	Intermolt	^{1}102.10 ± 6.71	^{1}102.62 ± 11.75	^{2}128.37 ± 14.10	^{2}115.20 ± 23.25
	Premolt	^{1}122.63 ± 33.11	^{1}96.96 ± 13.14	^{2}150.52 ± 39.13	^{2}122.36 ± 2.72
K (mg/100g)	$Intermolt^A$	^{1}165.85 ± 13.51	^{1}178.55 ± 17.36	^{2}199.72 ± 10.04	^{2}175.28 ± 21.54
	$Premolt^B$	^{1}203.89 ± 15.86	^{1}175.82 ± 17.22	^{2}196.23 ± 13.81	^{2}212.94 ± 19.16
Na (mg/100g)	Intermolt	514.05 ± 24.14	521.65 ± 85.98	539.36 ± 112.58	524.41 ± 79.34
	Premolt	493.42 ± 62.02	579.21 ± 22.28	506.18 ± 43.65	512.68 ± 86.87

Significant differences were found between the intermolt and the premolt stages with different superscript capital letters ($P < 0.05$) in the molting stage column for each tissue.

Significant differences were also found between male and female for each tissue with different superscript numbers ($P < 0.05$) in the same row.

Significant differences were also found between crabs fed tilapia meat and those fed bivalvia meat for each tissue with different superscript letters ($P < 0.05$) in the same row.

No superscript (capital letters, letters and numbers) in the same row or column in the same section shows no significant difference ($P > 0.05$).

The biochemical composition of the hepatopancreas of fattening mud crab in the intermolt and the premolt stages is shown in Table 4. Fiber, ash and Na content of hepatopancreas of crab in the intermolt and the premolt stage was not significantly different ($P > 0.05$), regardless of gender and kinds of fresh feed. On contrary, the moisture, protein and K content of hepatopancreas of crab in the intermolt and the premolt stage were different ($P < 0.05$), regardless of gender and fresh feed. The moisture content of crab in the intermolt stage was higher than that of crab in the premolt stage, while the protein and K content of crab in the intermolt was lower than those of crab in the premolt stage. Moreover, lipid and Fe content of hepatopancreas depended on ($P < 0.05$) gender and molting stage, regardless of fresh feed. The hepatopancreatic lipid and K content of crab in the intermolt stage were lower than those of crab in the premolt stage. Similarly, the hepatopancreatic lipid and K content of male crabs were lower than those of female crabs. In addition, regardless of gender and molting stage, the Ca and Mg content of the hepatopancreas of crabs were affected ($P < 0.05$) by fattening fresh feed. Crab fed bivalvia meat accumulated high amounts of Ca and Mg in the hepatopancreas as comparing with crab fed tilapia meat.

Table 4. Biochemical composition of the hepatopancreas of fattening mud crab between the intermolt and the premolt stages (% of wet weight)

