Biochemical Composition in Two Populations of the Mantis Shrimp, *Harpiosquilla raphidea* (Fabricius 1798) (Stomatopoda, Crustacea)

Yusli Wardiatno[1]*, Joko Santoso[2], and Ali Mashar[1]

[1]Department of Aquatic Resources Management, Faculty of Fisheries and Marine Sciences, Bogor Agricultural University (IPB), Kampus IPB Dramaga, Bogor 16680, Indonesia
[2]Department of Aquatic Products Technology, Faculty of Fisheries and Marine Sciences, Bogor Agricultural University (IPB), Kampus IPB Dramaga, Bogor 16680, Indonesia 0

Abstrak

Komposisi Biokimia dari Dua Populasi Udang Mantis, Harpiosquilla raphidea (Fabricius 1798) (Stomatopoda, Crustacea)

Udang mantis jenis Harpiosquilla raphidea merupakan salah satu jenis krustase hasil tangkapan bernilai ekonomi pada beberapa daerah pesisir di Indonesia. Namun komposisi biokimia jenis ini belum banyak diketahui. Oleh karena itu, tujuan penelitian ini adalah untuk memepelajari secara kuantitatif unsure-unsur penting yang terkandung dalam daging udang mantis yang berasal dari perairan Kuala Tungkal, Jambi dan Cirebon. Hasil penelitian memperlihatkan bahwa rendemen udang mantis dari kedua lokasi tidak berbeda nyata. Selain itu, udang dari kedua lokasi juga tidak memperlihatkan kandungan mikro mineral (seng, besi dan tembaga) yang berbeda. Namun demikian, udang mantis Kuala Tungkal, Jambi memiliki kandungan natrium, kalium dan kalsium lebih tinggi dibandingkan udang mantis Cirebon. Tetapi, udang mantis Cirebon kandungan magnesiumnya lebih baik. Pemasakan dengan media asam dan dengan proses perebusan akan menghasilkan tingkat kelarutan mineral tertinggi.

Kata kunci: *udang mantis, Harpiosquilla raphidea, komposisi biokimia, kelarutan mineral*

Abstract

The mantis shrimp, Harpiosquilla raphidea, is a valued crustacean species captured mainly in some Indonesian coastal waters. Yet, the biochemical composition of this species is still inadequately understood. For that reason, the aim of this study was to quantify the content of essential elements of specimens from the Kuala Tungkal, Jambi and Cirebon Coast. The meat yield of the shrimps collected from the two locations are not significantly different. In terms of proximate chemical composition, all chemical characters of the shrimps from Kuala Tungkal, Jambi and Cirebon are not significantly different, except the fat content. As far as the mineral composition is concerned, no differences were observed between either two locations for micro minerals (zinc, iron and copper). However, the shrimps of Kuala Tungkal, Jambi coast showed higher sodium, potassium and calcium contents than those of Cirebon coast. Yet, for magnesium the shrimp of Cirebon had higher content in comparison with that of Kuala Tungkal, Jambi. Media acid with boiling process would bring about the highest solubility of minerals.

Key words: *Scleractinia, Marabatuan Island, Matasirih Island, South Kalimantan*

Introduction

The chemical composition of food ingredients derived from marine organisms such as shrimp has a good value for human health. Almost all the minerals can be found in seafood. Types of minerals commonly found in seafood are magnesium, calcium, iron, potassium and fluorine (*e.g.* Ragab and Aiad, 2009). Some marine organisms are also rich of antioxidants, for example edible green benthic macro alga, *Caulerpa racemosa* (Santoso *et al*., 2010), *Kappaphycus alvarezii* (Kumar *et al*., 2008); etc.

Minerals play an important role in biochemical reactions in the body that is as co-enzyme factors. If a mineral deficiency in humans happens, it will cause health problems such as anemia, goiter, osteoporosis and osteomalacia. Minerals in humans needs might be obtained by eating good food derived from plants or animals. The best mineral source is food derived from animal mainly derived from marine animals.

