The Biochemical Composition and Quality of Adult Chinese Mitten Crab Eriocheir sinensis Reared in Carbonate Alkalinity Water

Shihui Wang , Liang Luo , Rui Zhang , Kun Guo , Zhigang Zhao *

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Article

The Biochemical Composition and Quality of Adult Chinese Mitten Crab *Eriocheir sinensis* Reared in Carbonate Alkalinity Water

Shihui Wang [1,2], Liang Luo [1,2], Rui Zhang [1,2], Kun Guo [1,2] and Zhigang Zhao [1,2,*]

[1] Key Open Laboratory of Cold Water Fish Germplasm Resources and Breeding of Heilongjiang Province, Heilongjiang River Fisheries Research Institute, Chinese Academy of Fishery Sciences, Harbin 150070, China

[2] Engineering Technology Research Center of Saline-alkaline Water Fisheries (Harbin), Chinese Academy of Fishery Sciences, Harbin 150070, China

* Correspondence: zhaozhigang@hrfri.ac.cn; Tel.: +86-451-8793-0948

Abstract: Saline-alkaline aquaculture has become important breakthrough to expand available space for aquaculture in China. However, the biochemical composition and quality of *Eriocheir sinensis* reared in carbonate alkalinity water are still unclear. Therefore, this study investigated the edible yield, coloration, nutritional and flavor quality of *Eriocheir sinensis*. Significantly lower gonadosomatic index (GSI) and meat yield (MY) were detected in intensive pond (IP) than those in semi intensive reed wetland (SIWR) ($P< 0.05$). Six color parameters differed between IP and SIRW in the hepatopancreas ($P< 0.05$). The contents of crude protein and fat in the female hepatopancreas of IP were significantly higher than those in SIRW($P< 0.05$). The higher concentrations of ∑MUFA, ∑EFA, h/H in the female edible tissues were checked in IP than those in SIRW, with significant difference including ∑MUFA in the hepatopancreas and ovary, ∑EFA in the muscle, and h/H in the ovary ($P<0.05$). Better total free amino acid (∑FAA) contents of muscle were detected in SIRW than that in IP. Significantly increasing tendency was detected in K, Ca, Mg, Fe, Zn of ovary from SIRW to IP ($P< 0.05$). Overall, the *Eriocheir sinensis* reared in carbonate alkalinity water is an important source of nutrient.

Keywords: *Eriocheir sinensis*; saline-alkaline; aquaculture; edible yield; mineral element

1. Introduction

Saline-alkaline land, accounting for 0.95 billion ha, covers approximately 7.26% of the total land area worldwide [1], of which 99.13 million ha saline-alkaline land are located in China including approximately 45.87 million ha of low-lying saline-alkaline water mainly distributed in northeast, northwest, and coastal areas [2]. Salinity and carbonate alkalinity, serving as the most significant stressors in saline-alkaline water, have a substantial impact on the aquatic animals of growth, survival, reproduction, and quality [3–5]. Physiological metabolism, osmoregulation and intestinal microbiota of aquatic animals can be significantly influenced by high saline-alkaline concentrations [6–12]. Therefore, not all the aquatic animals can be reared in the saline-alkaline water. Only a few species, such as Nile tilapia *Oreochromis niloticus* [9], crucian carp *Carassius auratus* [10], Chinese mitten crab *Eriocheir sinensis* [11], naked carp *Gymnocypris przewalskii* [12], Bulatmai barbel *Luciobarbus capito* [13] and White shrimp *Litopenaeus vannamei* [14] are domesticated for saline-alkaline water culture. Due to the shrinking aquaculture space, thus expanding new aquaculture space for aquaculture development is essential, especially in saline-alkaline water.

The saline-alkaline water distributed in China are mainly three types, including chloride, carbonate, and sulfate, where the main ions are Na^+, K^+, Ca^{2+}, Mg^{2+}, Cl^-, CO_3^{2-}, HCO_3^-, OH^- and SO_4^{2-}, separately [15]. Meanwhile, different types of saline-alkaline water also have different ionic compositions. Cl^- is the main anion of chloride alkalinity, while CO_3^{2-} and HCO_3^- in carbonate alkalinity, SO_4^{2-} in sulfate alkalinity are also observed [16]. Among these, Daqing area in Heilongjiang province is a typical saline-alkaline wetland with abundant carbonate alkalinity ($NaHCO_3$) located in the western Songnen plain of China, where high carbonate alkalinity and pH in the saline-alkaline

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water are characteristics of the environment [17]. High carbonate alkalinity can reduce the concentration of H^+ in the saline-alkaline water due to the high pH, thereby leading to the equilibrium state toward ammonia (NH_3) direction $NH_4^+ + OH^- \rightleftharpoons NH_3 \cdot H_2O$, and making the aquatic animals NH_3 poisoning [18–20]. Consequently, the growth and quality of aquatic animals may be influenced significantly.

The Chinese mitten crab, *Eriocheir sinensis*, is an important aquatic animal with high economic and nutritional values. In addition, its aquaculture yield reached 815,318 t in 2022 [21]. *E. sinensis* is a migratory aquatic animal that grows in freshwater until it reaches sexual maturity and reproduction occurs in brackish water, thereby leading to high salinity tolerance [22]. Recent studies have also illustrated that *E. sinensis* has a high carbonate alkalinity tolerance characteristics [5,11]. However, the edible yield and quality of *E. sinensis* reared in carbonate alkalinity water outside are still unclear. Therefore, the aim of this study was to investigate the edible yield, coloration, nutritional and flavor quality of *E. sinensis* in carbonate alkalinity water.

2. Materials and Methods

2.1. Experimental set up and culture management

The *E. sinensis* was reared in carbonate alkalinity water from a local aquaculture demonstration farm (124.62°E, 45.70°N) in Zhaoyuan City of Heilongjiang Province, China. The culture experiment began on 1st May 2021 and completed on 30th September 2021. The megalopa Guanghe No. 1 was originated from Panjin Guanghe Crab Industry Co., Ltd., with the average body weight of juveniles 5.32±0.26 g/ind. These juveniles were reared in carbonate alkalinity water with stocking density 15000/ha, and the water quality parameters were as follows: intensive pond (IP), salinity 0.68±0.05 ppt, carbonate alkalinity 8.48±0.32 mmol/L, pH 8.72±0.04; semi intensive reed wetland (SIWR), salinity 0.56±0.02 ppt, carbonate alkalinity 8.88±0.04 mmol/L, and pH 8.65±0.04. IP was transplanted with Canadian pondweed, *Elodea canadensis*, while SIWR was planted with natural *Phragmites australis*. During the culture stage, the juveniles were fed twice a day at 8:00 a.m. and 5:00 p.m. with a commercial formulated diet (crude protein≥39.0%, crude fat≥5.0%, moisture≤12.0%, ash≤18.0%. Nantong Charoen Pokphand Co., Ltd., Nantong, China). The feeding amount accounted for approximately 2% of the total body weights.