Biochemical composition	Molting stages	Male Crab		Female Crab	
		Tilapia meat	Bivalvia meat	Tilapia meat	Bivalvia meat
Moisture (%)	Intermolt^{A}	81.81 ± 2.37	80.50 ± 6.03	77.20 ± 2.99	82.24 ± 4.72
	Premolt^{B}	76.08 ± 7.25	80.55 ± 0.43	72.66 ± 4.29	72.66 ± 1.98
Crude Protein (%)	Intermolt^{A}	6.81 ± 2.39	7.71 ± 1.39	8.61 ± 0.88	7.36 ± 1.75
	Premolt^{B}	10.31 ± 2.32	8.07 ± 0.26	11.36 ± 2.98	13.49 ± 4.87
Lipid (%)	Intermolt^{A}	^{1}7.41 ± 1.31	^{1}4.20 ± 1.90	^{2}6.25 ± 1.11	^{2}7.56 ± 1.81
	Premolt^{B}	^{1}6.69 ± 0.72	^{1}7.25 ± 1.46	^{2}8.93 ± 0.45	^{2}8.65 ± 1.54
Crude Fiber (%)	Intermolt	1.06 ± 0.29	0.54 ± 0.14	0.55 ± 0.47	1.12 ± 0.27
	Premolt	2.04 ± 0.90	0.86 ± 0.30	1.06 ± 0.67	0.50 ± 0.16
Ash (%)	Intermolt	2.82 ± 0.42	3.85 ± 0.87	3.19 ± 0.29	3.40 ± 0.96
	Premolt	3.23 ± 0.48	2.97 ± 0.48	3.18 ± 1.17	2.98 ± 1.17
Ca (mg/100g)	Intermolt	287.98 ± 57.50^{a}	406.85 ± 41.17^{b}	358.89 ± 33.85^{a}	425.48 ± 65.41^{b}
	Premolt	276.54 ± 61.64^{a}	309.64 ± 83.99^{b}	276.47 ± 82.14^{a}	414.16 ± 65.27^{b}
Mg (mg/100g)	Intermolt	39.87 ± 3.59^{a}	144.95 ± 43.86^{b}	75.15 ± 24.92^{a}	83.81 ± 45.21^{b}
	Premolt	83.21 ± 6.27^{a}	90.97 ± 17.81^{b}	66.77 ± 12.89^{a}	171.64 ± 14.73^{b}
Fe (mg/100g)	Intermolt^{A}	^{1}12.54 ± 0.33	^{1}14.70 ± 1.58	^{2}13.98 ± 1.63	^{2}12.05 ± 1.43
	Premolt^{B}	^{1}12.35 ± 0.35	^{1}11.92 ± 1.11	^{2}10.16 ± 2.28	^{2}10.62 ± 1.01
P (mg/100g)	Intermolt	^{1}142.62 ± 55.87^{a}	^{1}213.44 ± 16.45^{b}	^{2}226.91 ± 42.14^{a}	^{2}229.98 ± 38.74^{b}
	Premolt	^{1}160.52 ± 31.74^{a}	^{1}148.07 ± 50.18^{b}	^{2}152.17 ± 35.06^{a}	^{2}344.85 ± 47.56^{b}
K (mg/100g)	Intermolt^{A}	114.60 ± 11.96	133.39 ± 25.10	117.97 ± 16.88	109.96 ± 21.71
	Premolt^{B}	153.29 ± 8.64	128.42 ± 3.28	173.66 ± 56.95	163.37 ± 18.98
Na (mg/100g)	Intermolt	573.63 ± 3.04	585.35 ± 74.15	577.06 ± 54.59	606.93 ± 55.68
	Premolt	580.91 ± 116.27	629.97 ± 6.32	511.27 ± 89.86	488.53 ± 53.80

Significant differences were found between the intermolt and the premolt stages with different superscript capital letters ($P < 0.05$) in the molting stage column for each tissue.

Significant differences were also found between male and female for each tissue with different superscript numbers ($P < 0.05$) in the same row.

Significant differences were also found between crabs fed tilapia meat and those fed bivalvia meat for each tissue with different superscript letters ($P < 0.05$) in the same row.

No superscript (capital letters, letters and numbers) in the same row or column in the same section shows no significant difference ($P > 0.05$).

4. Discussion

The results of this study are consistent with the results of Sreelakshmi et al. (2016), legs-claw muscle of male crabs was higher than that of female crabs in both species of *S. serrata* and *S. tranquabarica*. However, this study result showed slightly higher value of meat yield than the finding of Sreelakshmi et al. (2016) with 16.8% of male and 11.43% of female crab of *S. serrata*, and 13.4% of male and 11.4% of female crab of *S. tranquebarica*. This variation might be linked to different species, feed, seasonal capture and environmental live. Moreover, the current study also found that the hepatopancreatic yield of crab accumulated in the premolt stage was higher than in the intermolt stage. It could be a result of fully accumulating nutrition and energy to readily prepare the molting for the next molt cycle.

