

Nutritional Composition of *Callista erycina*, an Important Edible Economical Clam from the South China Sea

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Abstract The purpose of this study was to assess the nutritional composition of clam *Callista erycina* from the South China Sea, and determine its edible value and prospects for aquaculture development. The proximate composition, amino acid composition, fatty acid content and mineral elemental constituents of the soft tissues of clam *C. erycina* were analyzed. The results showed that the percentage edibility (PE) and condition index (CI) of clam *C. erycina* were 22.45 ± 3.00 and 95.51 ± 13.34 , respectively. The contents of protein, lipid, ash and moisture in the soft tissues (fresh sample) of the clam *C. erycina* were 13.84 ± 0.27 g, 0.53 ± 0.03 g, 2.56 ± 0.11 g and 77.86 ± 0.74 g per 100g, respectively. A total of 16 common amino acids were detected, including 9 essential amino acids and 4 umami taste amino acids, which accounted for 45.372 % and 42.881 % of the total amino acids. The amino acid score (AAS) of total essential amino acids were 134, and the first limiting amino acid was valine with 93 as AAS, which suggesting that the composition ratio of essential amino acids in soft tissues of clam *C. erycina* is in line with the FAO/WHO model. The clam *C. erycina* were rich in polyunsaturated fatty acids (33.08 ± 0.44 % of total fatty acid) with high levels of DHA (13.55 ± 0.55 % of total fatty acid) and EPA (7.58 ± 0.19 % of total fatty acid). Among the mineral elements, sodium (Na) and potassium (K) has the highest mass fraction, followed by phosphorus (P), magnesium (Mg), calcium (Ca), iron (Fe) and zinc (Zn). The results show that clam *C. erycina* are marine economic shellfish with high nutritional value and edible value, suggesting that the consumption increment and aquaculture activities of clam *C. erycina* should be encouraged.

Keywords: *Callista erycina*, nutrients, amino acid, fatty acids, minerals

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1. Introduction

Shelled molluscs, especially mussels, oysters and clams, belong to the commercially important benthic group of organisms and are food resources of nutrients such as proteins, lipids, and minerals. Knowledge about the biochemical composition of edible bivalve molluscs is very necessary for consumers, because the nutritional value is reflected in its biochemical content [1]. Clams are products with great commercial value and are regarded as a traditional food in many countries, because they are high-quality nutritious foods and are considered gourmet foods. The nutritional quality of clams depends not only

on the relatively low lipid content and high proportion of polyunsaturated fatty acid (PUFA), but also on its high quality of the protein [2,3]. In recent years, in order to meet the growing consumption of seawater shellfish, China's large-scale fishing and aquaculture of bivalve molluscs has developed rapidly, especially along the coast of the South China Sea.

Callista erycina belongs to the family Veneridae, and is widely distributed in South China Sea [4], Indian Ocean [5], Arabian Sea [6], etc. It mainly inhabits the sandy seabed within 20 m from the intertidal zone to the shallow sea. As a kind of economical shellfish with good taste, the clam *C. erycina* is getting more popular among consumers in China, and it is not sustainable by mainly be produced through harvesting natural resources. There is very little

research on clams *C. erycina*, only Wei et al. studied the correlation and path analysis of the quantitative traits of the clam *C. erycina* [4]. In addition, Palma et al. determined the calcium content in the shells of clams *C. erycina* and found that there was no significant difference comparing with the *Crassostrea echinata*, *Perna viridis*, and *Placuna placeta* [7]. Zou et al. reported that there were no detectable diarrhetic shellfish poisoning (DSP) toxins in clams *C. erycina* from Xincun Bay, Hainan Island, the South China Sea [8]. There is no research report on the comprehensive analysis of the nutrient composition of the clam *C. erycina*, only Lao et al. reported the fatty acid content and composition of the clam *C. erycina* collected from seafood market in Guangzhou, China [9].

In order to understand the nutritional characteristics of clams *C. erycina* and provide theoretical guidance for their artificial breeding. This article conducted a comprehensive analysis of the nutritional composition of the soft tissues of the clams *C. erycina* from South China Sea, including the proximate composition, amino acid content, fatty acid composition and mineral elements.