2.2. Sample collection and dissection

All *E. sinensis* procedures in this study were conducted according to the Guidelines for the Care and Use of Laboratory Animals of Heilongjiang River Fisheries Research Institute (HRFRI), Chinese Academy of Fishery Sciences (CAFS), Harbin, China. The *E. sinensis* used in the present study were reviewed and approved by the Committee for the Welfare and Ethics of Laboratory Animals of HRFRI, CAFS. On 4th and 29th September 2021, a total of one hundred mature *E. sinensis* (♀:♂=1:1) reared in IP and SIWR were collected respectively. Subsequently, these alive *E. sinensis* were transported to HRFRI, CAFS, and then accurately weighed with an electronic balance (JA2002, Shanghai Puchun measuring instrument Co., Ltd., Shanghai, China), and the carapace length and carapace width were also measured with a Vernier caliper (605, Harbin measuring tools and cutting tools Co., Ltd., Harbin, China). The anatomical procedures were according to the previous study [5]. The hepatosomatic index (HSI, %), gonadosomatic index (GSI, %), meat yield (MY, %), total edible yield (TEY, %), and condition factor (CF, g/cm^3) were calculated by the following equations (1-5):

$$\text{GSI (\%)} = 100 \times \text{Gonad weight/Body weight} \quad (1)$$

$$\text{HSI (\%)} = 100 \times \text{Hepatopancreas weight/Body weight} \quad (2)$$

$$\text{MY (\%)} = 100 \times \text{Muscle weight/Body weight} \quad (3)$$

$$\text{TEY (\%)} = \text{GSI (\%)} + \text{HSI (\%)} + \text{MY (\%)} \quad (4)$$

$$\text{CF (g/cm}^3\text{)} = \text{Body weight/Carapace length}^3 \quad (5)$$

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2.3. Measurements of color and nutritional parameters

The color parameters *L** (brightness), *a** (redness) and *b** (yellowness) of carapace, hepatopancreas and female gonad (ovary) between IP and SIRW were measured by a colorimeter (CR-400, Konica Minolta, Marunouchi, Tokyo, Japan). The measured method was carried out by the Long et al 's study [23]. The overall collected samples of each edible tissue were randomly selected and combined into three duplicate samples. The proximate composition, fatty acids, free amino acids, mineral elements of *E. sinensis* reared in IP and SIRW were measured by the previous study [24]. The hypocholesterolaemic/hypercholesterolaemic ratio (h/H), index of atherogenicity (AI), and index of thrombogenicity (TI) [25] were calculated using the following equations (6-8):

$$h/H=\sum(18:1n9,18:1n7,18:2n6,18:3n6,18:3n3,20:3n6,20:4n6,20:5n3,22:4n6,22:5n3,22:6n3)/\sum(14:0,16:0) \quad (6)$$

$$AI=(12:0+4\times14:0+16:0) / (\sum n\text{-}6\ PUFA+\sum n\text{-}3\ PUFA+\sum MUFA) \quad (7)$$

$$TI=(14:0+16:0+18:0)/(0.5\times\sum MUFA+0.5\times\sum n\text{-}6PUFA+3.0\times\sum n\text{-}3PUFA+n\text{-}3/n\text{-}6\ PUFA) \quad (8)$$

2.4. Statistical analysis

The results are presented as the mean values ± standard error (SE). SPSS 22.0 software (SPSS Inc, Chicago, IL, USA) was used for statistical analysis. Independent samples t-test was used to determine the differences between IP and SIWR. The comparison test $P< 0.05$ was regarded as the statistical significance, and $P< 0.01$ was regarded as the extremely statistical significance.

3. Results

3.1. Total edible yield

The edible yield and condition factor of adult *E. sinensis* reared in carbonate alkalinity water are presented in Figure 1. For females, the HSI and CF in IP were significantly higher than those of SIRW, however, significantly lower GSI and TEY in IP were observed ($P< 0.05$, Figure 1A and C). There was significantly increasing tendency observed in male GSI, MY and TEY from IP to SIRW ($P< 0.05$, Figure 1B).

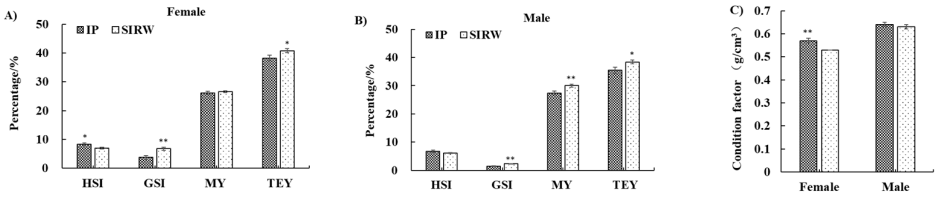

Figure 1. The edible yield (% body weight, A and B) and condition factor (%, C) of adult *Eriocheir sinensis* reared in carbonate alkalinity water. Data are presented as means ± standard error (SE) (n=25). *denotes significant difference ($P< 0.05$), **denotes extremely significant difference ($P< 0.01$). IP, *Eriocheir sinensis* reared in intensive pond; SIRW, *Eriocheir sinensis* reared in semi intensive reed wetland; HSI, hepatosomatic index; GSI, gonadosomatic index; MY, muscle yield; TEY, total edible yield.

3.2. Color parameters

The color parameters of adult *E. sinensis* reared in carbonate alkalinity water are shown in Table 1. Significantly higher *L** value of male dry carapace was observed in IP than that in SIRW ($P< 0.05$). For hepatopancreas, there were extremely significantly different *b** values of female *E. sinensis* between IP and SIRW ($P< 0.01$), while significant differences were also observed by *a** value of female

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wet hepatopancreas, L^* value of male wet hepatopancreas, and b^* values of male hepatopancreas ($P< 0.05$). No significant differences were found in ovary color between IP and SIRW ($P> 0.05$).

Table 1. The color comparison of adult *Eriocheir sinensis* reared in carbonate alkalinity water.