The biochemical composition of crabs varies significantly with regard to gender, crab sources (Sarower et al., 2013), size and season (Bharathi et al., 2018), species (Parvathi & Padmavathi, 2020), body parts (Sreelakshmi et al., 2016) and feed sources (Olakiya & Kotiya, 2022). Moisture content is the major component of proximate composition (Islam et al., 2022). In the present study, the moisture content varied from 77.92% to 82.50% in body muscle, from 76.98% to 82.36% in legs-claw muscle and from 72.66% - 82.24% in the hepatopancreas of fattening crabs. This finding is consistent with early report that showed 75.30% - 81.30% in fattening crab and 76.90% - 78.20% in natural crab of *S. serrata* (Sarower et al., 2013), 78.51% - 83.85% in *S. serrata* and 78.60% - 82.40% in *S. tranquebarica* (Sreelakshmi et al., 2016), 78.20% - 79.50% in blue swimmer crab of *Portunus pelagicus* (Wu et al., 2010), 82.10% in snow crab of *Chionoecetes opilio* (Mizuta et al., 2001). The present study showed that the moisture content of all body parts and hepatopancreas of crab in the intermolt stage was higher than that in the premolt stage. It is in agreement with the results of Benjakul & Suthipan (2008) who reported a higher moisture content of body meat of soft shell (postmolt stage) compared to that of hard shell (intermolt stage) mud crab *S. serrata*. Similar results have been reported by Mizuta et al. (2001) in snow crab *Chionecetes opilio*. During the molt cycle, crab's growth is an increase in the dry weight of the body when tissue water is replaced by a protein inside its new shell (Havens & McConaugha, 1990).

For the protein content, the current study presented that protein content of body parts and hepatopancreas were 11.03% - 15.88% and 6.81% - 13.49%, respectively. More or less similar to the current result provided by previous studies, which ranged from 10.27% to 16.42% in *S. serrata* and from 11.19% to 17.63% in *S. tranquebarica* (Sreelakshmi et al., 2016) and from 18.02% to 22.14% in *S. olivacea* (Parvathi & Padmavathi, 2020). Furthermore, the current result found that the legs-claw protein content of female crabs was higher than that of male crabs. This observation is in agreement with that of Sreelakshmi et al. (2016) and Sarower et al. (2013) in *S. serrata*. In addition, the legs-claw and hepatopancreatic protein content of crab in the premolt stage was higher than that of crab in the intermolt stage, however, this information is limited in other such studies.

For the lipid content, this parameter presented significantly at both the molting stage and gender. Especially, the lipid content of female crabs in whole body parts was definitely higher than that of male crabs. It is in agreement with the results of Sarower et al. (2013), Sreelakshmi et al. (2016) and Islam et al. (2022). The lipid content of crabs varied from 0.53% to 1.54% in *S. serrata* and 0.65% to 1.37% in *S. tranquebarica* (Sreelakshmi et al., 2016), from 5.3% to 6.9% in *S. serrata* (Bharathi et al., 2018) and 4.4% to 6.9% in the same species (Islam et al., 2022). It is a slightly lower value of lipid content than the present result. Variations in the lipid content of crabs might be due to sampling season, location, sexes and size (Sarower et al., 2013; Bharathi et al., 2018). Moreover, the lipid content of crab in the premolt stage was higher than that of crab in the intermolt stage. This finding was supported by Sudhakar et al. (2008) who reported that the lipid content of hard shell (intermolt stage) crab (*Portunus sanguinolentus*) was higher than that of soft shell (postmolt stage) crab.

In the present study, the ash content was only significantly different in body muscle. The ash content of male crabs was higher than that of female crabs. Similarly, the ash content of crabs fed bivalvia meat was higher than that of crabs fed tilapia meat. This result was supported by Islam et al. (2022) who showed the ash content of fattening male was higher than female. However, limited study supported for effect of diet on ash content. The ash content shown by a previous study was 4.2% - 4.9% (Islam et al., 2022) and 2.02% - 7.65% (Sarower et al., 2013) in fattening crab of *S. serrata*, 1.2% - 2.34% in natural crab of *S. serrata* (Zafar et al., 2004), 1.80% - 2.51% in natural crab of *S. serrata* and 1.60% - 2.63% in natural crab of *S. tranquebarica* (Sreelakshmi et al., 2016). Varied value might be linked to crab size, species to species, location and capturing season.