2. Materials and Methods

2.1. Sample Preparation, Percentage Edibility and Condition Index of *Callista erycina*

July 2020, a total of 124 clams *Callista erycina* with a similar size (body weight 76.48 ± 14.38 g, shell length 71.09 ± 4.86 mm, shell height 53.77 ± 3.18 mm, shell width 33.46 ± 2.39 mm) were collected from offshore in southern Hainan, China. After 7 days restoration at the floating raft of Tropical Aquaculture Research and Development Center, South China Sea Fisheries Research Institute in Xincun Port, Lingshui, Hainan ($18^\circ 40' N$, $109^\circ 96' E$), clams *C. erycina* were transferred to the laboratory for a 12 h starvation treatment in a cement pool with 5000 L filtered sea water. The clams *C. erycina* were randomly divided into four groups (31 clams for each group). The total clam, shell and soft tissues from each *C. erycina* were weighted, and mixed the soft tissues in one group then stored at $-80^\circ C$ until use for biochemical analysis. Percentage edibility (PE) and condition index (CI) of clams *C. erycina* were calculated following the Eqs. (1) and (2) described by Mohite et al. [10] and Orban et al. [11].

$$PE = (\text{soft tissues weight} / \text{total weight}) \times 100 \quad (1)$$

$$CI = (\text{soft tissues dry weight} / \text{shell dry weight}) \times 1000 \quad (2)$$

2.2. Proximate Composition Analysis

The proximate composition of soft tissues from each group was analyzed based on AOAC [12]. Determine moisture by drying the sample in the oven (DHG-9245A, Shanghai Yiheng Scientific Instrument Co., Ltd. China) at $105^\circ C$ overnight until reaching constant weight. Protein content was determined by an Automatic Kjeldahl nitrogen analyzer (SKD-5000, Shanghai Peiou Analytical

Instrument Co., Ltd. China). The crude lipid was extracted with petroleum ether, and the ash content was determined in the muffle furnace (JC-MF12-16, Qingdao Juchuang Environmental Protection Group Co., Ltd. China) at $550^\circ C$ overnight. The contents of moisture, protein, lipid and ash were expressed on g/100g wet soft tissues weight.

2.3. Amino Acid Analysis

In a sealed glass tube filled with nitrogen, the frozen portions of the sample were hydrolyzed with 6 M HCl at $110 \pm 1^\circ C$ for 22 hours. After hydrolysis, 1 mL of the hydrolyzate was taken out and evaporated to dryness under vacuum at $50^\circ C$. The hydrolysate was filtered with a $0.22 \mu m$ membrane after dissolved in 1 mL of sodium citrate buffer (pH 2.2). Amino acids were assessed by comparison with the standards (Sigma) by an Automatic Amino Acid Analyzer (SYKAM, S-433D). All measurements of the sample are repeated three times, and the contents of amino acids were expressed as mg/g wet soft tissues weight.

The amino acid score (AAS) was calculated using Eqs. (3) as reported by Yang et al. [13].

$$AAS = \left(\frac{EAA \text{ contents (g)}}{EAA \text{ content in FAO / WHO pattern (g)}} \right) \times 100 \quad (3)$$

2.4. Fatty Acid Analysis

For fatty acid analysis, the fatty acids in the samples were extracted with a 2:1 (v/v) chloroform/methanol mixture [14], and the fatty acid methyl esters (FAMES) were prepared by esterification using 2% sodium hydroxide methanol. FAMES were separated and quantified by means of a gas chromatography (Agilent 7890A) equipped with a Supelco SPTM-2560 capillary column (100 m long, 0.25-mm internal diameter, and 0.20 mm film thickness) and flame ionization detector (GCFID). Helium was used as carrier gas at a flow rate of 1.0 mL/min, while injector and detector with temperatures of 250 and $260^\circ C$ respectively were used. The temperature program was: initial temperature $60^\circ C$, increasing up to $160^\circ C$ at $4^\circ C$ per minute, then increasing up to $240^\circ C$ at $2^\circ C$ per minute. Each of the specific FAME peaks was identified by the retention time with reference to the known standard (Anpel Laboratory Technologies Inc., Shanghai, China). All samples were performed in triplicate, and the fatty acid content was measured using the peak area ratio (% total fatty acids).