Item		Color	Female		Male	
			IP	SIRW	IP	SIRW
Carapace	Wet sample	L^*	47.18±0.99	48.57±0.95	47.78±0.70	49.51±1.13
		a^*	2.76±0.29	2.78±0.21	3.26±0.24	3.26±0.40
		b^*	15.04±0.39	16.59±0.77	16.08±0.48	17.70±0.62
	Dry sample	L^*	67.09±1.15	64.89±0.95	70.16±1.00*	65.80±1.11
		a^*	21.30±0.96	21.29±1.02	20.79±1.12	20.95±1.53
		b^*	40.99±1.14	42.19±1.15	45.85±1.10	43.29±0.88
Hepatopancreas	Wet sample	L^*	62.22±1.61	61.52±1.25	54.65±2.18	62.46±2.18*
		a^*	15.52±1.89	21.65±1.31*	16.90±1.13	16.59±1.33
		b^*	43.38±2.94	54.23±1.32**	39.46±2.42	48.41±2.48*
	Dry sample	L^*	60.60±2.73	63.99±2.12	57.31±4.01	64.41±1.43
		a^*	12.53±3.25	15.43±1.42	14.01±1.48	13.22±0.92
		b^*	37.49±1.49	48.43±1.26**	35.17±1.31	45.26±2.37*
Gonad	Wet sample	L^*	28.55±0.48	28.25±0.32	——	——
		a^*	1.78±0.67	1.22±0.27	——	——
		b^*	3.96±0.41	3.88±0.24	——	——
	Dry sample	L^*	74.96±1.77	73.96±0.54	——	——
		a^*	30.93±2.00	32.31±0.86	——	——
		b^*	52.01±0.19	51.34±0.87	——	——

Note: Data are presented as means ± standard error (SE) (n=25). "——"means no detection. *denotes significant difference ($P< 0.05$), **denotes extremely significant difference ($P< 0.01$). Abbreviations: IP, *Eriocheir sinensis* reared in intensive pond; SIRW, *Eriocheir sinensis* reared in semi intensive reed wetland.

3.3. Proximate composition

The proximate composition of adult *E. sinensis* reared in carbonate alkalinity water are presented in Table 2. The contents of crude protein and crude fat in the female hepatopancreas in IP significantly increased compared with that in SIRW ($P< 0.05$). A significantly increasing tendency was observed by crude protein in male gonad from IP to SIRW ($P< 0.05$), while the content of crude protein in male muscle in IP was lower than that in SIRW, with an extremely significant difference ($P< 0.01$).

Table 2. The proximate composition of adult *Eriocheir sinensis* reared in carbonate alkalinity water (%, wet weight).

Item	Female		Male	
	IP	SIRW	IP	SIRW
Hepatopancreas				
Moisture	48.74±5.16	61.72±3.17	61.18±1.82	62.32±1.69
Crude protein	11.17±0.16*	9.63±0.10	8.79±1.46	8.51±1.03
Crude fat	35.39±0.05*	23.79±1.21	25.21±1.88	25.11±1.45
Ash	1.31±0.08	1.57±0.27	1.09±0.19	1.17±0.19
Gonad				
Moisture	56.46±2.89	55.25±2.66	76.08±0.62	75.05±0.77
Crude protein	28.90±0.23	28.83±0.10	15.90±0.06	16.62±0.09*
Crude fat	6.42±0.50	7.23±0.02	0.72±0.07*	0.37±0.02
Ash	1.89±0.11	1.83±0.04	2.08±0.05	2.20±0.05
Muscle				
Moisture	78.63±0.67	79.73±0.55	83.69±0.56	82.29±0.35
Crude protein	17.76±0.16	17.46±0.03	13.64±0.06	15.07±0.06**
Crude fat	0.50±0.03	0.42±0.03	0.44±0	0.39±0.02
Ash	1.44±0.03	1.54±0.02	1.38±0.01	1.48±0.08

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Notes: Data are presented as means ± standard error (SE) (n=3). * denotes significant difference (P<0.05), ** denotes extremely significant difference (P< 0.01). Abbreviations: IP, *Eriocheir sinensis* reared in intensive pond; SIRW, *Eriocheir sinensis* reared in semi intensive reed wetland.

3.4. Fatty acids profiles

Table 3 illustrates the evaluation and comparison of the main fatty acid composition, concentration and disease index of adult *E. sinensis* reared in carbonate alkalinity water. For females, the higher concentrations of ∑SFA, ∑n-3 PUFA, ∑LC-PUFA, ∑DHA+EPA in all the edible tissues, ∑PUFA in the ovary and muscle were observed in SIRW than those in IP, with no significant difference (P> 0.05). The higher concentrations of ∑MUFA, ∑EFA, h/H in all the edible tissues were observed in IP than those in SIRW, with the following significant differences: ∑MUFA in the hepatopancreas and ovary, ∑EFA in the muscle, and h/H in the ovary (P< 0.05). For males, significantly increasing tendency was detected of ∑SFA in the gonad system and muscle, ∑PUFA in the gonad system, ∑n-3 PUFA in the muscle, ∑DHA+EPA in the hepatopancreas from IP to SIRW (P< 0.05). The higher concentrations of ∑MUFA, h/H in all the edible tissues, ∑EFA in the hepatopancreas and muscle were detected in IP than those in SIRW, with the following significant differences: ∑MUFA, ∑EFA of the hepatopancreas between IP and SIRW (P< 0.05), ∑MUFA of the gonad system and muscle, ∑EFA of muscle between IP and SIRW (P< 0.01).

Table 3. The fatty acid composition in hepatopancreas, gonad and muscle of adult *Eriocheir sinensis* reared in carbonate alkalinity water (% of total fatty acids).