Shrimp has great importance in food consumed by human and other organisms. It is valuable in the diet, because apart from supply of good quality

*) Corresponding author

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proteins and vitamins, it also contains several dietary mineral such as calcium, iron etc, which are beneficial to human and other organisms. Although their frequent consumption is not advisable in general due to allergenic reactions or to its supposedly high cholesterol content, there are much studies encouraging crustacean consumption (Oehlenschläger, 1997; Bügel *et al*., 2001; Rosa and Nunes, 2003; Gökoolu and Yerlikaya, 2003; Küçükgülmez *et al*., 2006; Chen et al., 2007; Teixeira *et al*., 2008; Barrento *et al*., 2008).

Minerals that are required in relatively large amounts in the body are commonly grouped as major or macro elements. These minerals are essential components which are required in enzymatic biochemical activities in the body. The mineral ratios are very important in health at times they could pose as threat if their proportions are high. Mineral content in food is only one initial parameter to assess the quality of these foodstuffs. However, bioavailability is more important. Among the many nutritional components in foodstuffs, minerals play an important role in maintaining the survival of organisms in a healthy and normal metabolism. Bioavailability is the proportion of a nutritional component that can be used to run and maintain normal metabolism in the body (Watzke, 1998; O'Dell, 1984). Minerals can be bioavailable when in the form of dissolved minerals, but not all the dissolved minerals are bioavailable. Dissolved minerals are needed to facilitate the absorption of minerals in the human body (Newman and Jagoe, 1994).

Knowledge and information on mineral composition and data on the solubility in the mantis shrimp is very limited, although some researches on fishery resources (crab, fish, cephalopod) have been focused on the meat yield, proximate and biochemical composition (Yomar-Hattori, 2006; Barento *et al*. 2009, 2010; Laurenço *et al*., 2009; Aberoumad and Pourshafi, 2010; Afkami *et al.*, 2011). It is well known that the mineral composition of marine invertebrates might be influenced by their nutritional habits, age, sex, season, or habitat condition (Chapelle, 1977; Souchet and Laplante, 2007; Oliveira *et al*., 2007). Since mantis shrimp populations from different fishing grounds might have distinct mineral composition, the aim of this study was to determine the nutritional quality of *Harpiosquilla raphidea* harvested in Kuala Tungkal, Jambi and Cirebon coast by determining the meat yield, proximate chemical composition, and macro- and micro-minerals.

The shrimp commonly lives in muddy bottom in coastal waters around Indonesia, and it is exploited commercially to its economical value. Live mantis shrimp costs around USD 3.5 per individual with a 7-9 inch size (Wardiatno and Mashar, 2010). The shrimp is mostly exported to Hong Kong and Taiwan, but the local market is also increasing in demand. The biological aspects of the shrimp has been studied, *i.e*. distribution in their habibat (Mashar and Wardiatno, 2011); reproductive aspects (Wardiatno and Mashar, 2010), dynamic population (Wardiatno and Mashar, 2011), etc.

Food from the sea like shrimp is usually eaten after cooking and adding flavor, except directly consumed as sushi or sashimi. Boiling is a common cooking method. Boiling is usually done by adding spices that aims to change the taste and increase acceptability. Alipour *et al*. (2010[a]) has proved that cooking methods had the beneficial effects on nutritive value of Persian sturgeon (*Acipenser persicus*) fillets. Addition of salts and acids such as vinegar (acetic acid) in order to enhance flavor in food is common practice by the community. The second objective of this study is to reveal the influence of boiling in a variety of media (water, acetic acid 0.5% and salt 1%) on the solubility of minerals (Na, Ca, Fe and Zn). This research is expected to result in boiling method that produces the highest solubility of minerals so that the method can be a reference in the processing of fishery products in everyday life.