2.5. Minerals Determination

Sodium (Na), potassium (K), Calcium (Ca), magnesium (Mg), zinc (Zn), iron (Fe), copper (Cu) and selenium (Se) contents of frozen-dried portions were determined by iCE 3500 atomic absorption spectrometer (THERMO FISHER, USA), and the Phosphorus (P) was determined by UV-2550 UV-Visible Spectrophotometer (Shimadzu, Japan) according to the method of AOAC [15]. All samples were performed in triplicate.

3. Results and Discussion

3.1. Percentage Edibility (PE), Condition Index (CI) and Proximate Composition

Soft tissues of *C. erycina* is a high protein and moisture, and low-fat food based on its proximate composition (Table 1). Such composition is typical of other bivalve molluscs [16,17]. Similar to the *Meretrix lusoria* [18], it was established that the moisture content of the clams *C. erycina* soft tissues is 77.86 ± 0.74 g/100 g wet soft tissues weight. Since the percentage of edibility and condition index reflect the individual's status of gametogenesis and nutrient reserve storage consumption, they are of great economic significance because they can detect the commercial quality of clam species exploited. [19,20]. PE and CI, together with proximate composition of clams may be the simplest and most useful standards used in international trade [21]. In this study, the PE of *C. erycina* in July was 22.45 ± 3.00 , which is lower than that of the clam *Ruditapes decussatus* cultivated in the Ria Formosa (South Portugal) from the same period, while the CI of *C. erycina* was 95.51 ± 13.34 , in agreement to clams *R. decussatus* from the same period reported by Anibal et al. [21].

The protein content of *C. erycina* in this work was 13.84 ± 0.27 g/100g (Table 1), this value is similar to that of *Macra chinensis* reported by Tabakaeva et al. [22], and slightly higher than that of *M. lusoria* and *Mercenaria Mercenaria* reported by Karnjanapratum et al. [18] and Ogidi et al. [17] respectively, but significantly lower than that of *Egeria radiata* reported by Ivon et al. [23]. Apart from its rich protein content, the typical characteristic of *C. erycina* is its high ash content, which can reach to 2.56 ± 0.11 g/100g. The ash content of *C. erycina* was higher than that of *M. chinensis* and *Anadara broughtonii* from Amur Bay, Sea of Japan [22], *Meretrix meretrix* from the coast of Andaman Sea [18] and *Haliotis discus hannai* Ino from the Nanri Island, Putian, China [24]. And the ash content of *C. erycina* was significantly lower than that of *Flexopecten glaber* from the Central Mediterranean Sea [25], *Egeria radiata* from the Calabar river, Cross River State, [23] and *M. Mercenaria* from the Ekowe community [17]. The lipid content of *C. erycina* in this work was 0.53 ± 0.03 g/100g, which was close to the level of *M. chinensis* [22], but significantly lower than that of *Anadara broughtonii* [22], *M. lusoria* [18], *F. glaber* [25] and *E. radiata* [23].

3.2. Amino Acids

The ratio of major amino acids varies in clams [22]. In this work, the content of 16 amino acids (9 kinds essential amino acids and 7 kinds non-essential amino acids) in *C. erycina* were detected, and the amino acid profile was provided in Table 2. The soft tissues of the clam *C. erycina* showed high content of amino acids, the major amino acids in soft tissues of *C. erycina* were glutamic acid and aspartic acid, followed by arginine, leucine, lysine, glycine and alanine. Which was different from the others marine bivalve mollusks, such as *Perna viridis* L. [26], *Paphia malabarica* and *Villorita cyprinoids* [27]