Fatty acid	Hepatopancreas		Gonad		Muscle	
	IP	SIRW	IP	SIRW	IP	SIRW
Female						
C14:0	1.51±0.17	2.17±0.47	0.79±0.03	1.20±0.08*	0.33±0.05	0.51±0.05
C15:0	0.63±0.03	1.31±0.34	0.47±0.06	0.93±0.10	0.27±0.02	0.47±0.04*
C16:0	22.26±0.73	23.01±1.24	16.59±0.39	17.73±0.59	12.96±0.40	13.73±0.51
C17:0	0.61±0.01	1.34±0.14*	0.50±0.06	0.77±0.04	0.73±0.07	1.34±0.14
C18:0	3.14±0.13	3.72±0.34	2.72±0.09	3.05±0.14	8.98±0.01	9.33±0.20
C20:0	0.32±0.02	0.41±0.03	0.09±0.01	0.13±0	0.17±0.02	0.28±0.01*
∑SFA	**29.24±1.11**	**33.24±2.72**	**21.25±0.63**	**24.06±0.47**	**23.42±0.57**	**25.65±0.54**
C15:1n5	0.23±0.02	0.45±0.10	0.15±0	0.26±0.02*	0.85±0.09	0.78±0.06
C16:1n7	8.38±0.30	10.95±0.34*	11.40±0.01	13.65±1.04	3.04±0.21	4.26±0.18*
C18:1n9	39.15±0.15**	32.45±0.40	33.69±1.13*	26.10±1.12	25.92±0.65	22.20±0.63
C20:1n9	1.07±0.03	1.28±0.10	0.45±0.02	0.34±0.03	0.71±0.07	0.81±0.09
∑MUFA	**49.42±0.43***	**45.89±0.27**	**46.07±1.09***	**40.51±0.07**	**30.51±1.01**	**28.04±0.48**
C18:2n6	15.81±0.20*	11.56±0.78	17.19±0.80	13.87±0.84	13.46±0.87*	8.71±0.09
C18:3n3	2.17±0.04	2.93±0.51	3.78±0.58	6.21±1.39	1.89±0.05	2.73±0.14*
C20:2n6	0.95±0.26	0.88±0.02	0.95±0.06	0.81±0.05	1.50±0.11	1.47±0.06
C20:4n6 (ARA)	0.65±0.10	1.55±0.43	2.33±0.19	3.85±0.18*	5.40±0.42	8.14±0.47*
C20:3n3	0.24±0.06	0.48±0.08	0.38±0.03	0.55±0.08	0.43±0.03	0.74±0.05*
C20:5n3 (EPA)	0.77±0.12	1.61±0.60	4.72±0.53	6.68±0.12	14.05±0.19	16.21±1.16
C22:6n3 (DHA)	0.48±0.04	1.28±0.62	3.20±0.10	2.82±0.01	9.18±0.86	7.92±0
∑PUFA	**21.29±0.72**	**20.89±2.98**	**32.85±0.51**	**35.34±0.53**	**46.08±1.57**	**46.67±0.65**
∑EFA	17.97±0.24	14.48±1.28	20.97±0.22	20.07±0.55	15.35±0.81*	11.44±0.05
∑LC-PUFA	3.32±0.48	6.21±1.71	11.71±0.81	14.99±0.04	30.55±0.77	34.74±0.63
∑n-3 PUFA	3.65±0.18	6.29±1.27	12.08±0.87	16.26±1.11	25.54±0.72	27.59±0.95
∑n-6 PUFA	17.65±0.27	14.60±0.68	20.78±0.42	19.09±0.60	20.55±0.31	19.08±0.40
n-3/n-6 PUFA	0.21±0.01	0.42±0.09	0.58±0.08	0.86±0.13	1.24±0.02	1.45±0.12
∑DHA+EPA	1.25±0.15	2.89±1.22	7.92±0.62	9.50±0.11	23.22±1.05	24.13±1.16
DHA/EPA	0.63±0.04	0.76±0.11	0.68±0.06*	0.42±0.01	0.65±0.05	0.49±0.04
h/H	2.48±0.12	2.06±0.27	3.72±0.12*	3.15±0.05	5.23±0.23	4.65±0.18
AI	0.40±0.03	0.48±0.07	0.25±0.01	0.30±0.01	0.19±0.01	0.21±0.01
TI	0.60±0.04	0.60±0.11	0.29±0	0.28±0.02	0.22±0.01	0.22±0.01
Male						

C14:0	1.35±0.16	1.59±0.22	0.37±0.03	0.48±0.04	0.26±0.01	0.36±0.01**
C15:0	0.70±0.05	0.89±0.13	0.28±0.07	0.30±0.02	0.25±0.01	0.43±0.03*
C16:0	22.16±0.12	21.49±1.23	9.26±0.27	10.43±0.33	12.93±0.11	13.18±0.49
C17:0	0.53±0.05	0.94±0.02*	0.62±0.02	0.92±0.10	0.76±0.03	1.33±0**
C18:0	3.37±0.01	3.26±0.10	8.06±0.05	7.92±0.26	9.04±0.18	9.90±0.06*
C20:0	0.37±0	0.34±0.02	0.25±0	0.26±0.01	0.17±0.01	0.26±0**
∑SFA	**29.52±0.33**	**29.53±0.88**	**19.32±0.32**	**20.70±0.02***	**23.39±0.11**	**25.45±0.46***
C15:1n5	0.25±0.02	0.24±0.13	0.93±0.05	0.73±0.08	1.08±0.03	1.02±0.02
C16:1n7	7.79±0.99	10.79±1.18	2.03±0.27	2.31±0.10	2.03±0.11	2.64±0.04*
C18:1n9	36.24±0.77*	31.27±0.62	23.88±0.24	23.19±0.17	25.31±0.07**	20.52±0.16
C20:1n9	1.09±0.05	1.01±0.04	1.34±0.04	1.22±0.10	0.79±0.01	0.79±0.07
∑MUFA	**46.03±0.21***	**43.86±0.43**	**35.91±0.02****	**30.20±0.43**	**29.20±0.06****	**24.96±0.25**
C18:2n6	19.19±0.04*	14.51±0.79	9.84±0.79	10.13±3.01	12.10±0.21*	8.59±0.35
C18:3n3	1.98±0.07	3.35±0.89	1.00±0.09	1.60±0.17	1.40±0.04	2.10±0.27
C20:2n6	0.76±0.19	0.86±0.04	3.17±0.11*	2.34±0.08	1.80±0.01	1.61±0.11
C20:4n6 (ARA)	0.65±0.11	2.11±0.28*	11.78±0.63	15.16±0.52	6.92±0.15	9.96±0.70*
C20:3n3	0.17±0.03	0.52±0.16	0.61±0.02	0.80±0.09	0.44±0.01	0.70±0.03**
C20:5n3 (EPA)	0.83±0.08	2.20±0.23*	11.13±0.10	12.35±1.31	14.74±0.09	16.18±0.02**
C22:6n3 (DHA)	0.67±0.23	2.38±0.41	6.81±0.37	5.98±0.72	9.82±0.09	9.85±0.58
∑PUFA	**24.45±0.54**	**26.62±1.31**	**44.78±0.31**	**49.10±0.45***	**47.41±0.06**	**49.59±0.72**
∑EFA	21.17±0.11**	17.86±0.11	10.84±0.88	11.73±3.18	13.50±0.17*	10.67±0.62
∑LC-PUFA	3.29±0.64	8.59±1.21	33.70±1.19	36.93±2.73	33.71±0.13	38.56±1.41
∑n-3 PUFA	3.65±0.19	8.44±1.20	19.55±0.28	20.72±1.37	26.39±0.03	28.82±0.30*
∑n-6 PUFA	20.80±0.16*	18.18±0.22	25.23±0.05	28.38±1.38	21.02±0.05	20.78±0.43
n-3/n-6 PUFA	0.18±0.01	0.47±0.10	0.78±0.02	0.74±0.13	1.26±0.01	1.39±0.01*
∑DHA+EPA	1.50±0.31	4.58±0.65*	17.94±0.47	18.32±2.02	24.56±0	26.03±0.59
DHA/EPA	0.79±0.20	1.08±0.07	0.61±0.03	0.48±0.01	0.67±0.01	0.61±0.03
h/H	2.52±0.08	2.44±0.18	6.65±0.21	6.26±0.13	5.30±0.04	4.97±0.21
AI	0.39±0.01	0.40±0.01	0.13±0.01	0.16±0	0.18±0	0.20±0.01
TI	0.60±0.02	0.47±0.06	0.20±0.01	0.20±0.01	0.21±0	0.21±0.01

