

Effects of Conventional Versus Organic Production Systems on Amino Acid Profiles and Heavy Metal Concentrations in the Juveniles of Chinese Mitten Crab, *Eriocheir Sinensis*

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Abstract. Amino acid composition and heavy metal concentration were examined in organic and conventional juvenile Chinese mitten crab *Eriocheir Sinensis* production systems during the production cycle. The crude protein and total amino acid contents for organic crab juvenile samples were 5.543 and 4.807 mg/g d.w., as opposed to 4.655 and 4.064 mg/g d.w., respectively, for conventionally produced samples. The ratios of essential amino acids to nonessential amino acids in organic and conventional cultured crab juveniles were 0.58 and 0.59, respectively. Crab juvenile samples from the conventional system were significantly richer in Cu (4.6 vs. 3.5 mg kg⁻¹), Pb (0.101 vs. 0.098 mg kg⁻¹), Cd (0.0533 vs. 0.0233 mg kg⁻¹), Hg (0.010 vs. 0.004 mg kg⁻¹) and As (0.47 vs. 0.39 kg⁻¹) when compared with those obtained from the organic system. It is concluded that organic crab juvenile production systems can produce better growth and nutritional quality benefits.

Keywords: organic aquaculture, conventional aquaculture, Chinese mitten crab, amino acid, heavy metal

1. Introduction

The organic food product sector is booming around the world in terms of diversity of produce, production volumes and values. Organic aquaculture has experienced a remarkable growth over the last decade in China. The total organic aquaculture production increased by 1700%, from 5000 tonnes in 2003 to 85,000 tonnes in 2012 [1]. The Chinese mitten crab *Eriocheir Sinensis* is a popular delicacy in China [2] The production of Chinese mitten crab has reached about 520000 tons and valued more than 6 billion US dollars in 2008 in China. About 2200 tons Chinese mitten crab was certified as organic in 2012 [1]. Consumers are drawn to the fact that organic crab can be produced without using any chemical ingredients, and thus the crabs are free from elements harmful to the human body. Quality differences have been the subject of many recent comparisons between conventional and organic food. Essential amino acid composition is one of the most important nutritional qualities of protein. Heavy metals such as copper (Cu), lead (Pb), cadmium (Cd), mercury (Hg) and arsenic (As) are toxic, even in trace amounts [3]. There have been no published studies analyzing the effects of conventional versus organic production systems on nutritional quality of market-sized mitten crabs, especially crab juveniles. This present study is an attempt to assess the differences in growth, amino acid composition, crude protein content and heavy metal concentrations (Cu, Pb, Cd, Hg and As) of *E. Sinensis* juvenile samples obtained from two different farming systems (one organic and other conventional).

2. Methods, Results and Discussion

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3. Methods

The study was carried out during the growing season from May to September 2004 (136 days) in a commercial intensive Chinese mitten crab juvenile farm in Ganyu County, near the shore of the Yellow Sea, Lianyungang City of Jiangsu Province, China (34.5-34.6 N; 119.5-119.6 E). Two triplicate crab juvenile farming ponds for each of the organic and conventional production systems, respectively, were chosen for the study. Each pond was about 50m length × 8m width and 1.2 m in depth. Appropriate management practices were chosen for the organic and conventional farming systems (Table 1). The management of organic crab ponds was based on the regulations in the Naturland Standards for Organic Aquaculture.

Table 1: Main management practices for organic and conventional juvenile crab ponds

Management items	Organic juvenile crab pond	Conventional juvenile crab pond
Selection of site, interaction with surrounding ecosystems	Physical buffer zones around the organic pond; no mangrove existed.	No buffer zones; no mangrove existed.
Species and origin of stock	Native <i>Eriocheir Sinensis</i> adopted; no GMO involved;	Native <i>Eriocheir Sinensis</i> adopted; no GMO involved;
Breeding	Natural reproduction, no hormones used.	Natural reproduction, no hormones used.
Designing of holding systems, water quality, stocking density	Water quality conforming to the natural requirements of the species; 270 pieces/m ³	Water quality conforming to the natural requirements of the species; 270 pieces/m ³
Health and Hygiene	No medicine and treatment used; adopting optimized husbandry, rearing and feeding measures permitted in the Naturland Standards for Organic Aquaculture.	Bleaching powder, Calcium oxide, Keng iodine disinfectant and bioremediation products used before stocking
Feeding	Organic soybean, organic wheat, organic flour, organic rice and natural wild fish meal	Commercial pellets

E. Sinensis megalopa with 180000 individuals/kg were stocked in both systems at a density of 270 individuals/m³. Commercial (conventional) pellet manufactured were supplied for the conventional ponds. The organic feed consisted of organic soybean, organic wheat, organic flour and organic rice, wild fish meal and Chinese herbal medicine was fed to the organic juvenile crab.