indicated arginine, leucine, and lysine as dominating fundamental amino acids. The purpose of protein intake is to obtain various amino acids suitable for human needs. Essential amino acids (EAA) are the nutritional needs of humans under all conditions, and they play a central role in the quality of food protein [28]. Therefore, EAA level is the main factor affecting the nutritional value of protein. In this study, 9 essential amino acids (including arginine and histidine) of the brown-banded fairy clam were tested, and the ratio of essential amino acids to total amino acids (TAA) is 45.372 %. Which is slightly below than that of Japanese abalone (*H. discus hannai* Ino) (47.37 %) [24], but higher than that of *M. chinensis* and *A. broughtonii* (32.1 %-41.8 %) [22]. The highest values of EAA in soft tissues of *C. erycina* was observed for arginine (9.555 ± 0.108 mg/g wet soft tissues weight), followed by lysine and leucine (8.830 ± 0.035 and 8.752 ± 0.277 mg/g wet soft tissues weight respectively). The similar results were also found at the foot of *M. lusoria* reported by Karnjanapratum et al. [18]. According to reports, arginine can regulate the synthesis of nitric oxide in endothelial cells, which is related to reducing the risk of cardiovascular disease [29]. Intake of arginine in protein can also have a beneficial effect on nutritional and metabolic status by regulating the utilization and metabolism of amino acids in the small intestinal microflora [30]. The nutritional importance of lysine is a possible limiting amino acid in grains (especially wheat), so its nutritional importance has attracted much attention [31], and leucine supplementation in the diet has been widely used to treat obesity and metabolic dysfunction caused by obesity [32].

There are 4 kinds of umami taste amino acids (UAA) in *C. erycina*, account for 42.881 % of the total amino acids (Table 2), which is higher than that of *M. lusoria* (35.907 %) [18]. Glycine and valine are characteristic amino acids with sweet taste, the contents were 8.700 ± 0.334 and 8.545 ± 0.144 mg/g wet soft tissues weight, respectively. The umami taste of clam *C. erycina* is sufficient, as glutamic acid and aspartic acid are characteristic amino acids with umami taste, and their contents were 20.010 ± 0.124 and 13.147 ± 0.235 mg/g wet soft tissues weight, respectively. Which were higher than that of *H. discus hannai* Ino [24], *M. lusoria* [18], *M. chinensis* and *A. broughtonii* [22]. In addition, there are 7 kinds non-essential amino acids (NEAA), account for 54.628 % of the total amino acids in *C. erycina* (Table 2). The highest NEAA content of *C. erycina* was determined to be glutamic acid (20.010 ± 0.124 mg/g wet soft tissues weight), followed by aspartic acid. Glutamic acid has been known to be one of the most abundant intracellular amino acids in mammals. The pool size of free glutamic acid in most brain regions is quite high [33]. The high concentration of glutamic acid may be because glutamate not only acts as a neurotransmitter, but also acts as a key component of intermediate metabolism in brain [34]. Generally, the protein with larger EAA/NEAA ratio is considered to be more beneficial for well-being. Similar to the EAA/NEAA ratio for *Ensis siliqua* (~80 %) [35], the ratio for *C. erycina* was 83.056 % in this study. Which was higher than that of *H. discus hannai* Ino (24 %-67 %) [24], but less than those found in *P. malabarica* and *V. cyprinoids* (107 %-113 %) [27].

Table 1. Comparison of the proximate composition of *C. erycina* with other bivalves (g/100g wet soft tissues weight)

Bivalves	Protein	Lipid	Ash	Moisture
<i>Callista erycina</i>	13.84±0.27	0.53±0.03	2.56±0.11	77.86±0.74
<i>Macra chinensis</i> [22]	12.20-14.55	0.43-0.73	1.45-1.89	80.16-82.32
<i>Anadara broughtonii</i> [22]	13.14-16.50	0.87-1.37	0.95-1.16	78.55-80.70
<i>Meretrix meretrix</i> [16]	9.22-10.90	0.18-0.22	1.87-2.25	82.72-82.87
<i>Meretrix lusoria</i> [18]	9.09-12.75	1.58-6.58	1.23-2.58	76.23-84.22
<i>Flexopecten glaber</i> [25]	8.50-11.62	1.45-1.70	3.51-3.78	83.71-84.53
<i>Egeria radiata</i> [23]	32.10±0.06	1.36±0.02	3.80±0.01	61.20±0.11
<i>Haliotis discus hannai</i> Ino [24]	15.87±0.15	0.22±0.02	1.36±0.03	74.93±0.25
<i>Mercenaria Mercenaria</i> [17]	12.74±0.01	0.07±0.01	3.45±0.01	78.40±0.06

Table 2. Amino acid content of the *C. erycina* (mg/g)