Notes: Data are presented as means ± standard error (SE) (n=3). * denotes significant difference ($P< 0.05$). ** denotes extremely significant difference ($P< 0.01$). Abbreviations: IP, *Eriocheir sinensis* reared in intensive pond; SIRW, *Eriocheir sinensis* reared in semi intensive reed wetland;∑SFA, total saturated fatty acids; ∑MUFA, total monounsaturated fatty acids; ∑PUFA, total polyunsaturated fatty acids; ∑EFA, total essential fatty acids; ∑LC-PUFA, total long chain polyunsaturated fatty acids; ∑n-3 PUFA, total ω-3 polyunsaturated fatty acids; ∑n-6 PUFA, total ω-6 polyunsaturated fatty acids; DHA, docosahesaenoic acid; EPA, eicosapentaenoic acid, ARA, arachidonic acid; h/H, hypocholesterolaemic/hypercholesterolaemic ratio; AI, index of atherogenicity; TI, index of thrombogenicity.

3.5. Free amino acids composition and taste activity value

The composition and contents of free amino acids (FAAs) of adult *E. sinensis* reared in carbonate alkalinity water are presented in Table 4. With respect to females, the concentrations of Serine (Ser), Isoleucine (Ile), Lysine (Lys), Valine (Val) and ∑EFAA in the hepatopancreas significantly increased from SIRW to IP ($P< 0.05$), however, the higher concentrations of Alanine (Ala), Histidine (His), Lys, Methionine (Met) in the muscle were observed in SIRW compared with those in IP ($P< 0.05$). For males, significant differences were checked by Ile in the gonad system and ∑FAA in the muscle ($P< 0.05$), while extremely significant differences were also observed by Ala in the hepatopancreas and muscle, Glycine (Gly) in the muscle between IP and SIRW ($P< 0.01$).

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Table 4. The free amino acid composition in hepatopancreas, gonad and muscle of adult *Eriocheir sinensis* reared in carbonate alkalinity water (mg/100 g, wet weight).

Free amino acids	Hepatopancreas		Gonad		Muscle	
	IP	SIRW	IP	SIRW	IP	SIRW
Female						
Aspartic acid	61.64±1.28	41.42±6.26	2.80±0.54	3.45±0.50	2.18±0.27	2.94±0.31
Arginine	370.76±18.22	324.80±57.25	222.08±11.32	274.41±6.80	556.48±11.41	548.28±35.14
Alanine	233.89±25.35	285.79±53.52	100.10±10.94	137.58±3.70	338.37±8.75	530.03±25.96*
Cysteine	17.16±0.92	14.76±2.11	2.68±0.76	2.73±0.27	2.17±0.18	1.68±0
Glutamic acid	135.80±11.69	113.99±0.14	97.72±7.99	86.44±5.72	33.63±3.46	46.17±14.28
Glycine	130.66±21.38	133.69±24.05	60.24±5.88	64.19±10.08	347.70±24.21	453.18±78.36
Histidine	43.34±7.62	39.31±4.41	27.93±4.53	32.22±5.14	22.88±2.42	35.61±1.30*
Proline	92.75±16.01	107.32±23.94	71.14±5.25	73.86±2.83	135.70±7.48	147.75±23.28
Serine	28.33±0.66*	21.30±0.68	8.21±0.55	9.60±1.23	9.94±1.17	12.84±1.79
Tyrosine	98.84±8.62	73.88±3.42	18.61±1.70	19.23±1.67	18.08±2.52	20.06±2.60
Isoleucine▲	67.41±0.04*	60.24±1.08	9.32±1.38	10.26±2.22	8.61±0.03	13.76±3.10
Leucine▲	156.88±3.55	130.35±6.04	13.60±1.94	14.58±2.94	15.91±0.94	27.06±6.37
Lysine▲	155.55±1.00*	138.35±3.31	38.97±9.97	43.95±11.31	28.99±0.07	39.34±0.96**
Methionine▲	50.09±0.52	51.19±1.91	22.30±2.65	22.31±5.50	24.28±2.51	43.56±3.02*
Phenylalanine▲	92.75±4.09	74.59±2.04	15.49±2.05	15.18±2.40	11.57±1.02	14.83±1.23
Threonine▲	94.83±5.28	85.27±7.19	66.20±6.70	94.49±5.91	25.18±0	32.52±10.71
Valine▲	106.61±2.37*	92.42±1.26	26.09±3.65	28.94±4.53	21.70±0.40	31.46±5.97
∑EFAA	724.11±14.76*	632.4±5.94	191.98±28.34	229.71±34.81	136.24±2.23	202.54±31.35
∑FAA	**1937.29±85.06**	**1788.67±146.25**	**803.48±77.8**	**933.42±45.92**	**1603.38±9.64**	**2001.07±162.46**
PETFAA	37.42±0.89	35.62±3.24	23.77±1.22	24.49±2.52	8.50±0.19	10.06±0.75
Male						
Aspartic acid	43.85±3.26	48.34±24.86	24.44±3.22	28.43±5.07	2.27±0.56	2.74±0.04
Arginine	188.15±29.12	266.95±79.80	60.46±5.69	47.63±7.49	408.25±8.95	451.24±24.15
Alanine	139.45±13.65	318.65±0.04**	97.27±5.28	100.84±10.70	331.50±8.40	471.54±7.67**
Cysteine	8.73±1.51	16.25±8.61	1.44±0.14	2.31±0.58	3.06±0.07*	1.83±0.12
Glutamic acid	94.93±3.21	114.46±46.49	68.52±0.56	49.61±5.25	53.15±0.61	53.69±1.81
Glycine	79.84±1.00	135.22±48.32	43.29±6.29	42.69±3.20	321.59±12.02	465.93±6.64**
Histidine	30.11±0.21	41.39±11.40	8.26±1.31	6.97±0.41	22.76±1.25	25.80±1.42
Proline	66.41±2.52	93.25±8.48	61.24±4.80	41.13±1.57	97.51±6.49	121.40±22.25
Serine	17.96±1.13	22.84±7.64	3.11±0.07*	2.30±0.14	6.54±0.84	7.81±1.76
Tyrosine	70.26±1.48	83.70±39.02	17.70±0.46	18.37±1.92	26.17±4.63	23.25±1.65
Isoleucine▲	37.64±2.23	64.30±29.24	7.64±0.37	11.55±0.52*	14.99±2.55	12.50±0.52
Leucine▲	99.65±11.15	138.90±64.09	11.01±0.50	13.65±1.10	24.63±3.85	23.31±0.68
Lysine▲	91.37±13.89	145.85±67.58	13.49±2.08	12.36±1.65	41.75±4.79	30.91±2.93
Methionine▲	36.67±2.62	53.00±23.41	7.50±1.90	11.32±0.43	31.16±3.14	32.16±3.17
Phenylalanine▲	60.00±2.35	81.29±37.07	10.27±0.29	13.43±1.35	14.21±1.94	16.85±1.25
Threonine▲	57.42±2.41	85.36±25.80	15.66±2.54	10.54±0.89	35.47±2.69	27.29±2.66
Valine▲	60.49±5.91	94.62±36.67	17.26±0.96	17.16±1.50	34.95±1.08	30.06±0.48
∑EFAA	443.23±40.57	663.33±283.85	82.82±8.64	90.01±7.45	197.17±8.38	173.08±5.84
∑FAA	**1182.92±95.24**	**1804.37±558.45**	**468.56±25.61**	**430.3±43.77**	**1469.95±5.52**	**1798.31±56.21***
PETFAA	37.44±0.42	35.27±4.81	17.63±0.88	20.96±0.40	13.42±0.62*	9.62±0.02