Twenty juvenile crabs were sampled randomly with a 10 mm mesh size seine from each pond of each system at the end of the study. The samples were immediately taken to the laboratory on ice and then frozen at -20°C. Total crab length weighed and measured to the nearest centimeter and gram respectively, before analysis. The edible tissues of each sampled crab were pooled and divided in triplicate for analysis. These were homogenized with a grinder and stored at -20°C.

The crude protein content was calculated by converting the nitrogen content determined by Kjeldahl's method (6.25 × N). For amino acid analysis the samples were hydrolyzed in 6 M HCl at 110°C for 24 h in evacuated sealed ampoules. Excess acid from the hydrolysate were removed by flash evaporation under reduced pressure. The analysis was carried out using a Hitachi 835-50 Amino Acid high speed analyzer.

For heavy metal analysis, sample preparation and analysis were carried out according to the procedure described in the Reference Methods of Ministry of Health of the People's Republic of China. All digested samples were analyzed three times for each metal.

One-way analysis of variance tests with the level of significance set to 5% were conducted on each metal to test for significant differences between crabs. The amino acid and heavy metal analyses were recorded as means and standard deviation (SD) of triplicate measurements.

4. Results

Table 2: Amino acid profiles and crude protein contents (mg/g d.w.) of juvenile crab from different systems

Amino acid/ Crude protein	Content (mg/g meat: mean \pm SD)	
	Conventional	Organic
Aspartic acid	0.403 \pm 0.082	0.464 \pm 0.115
Glutamic acid	0.621 \pm 0.123	0.732 \pm 0.187
Serine	0.159 \pm 0.003	0.182 \pm 0.006
Histidine	0.096 \pm 0.004	0.108 \pm 0.009
Glycine	0.289 \pm 0.011	0.370 \pm 0.045
Proline	0.207 \pm 0.022	0.218 \pm 0.033
Arginine	0.308 \pm 0.065	0.396 \pm 0.047
Alanine	0.298 \pm 0.062	0.355 \pm 0.089
Tyrosine	0.129 \pm 0.003	0.159 \pm 0.007
Cysteine	0.047 \pm 0.001	0.058 \pm 0.002
Valine*	0.225 \pm 0.034	0.268 \pm 0.056
Methionine*	0.101 \pm 0.009	0.130 \pm 0.012
Phenylalanine*	0.205 \pm 0.021	0.236 \pm 0.019
Isoleucine*	0.240 \pm 0.032	0.260 \pm 0.042
Leucine*	0.333 \pm 0.057	0.376 \pm 0.073
Lysine*	0.217 \pm 0.045	0.279 \pm 0.051
Threonine*	0.175 \pm 0.023	0.193 \pm 0.038
Tryptophan*	0.020 \pm 0.001	0.023 \pm 0.002
TAA	4.064	4.807
Crude protein	4.655	5.543
EAA/NEAA	0.59	0.58

*Essential amino acid for humans.

The harvested organic juvenile crab had a mean body length of 2.80 \pm 0.76 cm, a mean body width of 2.95 \pm 0.84 cm, and a mean fresh body weight of 7.20 \pm 1.55 g, which are higher than the values for conventional crab (a mean body length of 1.74 \pm 0.53 cm, a mean body width of 1.96 \pm 0.58 cm, and a mean fresh body weight of 4.85 \pm 1.21 g). There were significant differences in body weight, body length and body width between juvenile crabs harvested from organic and conventional farming ponds. Survival in ponds was 9.72% for organically farmed juvenile crab and 9.26 % for conventional ones respectively. The net organic juvenile crab yield was 21080 individuals compared to 19780 individuals for conventionally farmed ones. Net economic incomes in organic and conventional systems were 1373 and 496 RMB yuan (here, RMB is the abbreviation of the currency used in P.R. China, and Yuan is its monetary unit whose exchange rate to US dollar is 1:6.3 or so), with the ratio of total costs to gross receipts of 1:1.15 and 1:1.09, respectively. The organic juvenile crab system exhibited higher economic efficiency.