Amino acid	proportion in wet soft tissues weight	proportion in dry soft tissues weight	proportion in protein
Arginine*	9.555±0.108	43.162±0.490	69.027±0.784
Histidine*	3.445±0.130	15.562±0.584	24.887±0.934
Isoleucine*	5.045±0.097	22.789±0.437	36.446±0.699
Leucine*	8.752±0.277	39.537±1.252	63.229±2.001
Lysine*	8.830±0.035	39.887±0.156	63.789±0.250
Methionine*	2.995±0.067	13.529±0.280	21.636±0.447
Phenylalanine*	4.055±0.197	18.317±0.892	29.294±1.426
Threonine*	5.640±0.067	25.477±0.302	40.744±0.483
Valine*	5.012±0.097	22.643±0.440	36.211±0.704
Aspartic acid**	13.147±0.235	59.390±0.1062	94.979±1.699
Serine	5.465±0.223	24.687±1.006	39.480±1.609
Glutamic acid**	20.010±0.124	90.390±0.558	144.555±0.893
Glycine**	8.700±0.334	39.300±1.510	62.850±2.415
Alanine**	8.545±0.144	38.600±0.654	61.730±1.046
Tyrosine	4.332±0.109	19.571±0.493	31.299±0.788
Proline	4.010±0.116	18.114±0.727	28.969±1.162
EAA	53.33±0.037	240.903±1.666	385.263±2.665
NEAA	64.21±0.074	290.051±3.350	463.861±5.357
UAA	50.40±0.041	227.679±1.872	364.114±2.995
TAA	117.54±0.105	530.954±4.742	849.124±7.584
EAA /TAA (%)	45.372	45.372	45.372
NEAA/TAA (%)	54.628	54.628	54.628
EAA/NEAA (%)	83.056	83.056	83.056
UAA/TAA (%)	42.881	42.881	42.881

Note: * Essential amino acids. **Umami taste amino acids.

Table 3. Amino acid evaluation of *C. erycina*

Amino acids	<i>C. erycina</i> (mg/g protein)	FAO/WHO standard (mg/g protein) [31]	AAS (%)
Histidine	24.9	10	249
Isoleucine	36.4	30	121
Leucine	63.2	59	107
Lysine	63.8	45	142
Methionine	21.6	16	135
Phenylalanine + Tyrosine	60.6	38	159
Threonine	40.7	23	177
Valine	36.2	39	93
Total	347.4	260	134

The results of the evaluation of amino acid scores (AAS) for the soft tissues of *C. erycina* are presented in Table 3. Amino acid scores and the first limiting amino acid are established methods of assessing the quality of proteins, which are widely used in studies on the nutritive value of proteins [31,36]. In this study, the total essential amino acids content in the soft tissues of *C. erycina* (347.4 mg/g protein) was higher than the recommended daily intake

(260 mg/g protein) [31]. Comparing our results with the amino acid composition of the reference protein recommended by FAO/WHO/UNU, it was found that almost all the main indicators of the amino acids in the soft tissues of clams *C. erycina* were higher than 100 %, with the exception of valine (93 %). Therefore, *C. erycina* had only one limiting amino acid (valine), which is less than the *M. chinensis* and *A. broughtonii* [22]. The first

limiting amino acid score in the soft tissues of clams *C. erycina* was close to 100 %, indicating that clams *C. erycina* possesses good protein nutrients. By contrast, the AAS of histidine in soft tissues of clams *C. erycina* was highest as 249 %, followed by threonine (177 %), which was approximately twice as high as the reference standard concentration. Histidine supplementation is beneficial to various several health benefits, such as antioxidant, anti-inflammatory, body weight management, gluco-regulatory and cognitive function [37], the lack of threonine is known to impair intestinal paracellular permeability and is associated with fewer goblet cells and mucus synthesis [38,39], and the clams *C. erycina* happens to be a rich source of histidine and threonine. All in all, the amino acid pattern of the *C. erycina* is basically in line with the ideal model of FAO/WHO, indicating that the *C. erycina* has high nutritional value and it's an ideal high-quality protein source for humans.