Notes: Data are presented as means ± standard error (SE) (n=3). ▲ essential amino acid. * denotes significant difference (P< 0.05). ** denotes extremely significant difference (P< 0.01). Abbreviations: IP, *Eriocheir sinensis* reared in intensive pond; SIRW, *Eriocheir sinensis* reared in semi intensive reed wetland; ∑EFAA, total essential free amino acids; ∑FAA, total free amino acids; PETFAA, percentage of ∑EFAA to ∑FAA.

The flavor characteristics and taste activity value (TAV) of adult *E. sinensis* reared in carbonate alkalinity water are shown in Table 5. The 17 FAAs were separated as two tastes including pleasant taste (umami and sweetness) and unpleasant taste (bitterness). The concentrations of ∑TUV and ∑TBV in the female hepatopancreas of IP were higher than those in SIRW, however, higher concentration of ∑TSV was observed in SIRW. Higher concentrations of ∑TSV and ∑TBV in the ovary

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were detected in SIRW than those in IP. In the muscle and male hepatopancreas , the ∑TUV, ∑TSV and ∑TBV values of IP were lower than those of SIRW.

Table 5. The threshold and taste activity value of free amino acid composition in hepatopancreas, gonad and muscle of adult *Eriocheir sinensis* reared in carbonate alkalinity water.

Free amino acids	Flavor characteristics	Threshold (mg/100 mL)	Hepatopancreas		Gonad		Muscle	
			IP	SIRW	IP	SIRW	IP	SIRW
Female								
Aspartic acid	umami (+)	100	0.62	0.41	0.03	0.03	0.02	0.03
Glutamic acid	umami (+)	30	4.53	3.80	3.26	2.88	1.12	1.54
∑TUV			**5.14**	**4.21**	**3.29**	**2.92**	**1.14**	**1.57**
Alanine	sweetness (+)	60	3.90	4.76	1.67	2.29	5.64	8.83
Glycine	sweetness (+)	130	1.01	1.03	0.46	0.49	2.67	3.49
Serine	sweetness (+)	150	0.19	0.14	0.05	0.06	0.07	0.09
Threonine	sweetness (+)	260	0.36	0.33	0.25	0.36	0.10	0.13
Proline	sweetness/bitterness (+)	300	0.31	0.36	0.24	0.25	0.45	0.49
∑TSV			**5.77**	**6.62**	**2.68**	**3.46**	**8.93**	**13.02**
Arginine	sweetness/bitterness (-)	50	7.42	6.50	4.44	5.49	11.13	10.97
Lysine	sweetness/bitterness (-)	50	3.11	2.77	0.78	0.88	0.58	0.79
Valine	sweetness/bitterness (-)	40	2.67	2.31	0.65	0.72	0.54	0.79
Methionine	bitterness/sweetness/sulphur (-)	30	1.67	1.71	0.74	0.74	0.81	1.45
Histidine	bitterness (-)	20	2.17	1.97	1.40	1.61	1.14	1.78
Isoleucine	bitterness (-)	90	0.75	0.67	0.10	0.11	0.10	0.15
Leucine	bitterness (-)	190	0.83	0.69	0.07	0.08	0.08	0.14
Phenylalanine	bitterness (-)	90	1.03	0.83	0.17	0.17	0.13	0.16
∑TBV			**19.60**	**17.40**	**8.40**	**9.80**	**14.50**	**16.20**
Male								
Aspartic acid	umami (+)	100	0.44	0.48	0.24	0.28	0.02	0.03
Glutamic acid	umami (+)	30	3.16	3.82	2.28	1.65	1.77	1.79
∑TUV			**3.60**	**4.30**	**2.53**	**1.94**	**1.79**	**1.82**
Alanine	sweetness (+)	60	2.32	5.31	1.62	1.68	5.52	7.86
Glycine	sweetness (+)	130	0.61	1.04	0.33	0.33	2.47	3.58
Serine	sweetness (+)	150	0.12	0.15	0.02	0.02	0.04	0.05
Threonine	sweetness (+)	260	0.22	0.33	0.06	0.04	0.14	0.10
Proline	sweetness/bitterness (+)	300	0.22	0.31	0.20	0.14	0.33	0.40
∑TSV			**3.50**	**7.14**	**2.24**	**2.20**	**8.50**	**12.00**
Arginine	sweetness/bitterness (-)	50	3.76	5.34	1.21	0.95	8.17	9.02
Lysine	sweetness/bitterness (-)	50	1.83	2.92	0.27	0.25	0.84	0.62
Valine	sweetness/bitterness (-)	40	1.51	2.37	0.43	0.43	0.87	0.75
Methionine	bitterness/sweetness/sulphur (-)	30	1.22	1.77	0.25	0.38	1.04	1.07
Histidine	bitterness (-)	20	1.51	2.07	0.41	0.35	1.14	1.29
Isoleucine	bitterness (-)	90	0.42	0.71	0.08	0.13	0.17	0.14
Leucine	bitterness (-)	190	0.52	0.73	0.06	0.07	0.13	0.12
Phenylalanine	bitterness (-)	90	0.67	0.90	0.11	0.15	0.16	0.19
∑TBV			**11.40**	**16.80**	**2.80**	**2.70**	**12.50**	**13.20**

Note: + means pleasant taste; − means unpleasant taste. Abbreviations: IP, *Eriocheir sinensis* reared in intensive pond; SIRW, *Eriocheir sinensis* reared in semi intensive reed wetland; ∑TUV, total umami values; ∑TSV, total sweetness values; ∑TBV, total bitterness values.