The amino acid compositions of the juvenile crab meat from the different systems is given in Table 2. The mean concentrations of the heavy metals in the juvenile crab meat from the studied conventional and organic systems are reported in Table 3.

5. Discussion

Levels of essential amino acids (EAA) are higher in organic juvenile crab than in conventional ($p < 0.05$), possibly because of the higher quality of feed used. A higher glycine content was found in organic juvenile *E. sinensis* (0.370 mg/g d.w.) than in conventional ones (0.289 mg/g d.w.). This means that organic juveniles should be sweeter than its counterpart since the sweetness of fresh crab is attributed to the abundance of free

glycine in their muscle^[4]. The ratios of EAA to nonessential amino acids (NEAA) in organically and conventionally cultured juvenile *E. sinensis* were 0.58 and 0.59, respectively. Pan and Wang reported that the ratio of EAA to NEAA in the juveniles of *E. Sinensis* ranged from 0.67 to 0.72 in different larviculture stages^[5]. Xie et al. demonstrated that the ratios of EAA to NEAA in organically and conventionally produced Chinese shrimp (*Penaeus chinensis*) were 0.58 and 0.63, respectively^[6]. When compared to the reference amino acid pattern of preschool children (2–5 years old), all of the amino acid scores were more than 100, except that of tryptophan and lysine. It was reported that the proteins from Chinese mitten crab meat were well-balanced in their essential amino acid compositions^[7]. When compared with the amino acid composition of *E. sinensis*, there was no significant difference in the non-essential amino acid composition. In this study, average tryptophan and lysine contents in juvenile crab meat from two different systems was low, which was the limiting amino acid in juvenile crab meat protein. Amino acid profile was similar to those in the juveniles of *E. Sinensis* at different larviculture stages^[5]. By contrast, the tryptophan and lysine contents in Chinese mitten crab meat was relatively higher, and its contents (28 and 81 mg/g protein) was almost six and two times higher than those in juvenile Chinese mitten crab meat respectively.

Table 3: Heavy metal contents of juvenile crab in the organic and conventional systems (mg/kg d.w.)

	Larval crab in the organic system	Larval crab in the conventional system	Reference Value *
Cu	4.6±0.95	3.5±0.86	50
Pb	0.101±0.001	0.098±0.003	0.5
Cd	0.0533±0.0011	0.0233±0.0008	0.1
Hg	0.010±0.001	0.004±0.001	0.3
As	0.47±0.02	0.39±0.05	0.5

*Reference value for heavy metal contents (tolerance limit in foods set by the Ministry of Health of the People's Republic of China).

Cu, Pb, Cd, Hg and As concentrations in the meat were higher in conventional juvenile *E. sinensis*, possibly due to the different quality of feeds used. It has been reported that aquatic organisms in the food chain often accumulate large amounts of metals by ingesting suspended particulates, food materials, and/or through a constant ion-exchange process involving metals dissolved in the water^[8]. In this study, the inlet water from the Yellow Sea in Eastern China contained undetectable concentrations of Pb, Cd, Hg and As, and a very low concentration of Cu (0.0007 mg/l)^[9]. Since no medicines were used in the organic and conventional ponds, the conventional pellets used are apparently the key cause of the higher concentrations of heavy metals in conventional ponds. Levels of Cu and As in juvenile *E. sinensis* meat have been found to be significantly higher than Pb, Cd and Hg in both organic and conventional systems (Table 3). This could be because these metals play a role in the enzymatic and respiratory processes of aquatic animals, especially crustaceans, since they use hemocyanin as a respiratory pigment^[10].

6. Acknowledgements

This work was primarily supported by the National Natural Science Foundation of China (Grant Nos. 41273102) and the Scientific and Technological Project of Jiangsu Province (BE200331).

7. References

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