3.3. Fatty Acids

In this study, the contents of 9 kinds saturated fatty acids (SFA), 5 kinds monounsaturated fatty acids (MUFA) and 7 kinds polyunsaturated fatty acids (PUFA) in soft tissues of *C. erycina* is determined, and the content of the other 15 kinds fatty acids is too low to be detected (Table 4). The highest values of SFA in soft tissues of *C. erycina* was observed for palmitic acid (C16:0, 28.15±0.87 %), followed by stearic acid (C18:0, 12.02±0.36 %). The same results were also found at the *Flexopecten Glaber* [24], *Paphia malabarica* and *V. cyprinoids* [27]. Same as Asian hard clam *M. lusoria* [18], Palmitoleic acid (C16:1n7, 8.16±0.11 %) and Cis-9-octadecenoic acid (C18:1n9c, 7.45±0.06 %) were also the major MUFAs in clams *C. erycina*. But in the bivalves *Arca noae* and *F. glaber* [40], Cis-9-hexadecenoic acid (C16:1) and C18:1n9c are the major MUFAs. Among PUFAs, Cis-4,7,10,13,16, 19-docosahexaenoic acid (C22:6n3, DHA, 13.55±0.55 %), Cis-5, 8, 11, 14, 17-eicosapentaenoic acid (C20:5n3, EPA, 7.58±0.19 %) and Cis-5, 8, 11, 14-eicosatetraenoic acid (C20:4n6, 6.25±0.23 %) were

dominant in clams *C. erycina*, which was similar to the results found in *Crassostrea gigas*, but different from the results in *Limaria tuberculata* and *Mimachlamys varia* [40].

SFA (48.86±0.44 % of total fatty acids (FA)) was the dominant group in clams *C. erycina*, followed by PUFA (33.08±0.44 % of FA) and MUFA (18.43±0.32 % of FA, Table 4). The high intake of SFA could increase the low-density lipoprotein in the blood [41], and increase the risk of cardiovascular disease or coronary heart disease [42]. In contrast, MUFA and PUFA are considered good fats, because they help in reducing risk of chronic metabolic diseases, different cancers, asthma, rheumatoid arthritis, osteoporosis, psoriasis and inflammatory bowel disease [43,44,45]. Most healthy diet recommendations focus on reducing SFA intake, but increasing MUFA and PUFA intake. $\Sigma n3$, $\Sigma n6$ and $\Sigma n3/\Sigma n6$, $\Sigma PUFA/\Sigma SFA$, $\Sigma UNS/\Sigma SFA$ ratios are widely used to assess the nutritional value of lipids [46]. It is well known that of n3 FA have beneficial effects on human health [45], and seafood products are the important source of high level n3 FA in the diet [47]. In this study, the n3 PUFA (23.08±0.47 % of FA) with DHA and EPA identified as the main PUFAs was the dominant family (Table 4). The DHA/FA and EPA/FA ratio in *C. erycina* were much higher than that in *Ruditapes philippinarum* (3.09 % and 1.92 % of FA, respectively), but little lower than that in *M. varia* (15.16 % and 9.71 % of FA, respectively) [46]. According to the reports by UK Department of Health [48], Simopoulos [49] and Chow [50], high ratio of $\Sigma n3/\Sigma n6$ is favorable to human health, and the recommended ratio for health benefits is 1.0 at minimum, but of 4.0 at maximum. In this study, the ratio of $\Sigma n3/\Sigma n6$ in *C. erycina* was 2.95, suggesting that clams *C. erycina* could be categorized as ideal to human health consumption. And which was similar to the *F. Glaber* (2.7-3.1) [25] but higher than that in Asian hard clam *M. lusoria* (0.99-1.58) [18], and lower than that in *C. gigas* (6.35-8.11) [51]. According to the current nutritional recommendations [48], the recommended ratio of PUFA/SFA is above 0.45. In our study, the value (0.68) in clams *C. erycina* was well above of established limits.