Materials and Methods

Location and period of research

The main material used in this study is the mantis shrimp (*Harpiosquilla raphidea*) freshly collected from coastal waters of Jambi and Cirebon. Collections were made by gill-net. The two sampling sites are presented in Figure 1. The research was conducted from February to April 2010. Sample preparation and proximat analysis was conducted in Laboratory of Aquatic Product Microbiology and Laboratory of Aquatic Product Biochemistry in Department of Aquatic Products Technology, Faculty of Fisheries and Marine Sciences, Bogor Agricultural University. While total and mineral solubility analysis were conducted in Laboratory of Animal Nutrition and Science in Faculty of Animal Husbandry, Bogor Agricultural University.

Biological materials and samples preparation

Twenty *Harpiosquilla raphidea* from the Kuala Tungkal, Jambi Coast and twenty specimens from the Cirebon coast, were collected and transported to the laboratory. Animals were kept under refrigerated conditions (about 5^{o}C) for 1 h to decrease their metabolism before being euthanized.

All shrimp samples were measured to get total length and their weight. The total length was measured

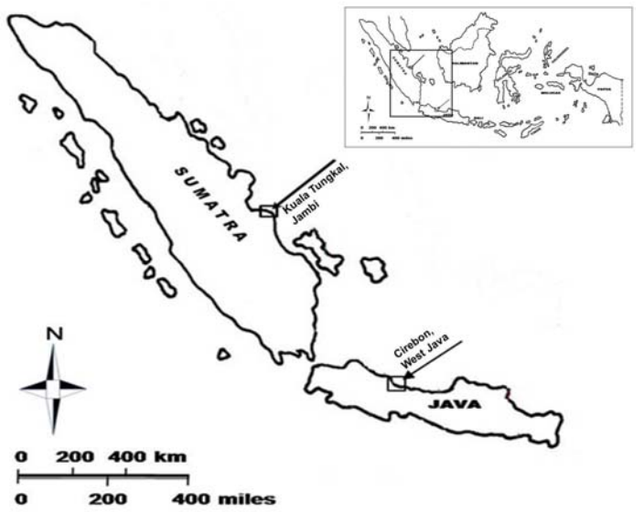

Figure 1. The two sampling sites where the mantis shrimp (*Harpiosquilla raphidea*) were collected as indicated by the two arrows.

by a vernier caliper (0.05 mm), while the weight is obtained by weighing the sample using a scale (0.01 g). The samples were then washed with fresh running water, crushed and homogenized using a food processor. Samples were subsequently placed into plastic containers and frozen at the freezing temperature of -18 °C, until used for further analysis. Before the sample was placed into the freezer, moisture and ash contents of fresh samples were first analyzed. The plastic tools were intended used in all processes in order to avoid any contamination from processing equipment with trace elements measured.

Meat yield

Meat yield was analyzed according to AOAC (2007); i.e. MY (%): [wet meat weight (g)/total weight (g)] X 100%.

Proximate analysis

In general, proximate analysis of a food sample determines the total protein, fat, carbohydrate, ash, and moisture reported as the percentage composition of the product. In this study, the analysis of the moisture ash, protein, fat and carbohydrate contents was determined using the methods described by standard methods of analysis of the AOAC (2007).

Total mineral analysis

Total mineral contents were determined according to the research conducted by Santoso *et al*. (2006[a]). Each sample (2 g wet weight) was weighed in a Kjeldahl flask. Twenty milliliters of concentrated nitric acid was added to each sample and the flask was left to stand overnight. Five milliliters of concentrated perchloric acid and 0.5 mL of concentrated sulfuric acid were added, and the flask was then heated until no white smoke was emitted. The samples were dissolved in 2% of hydrochloric acid and tranferres into a volumetric flask, then analyzed using an atomic absorption spectrophotometer (Model AA-600, Shimazu Co. Ltd., Kyoto Japan) with acetylene flame, a single-sot head, and Pt-Rh corrosion resistant nebulizer for measuring the total sodium (Na), Pottasium (K), calcium (Ca), magnesium (Mg), zinc (Zn), iron (Fe) and copper (Cu).