3.6. Mineral element composition

The mineral element composition and contents of adult *E. sinensis* reared in carbonate alkalinity water are presented in Table 6. Regarding the hepatopancreas, there was no significant difference observed between IP and SIRW ($P > 0.05$). Significantly increasing tendency was detected in K, Ca, Mg, Fe, Zn of ovary from SIRW to IP ($P < 0.05$), meanwhile, the content of ∑TME in IP was extremely

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significantly different compared with that in SIRW ($P< 0.01$). The contents of K and Mg in female muscle, Na and ∑TME in male muscle were significantly increased from SIRW to IP ($P< 0.05$). Overall, the higher contents of hepatopancreas ∑TME were observed in SIRW, however, the contents of gonad and muscle ∑TME in IP were higher than those in SIRW.

Table 6. The mineral element composition in hepatopancreas, gonad and muscle of adult *Eriocheir sinensis* reared in carbonate alkalinity water (mg/kg, wet weight).

Element	Hepatopancreas		Gonad		Muscle	
	IP	SIRW	IP	SIRW	IP	SIRW
Female						
Na	1635.77±148.67	1710.28±312.14	2113.71±440.18	1061.98±78.54	3027.63±495.63	2472.82±56.59
K	2407.05±82.20	2642.24±599.61	2715.20±201.54*	2090.29±72.20	3947.00±129.33*	3383.32±118.73
Ca	488.47±97.24	835.46±147.10	487.54±65.58*	230.54±26.95	1135.93±93.36	894.56±73.72
Mg	349.11±22.89	367.95±77.81	1514.93±100.57*	705.99±102.58	696.91±50.97*	491.37±11.33
Fe	79.48±8.06	79.82±9.65	41.61±4.00*	15.42±4.82	10.28±0.46	9.78±0.24
Zn	14.43±0.88	13.74±0.79	59.64±6.92*	32.65±1.53	42.05±1.27	39.76±1.36
Cu	5.98±1.41	6.29±1.16	5.97±1.36	5.05±0.40	9.87±0.53	6.63±1.19
Mn	3.69±0.67	1.61±0.34	4.66±1.51	2.48±0.44	0.63±0.02	0.66±0.01
∑TME	**4983.97±319.40**	**5657.39±1101.56**	**6943.27±592.93****	**4144.40±33.23**	**8870.30±763.43**	**7298.90±167.45**
Male						
Na	1626.64±411.30	1567.84±306.79	4430.63±240.01	4502.20±49.07	3459.41±235.32*	1977.00±317.44
K	2414.57±490.21	2510.66±367.45	3397.72±166.22	2954.14±616.72	3617.96±328.32	2828.30±229.34
Ca	467.16±170.51	780.07±114.32	1129.46±76.44	1064.87±160.05	1084.10±88.74	869.42±150.51
Mg	324.33±79.49	256.74±34.56	554.40±45.71	513.87±5.79	607.20±76.02	456.52±34.59
Fe	108.43±11.12	115.75±17.56	8.47±1.03	8.05±1.40	10.10±1.35	14.08±3.65
Zn	12.20±4.04	14.97±2.14	12.11±1.68	10.38±1.39	31.96±8.21	35.04±0.73
Cu	4.54±1.94	4.04±1.28	5.06±1.03	5.71±0.91	5.90±1.83	5.04±0.69
Mn	3.68±0.61	3.14±0.80	3.55±0.42	3.52±0.44	0.80±0.23	1.21±0.63
∑TME	**4961.54±1142.91**	**5253.21±814.49**	**9541.40±194.67**	**9062.75±514.79**	**8817.43±664.45***	**6186.61±612.24**

Notes: Data are presented as means ± standard error (SE) (n=3). * denotes significant difference ($P< 0.05$). ** denotes extremely significant difference ($P< 0.01$). Abbreviations: IP, *Eriocheir sinensis* reared in intensive pond; SIRW, *Eriocheir sinensis* reared in semi intensive reed wetland; ∑TME, total mineral elements.

4. Discussion

4.1. Total edible yield

The hepatopancreas, gonad and muscle are important edible tissues of *E. sinensis*. However, previous studies were focused on the total edible yield of *E. sinensis* reared in the freshwater [26,27], chloride or sulfate-type saline-alkaline water [28], while little literature was paid close attention to the *E. sinensis* reared in carbonate alkalinity water. The present study indicated that the *E. sinensis* can complete gonadal development normally compared with the previous studies [5,24]. The GSI value of female *E. sinensis* was 3.78±0.67% reared in IP on 4th September and 6.75±0.55% in SRW on 29th September, while the GSI value of female *E. sinensis* was 5.30±0.22% in freshwater pond on 15th September [24]. It has been demonstrated that usually the later the sampling period, the higher the GSI in the same location, which was consistent with the present study. The specific values between previous and present studies were different, which were mainly caused by the difference in water temperature and sampling period [5,24,26,27]. The MY and TEY values of female *E. sinensis* in present study were 26.11±0.67%, 26.53±0.28%, 38.19±0.98%, and 40.78±0.68%, respectively, indicating that *E. sinensis* reared in carbonate alkalinity water have similar MY and TEY values compared with that in the previous studies [5,26,27]. Overall, the above results showed that the *E. sinensis* reared in carbonate alkalinity water will not significantly affect the gonadal development and the total edible yield.

4.2. Color parameters

The color is one of the important indicators for sensory and quality evaluation of *E. sinensis*. In the cognition of consumers, the higher reddish values of the dried carapace and ovary, as well as the higher reddish and yellowish values of the wet hepatopancreas, suggest better quality [23]. It has been demonstrated that the reddish and yellowish parameters of *E. sinensis* tissues are significantly related to the deposition of carotenoids [29]. The present study illustrated that the *b** values of the IP [female: 40.99±1.14; male: 45.85±1.10] and SIRW [female: 42.19±1.15; male: 43.29±0.88] freeze-dried *E. sinensis* carapace reared in carbonate alkalinity water were obviously higher than those of wild-caught mitten crabs in the natural Suifenhe and Nanliujinag delta [30], suggesting that *E. sinensis* reared in carbonate alkalinity water accumulated more carotenoids. Similar *b** values of freeze-dried three-year-old *E. sinensis* carapace were also observed in the pond of Zhaodong city, Heilongjiang Province, China [24]. In addition, the higher *b** values of the IP [52.01±0.19] and SIRW [51.34±0.87] freeze-dried *E. sinensis* ovary in the present study were also detected in carbonate alkalinity water compared with previous studies [24,30]. These results suggested that *E. sinensis* reared in carbonate alkalinity water accumulated more carotenoids and represented better quality.