Table 4. Fatty acid composition and evaluation of *C. erycina*

Fatty acid	Content (%)	Fatty acid	Content (%)
Myristic acid (C14:0)	3.06±0.12	Cis-13-docosenoic acid (C22:1 n9)	0.59±0.19
Pentadecanoic acid (C15:0)	0.64±0.04	Σ MUFA	18.43±0.32
Palmitic acid (C16:0)	28.15±0.87	Cis-vaccenic acid (C18:2n6c)	0.84±0.35
Heptadecanoic acid (C17:0)	2.08±0.12	Cis-9,12,15-octadecatrienoic acid (C18:3n3)	1.95±0.14
Stearic acid (C18:0)	12.02±0.36	Eicosadienoic acid (C20:2)	2.16±0.08
Arachidic acid (C20:0)	1.04±0.08	Cis-8, 11, 14-eicosatrienoic acid (C20:3n6)	0.72±0.02
Heneicosylic acid (C21:0)	0.43±0.05	Cis-5, 8, 11, 14-eicosatetraenoic acid (C20:4n6)	6.25±0.23
Behenic acid (C22:0)	0.67±0.11	Cis-5, 8, 11, 14, 17-eicosapentaenoic acid (C20:5n3, EPA)	7.58±0.19
Tetracosic acid (C24:0)	0.43±0.02	Cis-4,7,10,13,16,19-docosahexaenoic acid (C22:6n3, DHA)	13.55±0.55
Σ SFA	48.86±0.44	EPA+DHA	21.13±0.56
Myristoleic acid (C14:1n5)	0.37±0.18	Σ PUFA	33.08±0.44
Palmitoleic acid (C16:1n7)	8.16±0.11	Σ UNS	51.51±0.62
Cis-9-octadecenoic acid (C18:1n9c)	7.45±0.06	$\Sigma n3$	23.08±0.47
Cis-11-eicosanoic acid (C20:1)	1.85±0.05	$\Sigma n6$	7.83±0.20

3.4. Mineral Elements

Figure 1 shows the level of elements in the soft tissues of *C. erycina*. Sodium (Na, 4292.500 ± 187.506 mg/kg soft tissues wet weight) and potassium (K, 2794.925±202.484 mg/kg soft tissues wet weight) were the main macro elements in clams *C. erycina*, followed by magnesium (Mg, 887.350±34.596 mg/kg soft tissues wet weight), calcium (Ca, 637.350±15.186 mg/kg soft tissues wet weight). Similar results were also found in *P. malabarica* [27]. Na and K are the minerals involved in maintenance of muscular irritability, acid-base balance osmotic equilibrium, and normal water balance. The suitable of Na/K ratio in the human body play an important role in preventing hypertension and arteriosclerosis, and it is recommended that the Na/K ratio be less than one [52]. In our study, the Na/K ratio in clams *C. erycina* was 1.54, much higher than that in *H. discus hannai Ino* (0.69), suggesting that the soft tissues of clams *C. erycina* was not as suitable as abalone muscle for humans with high blood pressure [24]. Ca is important to the human body health for the effects on the bone health and play an important role in the contraction and relaxation of muscle [53], and Mg is a coenzyme involved in many important biochemical reactions in the body [18]. Dietary Reference Intakes (DRI) of Ca and Mg for adult human are not more than 1000 and 400 mg per day, respectively [54]. The Ca and Mg contents in clams *C. erycina* were higher than that in *P. malabarica* (342.5 and 367.5 mg/kg wet soft tissues weight respectively) and *V. cyprinoids* (285.2 and 258.6 mg/kg wet soft tissues weight respectively) reported by Joy et al. [27]. Phosphorus(P) is an important component of human bones,

teeth and nerve tissue. The P content in *C. erycina* was (1451.750±53.631 mg/kg wet soft tissues weight), which was lower than that in *Crassostrea madrasensis L.* (3197-5302 mg/kg wet soft tissues weight) [55], but higher than that in *H. discus hannai Ino* (1001.21 mg/kg wet soft tissues weight) [24].

The essential trace minerals, such as iron (Fe), zinc (Zn), copper (Cu) and selenium (Se) play a key role in keeping good condition of physiological fluid [56]. In addition, iron is participating in a wide variety of metabolic processes in human body, including electron transport, oxygen transport and DNA synthesis [57], and Zn deficiency could lead children to increase in infectious diseases, retarded growth and impaired cognitive function. Cu is an important component of certain proteins that have biological functions required for development and growth [58], and Se as an antioxidant, plays a pivotal role in proper organ function and development [59]. In this study, the Fe and Zn contents of clam *C. erycina* (31.775±1.654, 0.515±0.019 mg/kg wet soft tissues weight respectively) were lower than the *P. malabarica*(76.4±1.4 and 30.1±1.3 mg/kg wet soft tissues weight respectively) and *V. cyprinoids* (56.5±0.4 and 32.6±0.7 mg/kg wet soft tissues weight respectively) [27], while the Cu and Se contents of clam *C. erycina* (4.6±0.6 and 0.302±0.001 mg/kg wet soft tissues weight respectively) were higher than the *P. malabarica* (3.0±0.2 and 0.273±0.000 mg/kg wet soft tissues weight respectively) and *V. cyprinoids* (56.5±0.4 and 32.6±0.7 mg/kg wet soft tissues weight respectively) [27]. Overall, soft tissues of clam *C. erycina* could be a good source of nutritionally important elements for consumers.