All the reagents used were of analytical grade and their solutions were prepared using double-distilled deionized water. All the glassware and plastic bottles used were dipped in 2% Contaminon-L (Wako Pure Chemical Industries, Ltd., Osaka Japan) for at least 2 h, and then rinsed with double-distilled deionized water to remove contaminants.

Analysis of soluble minerals

Sample preparation to get soluble mineral fraction was conducted following Santoso *et al.* (2006[a]) with modification. The samples (10 g) were blended in a tube with water or 1% sodium chloride or 0.5% acetic acid (40 mL) at 5,00 – 10,000 rpm for 2 min using a blender (Ultra-Turrax T-25; Janke and Kunkel, IKA-Labortechnik, GmbH Co., Staufen, Germany) to produce a water soluble fraction (0 min

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Data analysis

To find out the difference between the physical characters and the biochemical composition of the mantis shrimp from the two locations, the t-test analysis were performed. In order to differentiate the solubility of minerals, the statistical test analysis of variance based on randomized factorial experimental design with two factors, namely the boiling process and boiling medium, was performed, and it is followed by the Duncan test, if necessary.

Results and Discussion

Biometric data and biochemical composition

Biometric data of all specimens analyzed, proximate chemical composition, and macro- and micro-minerals composition were displayed in Table 1.

Table 1. Biometric data, proximate chemical composition, and macro- and micro-minerals of the mantis shrimp, *Harpiosquilla raphidea* from Kuala Tungkal, Jambi and Cirebon coast.

Characteristics	Sample of Origin	
	Jambi (n = 20)	Cirebon (n = 20)
Physical characters		
Total Length (cm)	20.26 ± 2.05[a]	12.67 ± 1.60[b]
Total Weight (g)	89.15 ± 16.40[a]	23.95 ± 9.16[b]
Meat Weight (g)	36.18 ± 9.37[a]	9.77 ± 4.29[b]
Meat Yield (%)	40.28 ± 4.03[a]	39.91 ± 3.66[a]
Proximate Chemical Composition		
Moisture (%)	78.27 ± 1.42[a]	78.49 ± 1.65[a]
Ash (%)	1.60 ± 0.71[a]	1.64 ± 0.11[a]
Protein (%)	13.11 ± 0.88[a]	14.39 ± 0.39[a]
Fat (%)	1.29 ± 0.30[a]	0.6 ± 0.00[b]
Carbohydrate (%)	5.72 ± 0.45[a]	4.88 ± 1.45[a]
Macro Minerals		
Sodium (Na) [mg/100 g dw]	887.14 ± 30.79[a]	604.53 ± 27.37[b]
Potassium (K) [mg/100 g dw]	674.79 ± 44.05[a]	511.03 ± 25.81[b]
Calcium (Ca) [mg/100 g dw]	137.16 ± 2.41[a]	57.91 ± 13.43[b]
Magnesium (Mg) [mg/100 g dw]	68.50 ± 2.54[a]	123.73 ± 10.05[b]
Micro Minerals		
Zinc (Zn) [mg/100 g dw]	9.86 ± 0.54[a]	9.86 ± 2.51[a]
Iron (Fe) [mg/100 g dw]	0.88 ± 0.08[a]	1.00 ± 0.10[a]
Copper (Cu) [mg/100 g dw]	0.19 ± 0.01[a]	0.72 ± 0.51[a]

Note: The numbers in the same row followed by different superscript letters (a, b) indicate significantly different ($p < 0.05$)

In general, the physical characters, in this case the meat yield, of the shrimps from the two different sites are not significantly different. Although the size of the samples collected from the two sites is significantly different. The same result was obtained by Barento *et al*. (2010) who studied two population of the brown crab, *Cancer pagurus* from two fishing grounds. However, they found that males, in parallel of location, contributed with a higher proportion of meat yield from claws than females of the same size, and they believed the discrepancy was caused by sexual dimorphism phenomenon. As known, males have bigger claws than females (Edwards, 1979). On the other hand, the crab females were responsible by a larger proportion for gonads, although the gonadosomatic index showed a high variation depending on maturation stages.