4.3. Biochemical composition

The biochemical composition, especially crude protein, has become one of the most important indicators for evaluating the nutritional value of aquatic animals, and can be affected by numerous factors, such as the culture environment [24]. The present study demonstrated that although the culture environment of IP and SIRW were all belonged to the carbonate alkalinity water, significant differences were still observed between IP and SIRW. The crude protein of female IP [11.17±0.16%] and SIRW [9.63±0.10%] hepatopancreas were higher than those cultured in the Shandong, Qinghai, and Shanghai [26,28], wild mitten crabs caught in the Suifenhe, Liaohe, and Nanliujiang [30]. At the same time, the crude protein of *E. sinensis* gonad and muscle reared in carbonate alkalinity water were similar with those in the previous studies [24,26,28,30]. All these results illustrated that *E. sinensis* reared in carbonate alkalinity water was a good high-protein seafood source.

4.4. Fatty acids composition

The fatty acid composition and contents have also been one of the most important nutritional indicators for aquatic animals, particularly essential fatty acids (EFAs), and unsaturated fatty acids (UFAs) [24,30]. The present study showed that the total saturated fatty acids (∑SFA), total monounsaturated fatty acids (∑MUFA) and total polyunsaturated fatty acids (∑PUFA) of *E. sinensis* reared in carbonate alkalinity water were similar to those cultured in the other regions [24,27,28,30], implying that alkalinity water did not significantly alter the fatty acid composition of *E. sinensis*. It can be estimated that the fatty acid composition and content changes of the *E. sinensis* differential edible tissues should be mainly contributed by heredity, and then followed by culture environment and diet. The culture environment can slightly regulate the fatty acid contents other than that of composition.

Due to the fact that PUFAs are more beneficial to the human health, it has been received widespread attention, especially the DHA, EPA, and ARA [31]. Numerous studies have confirmed that DHA and EPA can play an important role in preventing inflammation and cardiovascular diseases, while ARA can promote the development of the central nervous system [31–33]. The present study demonstrated that alkalinity water affected the fatty acid contents of *E. sinensis* compared with previous studies [26,27]. Furthermore, increasing DHA, EPA, and ARA contents in males, but decreasing DHA and EPA contents in females were detected, implying the differential effects of alkalinity on genders of *E. sinensis*. These results were consistent with our previous studies [5]. As *E. sinensis* reared in the similar carbonate alkalinity water with differential culture type, the EPA and ARA contents of male hepatopancreas and muscle in SIRW were significantly increased compared with those in IP. This phenomenon can be explained by the different developmental stage, because the EPA and ARA contents of hepatopancreas and muscle increased with the GSI improvement [27].

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The h/H, AI and TI are important indexes used to evaluate the beneficial effects of fatty acids on the human health [24,25]. Generally, the higher h/H, the lower AI and TI are illustrated to be better quality for human health. The three indexes of *E. sinensis* reared in carbonate alkalinity water were similar to the results of previous studies [24,30].

4.5. FAAs composition and TAV analysis

The FAAs composition and contents are one of the important factors affecting the taste and quality of crustaceans [24]. The present study illustrated that the ∑EFAA [IP: (724.11±14.76) mg/100 g; SIRW: (632.4±5.94) mg/100 g] and ∑FAA [IP: (1937.29±85.06) mg/100 g; SIRW: (1788.67±146.25) mg/100 g] contents of female *E. sinensis* hepatopancreas reared in carbonate alkalinity water were higher than wild-caught mitten crabs [30], and three-year-old *E. sinensis* [24], indicating better taste quality. These results were consistent with our previous studies, in which the prolonged alkalinity stress can improve the ∑EFAA and ∑FAA contents [5]. In terms of specific amino acid, differential amino acids present different taste characteristics, while the taste characteristics, TAV, is positively corelated with the ratio between the special amino acid value and its threshold. Table 5 showed that the main umami amino acid Glu, sweetness amino acid Ala were similar to previous studies [24,28,30]. Although we have classified Arg as a bitter amino acid, the flavor characteristics of Arg is actually significantly related to its concentration, with low concentration exhibiting bitterness and high concentration exhibiting umami [34]. The present study illustrated that the Arg content [IP: 7.42; SIRW: 6.50] in the female hepatopancreas was slightly higher than that of previous studies [5,24,30]. In addition, the ∑TUV, ∑TSV and ∑TBV values of female hepatopancreas were higher than those in the pond-reared and wild-caught mitten crabs [24,30], suggesting stronger flavor characteristics.

4.6. Mineral element analysis

Mineral elements are important nutritional substances required to maintain normal growth, development, and metabolism of the human beings, ensuring normal life activities [35]. Na, K, Ca, and Mg are macro-elements required by the human body and play differential roles for human health. Among these four macro-elements, Na and K play an important role in maintaining the acid-base balance and osmotic pressure of blood and body fluids. Ca is an important component of human bones and teeth. Mg participates in energy metabolism in the human body, catalyzes and activates various enzyme systems, and plays an important role in preventing cardiovascular diseases [36]. Of all the *E. sinensis* edible tissues, Na and K contents were significantly higher than other macro-elements, which was consistent with previous studies [24,37]. In addition, the K content was higher than that of Na content except for the testis, implying that the culture environment perhaps have influence on the Na and K accumulation. Fe, Zn, Cu and Mn are micro-elements required by the human body. Among these, Fe plays an important role in the body's hematopoietic, oxygen transport, and fluid balance. Zn is an important coenzyme factor in the human body and is involved in the synthesis of DNA, RNA and proteins. Cu can promote the production of hemoglobin in humans. Mn plays an important role in the central nervous system of the human brain [37]. The higher Fe content in the *E. sinensis* hepatopancreas was observed compared with that in the gonad and muscle tissues, which is an important Fe source for the human and has a certain significance in preventing iron deficiency anemia. The higher Zn contents in the *E. sinensis* ovary and muscle were checked compared with that in the testis and hepatopancreas tissues. Above results illustrated that *E. sinensis* reared in carbonate alkalinity water was a good source of mineral elements.

5. Conclusions

The present study investigated the gonadal development, edible yield, coloration, nutritional and flavor quality of *E. sinensis* reared in carbonate alkalinity water (IP and SIRW culture model). Due to the sampling time, the differential GSI and TEY values of *E. sinensis* were observed between IP and SIRW. IP accumulated more ∑MUFA, ∑EFA, h/H in the female edible tissues compared with those of SIRW, whereas SIRW had better ∑FAA content of muscle. IP also achieved more mineral

elements, such as K, Ca, Mg, Fe, Zn in the ovary. In summary, the *E. sinensis* reared in carbonate alkalinity water can complete the gonadal development, accumulate more carotenoids, rich in fatty acids, FFAs, and mineral elements, which are important nutritional sources.

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