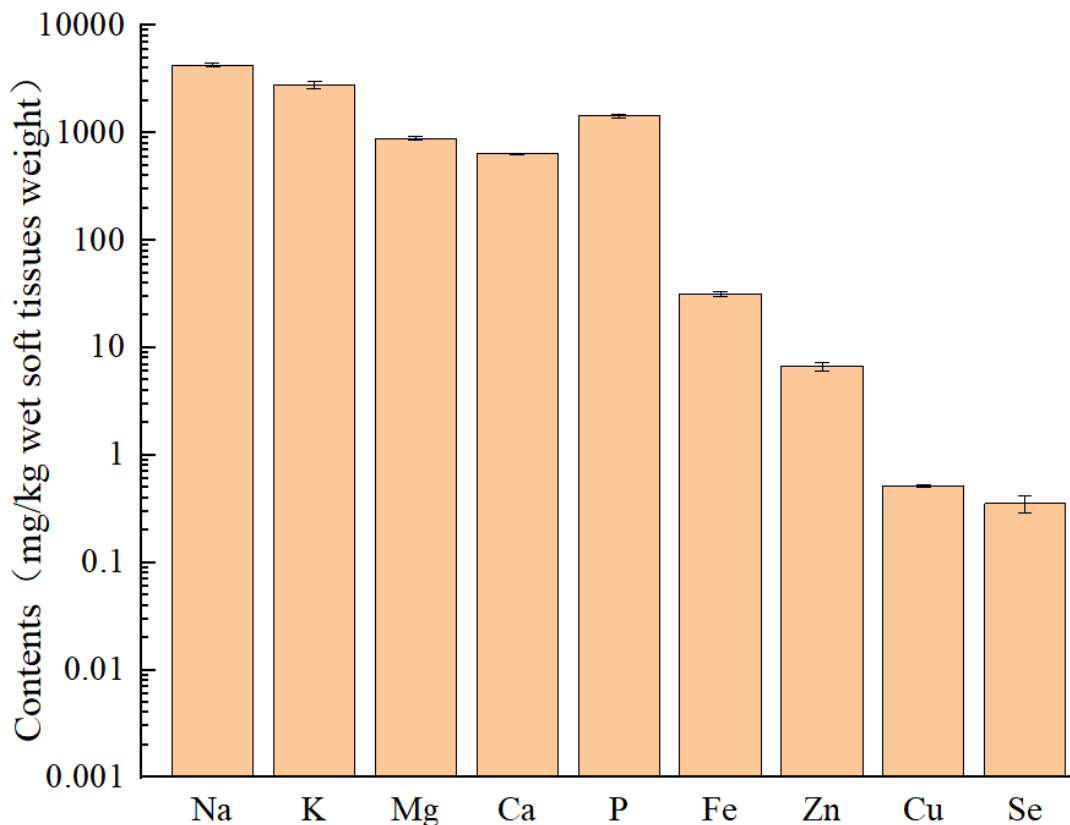


Figure 1. Mineral elements contents of clam *C. erycina*

4. Conclusion

The major amino acids in soft tissues of *C. erycina* were glutamic acid and aspartic acid, followed by arginine, leucine, lysine, glycine and alanine. C16:0, C18:0, C22:6n3, C16:1n7, C18:1n9c, C20:5n3, and C20:4n6 were the major fatty acids in clams *C. erycina*. Among the mineral elements, Na and K has the highest mass fraction, followed by P, Mg, Ca, Fe and Zn. Based on the results of this study, the soft tissues of clam *C. erycina* contained high amount of water, whereas the dry mass was rich in nutritionally important amino acids, fatty acid and mineral elements. Suggesting that clam *C. erycina* are suitable for human consumption. Therefore, seed breeding and aquaculture activities related to clams *C. erycina* should be encouraged to reduce the dependence on wild stock.

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Conflict of Interest

The authors declare that there are no conflicts of interest.

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