Macroelements and microelements are essential elements for several metabolic activities and biochemical processes as well as for human body development and maintenance (Barrento et al., 2009; Hosseini et al., 2014). In the present study, five macroelements (Na, K, Mg, Ca, and P) and one microelement (Fe) were determined in crab tissue and hepatopancreas. In there, three macroelements such as Ca, Mg and P content of hepatopancreas of crabs were affected by input feed source. These element contents in the crabs fed bivalvia meat were over the crabs fed tilapia meat. This may be because bivalvia meat contains appreciable amounts of mineral elements such as Ca, $CaCO_3$, Mg, K and P (Elegbede et al., 2023). Furthermore, the Mg content in all muscle parts and K content in both legs-claw muscle and hepatopancreas of crab in the premolt stage accumulated to be higher than those of crab in the intermolt stage. It limited study on the intermolt and the premolt stage of crabs to support for this result. Only one report by Sudhakar et al. (2009) stated the total contribution of minerals including calcium, sodium, potassium, zinc and magnesium in hard shell crab (*P. sanguinolentus*) over when compared to soft shell crab.

Another element such as Fe content showed a high level in the male crabs compared to the female crabs and the Fe of crab in the intermolt stage was higher than that of crab in the premolt stage. According to Benjakul & Sutthipan (2008) who showed the Fe content in the intermolt stage nearly doubled when compared to that in the postmolt stage. However, no study reported the Fe content of crab in the premolt stage.

Crab meat is rich in essential macroelements and microelements. Wang et al, (2021) showed that the Ca, Mg, Fe, P, K and Na in edible tissue of crab (*S. paramamosain*) were 47.8 - 59.9 mg/100 g, 25.2 - 35.5 mg/100 g, 1.6 - 3.0 mg/100 g, 191 - 226 mg/100 g, 277 - 358 mg/100 g and 138 - 310 mg/100 g, respectively, and in hepatopancreas were 111 - 341 mg/100 g, 33.3 - 74.6 mg/100 g, 3.9 - 11.2 mg/100 g, 327 - 679 mg/100 g, 240 - 517 mg/100 g and 211 - 492 mg/100 g, respectively. According to Benjakul & Sutthipan (2008), the Ca, Mg and Fe content of hard shell crab (*S. serrata*) legs were 69.9 mg/100 g, 40.6 mg/100 g and 1.3 mg/100 g, respectively, and crab claw was 64.4 mg/100 g, 41.8 mg/100 g and 1.0 mg/100 g, respectively. Similar reports were given by Islam et al. (2022) who showed that the Ca, Mg, Fe and P were 903 - 1199 mg/100 g, 22.6 - 29.5 mg/100 g, 12.6 - 14.2 mg/100 g and 46.5 - 56.9 mg/100 g, respectively, in fattening crab of *S. serrata*. The finding of minerals of tissue muscle and hepatopancreas in the present study is more or less similar to the results provided by Wang et al, (2021), Benjakul & Sutthipan (2008) and Islam et al. (2022) may be linked to different source, sexes, parts of body and molt stage.

5. Conclusions

This study shows that there exists a significant difference in the meat yield and biochemical compositions of mud crabs relative to the molting stage, gender and fattening fresh feed. Female crabs in the premolt stage had a higher value of meat and nutrition than male crabs in the intermolt stage. The crabs fattened by bivalvia meat accumulated a higher level of mineral content than crabs fattened by tilapia meat. This information supports the valuable knowledge to consumers who have more choices of select good crab sources in the market. Further studies are required to analyse on the amino acid profile to give full knowledge to consumers.

Conflict of interest

The authors have no conflict of interest to declare.

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