Regarding the proximate chemical composition, all chemical characters of the shrimps from Kuala Tungkal, Jambi and Cirebon are not significantly different, except the fat content. The finding is in contrast with Barento *et al*. (2010) who found differences in moisture, ash and protein of *C. pagurus* collected from two sites, but the fat was not in the case.

For comparison, Table 2 shows proximate composition of various shrimps. The proximate composition of the mantis shrimp is also presented in the table. The table shows that the mantis shrimp, either from Jambi or Cirebon are not better protein source compared to the other three shrimps. However, in terms of fat, mantis shrimp of Jambi coast would be a good food source.

Many findings have proven that cooking processes can change the proximate composition of aquatic fauna (see Peplow *et al*., 1973; Musaiger and D'Souza, 2008; Alipour *et al*., 2010[a]; Alipour *et al*., 2010[b]); different process would bring about different change of the proximate composition. Due to heat denaturation of protein, many of changes occur during food processing. However, it is affected by the duration of heating and temperature level, and also by natural features of the protein molecules or complexes. Heating process may result to deconformation resulting in exposure of the reactive groups. Most proteins are compounds that are vulnerable to quality and quantity changes during heat processing. Trouncing of solubility of temperature-sensitive proteins can be used as a marker of the time and temperature that had been implemented in heat processing of a variety of foods (Sikorski, 2001). The consumption level of processed foods has elevated due to the impositions of recent way of life, where food preparation time is considered to be wasting time (Saldana and Bragagnolo, 2007). Processing of food products is usually about applying high temperature treatment, high pressure, alkaline or acidic media and water elution. Changes to foods, if any, due to these treatments should be well-known in order to minimize the loss of precious compounds of natural products, and to improve the process itself, and finally to achieve foods with the most excellent nutritional value.

Macro minerals needed by the body in relatively large amount, including Ca, P, K, Na, Cl, S, and Mg (Gartenberg, 1990; Spears, 1999). Micro mineral is a mineral needed in very small amount and is generally found in tissues with very small concentrations, i.e. Fe, Mo, Cu, Zn, Mn, Co, I, and Se (Brown, 2004; Arifin, 2008). As far as the mineral composition is concerned, no differences were observed between either fishing ground locations for micro minerals (Zinc, Iron and Copper). However, an interesting result occurs in macro mineral. The shrimps of Kuala Tungkal, Jambi coast showed higher Sodium, Potassium and Calcium contents than those of Cirebon coast. Yet, for Magnesium the shrimp of Cirebon had higher content in comparison with that of Kuala Tungkal, Jambi. These results are definitely associated with the elements intake route, which in marine crustacean is either from food or living

Table 3. Macro and micro mineral composition of another type of crustaceans (the unit is mg/100 g dry weight).

Composition	Type of crustacean fauna				
	Mantis shrimp of Jambi	Mantis shrimp of Cirebon	Shrimp[1]	Brown Shrimp[2]	White shrimp[3]
Moisture (%)	78.27	78.49	65.69	77.6	75.48
Ash (%)	1.60	1.64	1.3	1.8	7.64
Protein (%)	13.11	14.39	17-20	19.6	83.81
Fat (%)	1.29	0.6	0.92	0.9	1.79

Source : 1) Peplow *et al*., (1973); 2) Ravichandran *et al*., (2009)

medium/seawater (Rainbow, 2002). There will be variation of the proportion from each intake route, and it will depend upon the invertebrate physiological needs/endogenous factors, such as sex, age, condition and tissue and also the bioavailability of the elements in water and food. The bioavailability is affected by external environmental factors like season, location, substrate, depth, water salinity, temperature and anthropogenic influence (Wang and Fisher, 1999; Turoczy *et al.*, 2001; Fabris *et al.*, 2006; Jop *et al.*, 1997; Kádár *et al.*, 2006; Küçükgülmez *et al.*, 2006). Davis and Gatlin III (1996) clearly explained the requirements of some essential mineral in the dietary of fish and marine crustaceans in their review. The present study considers solely on one external factor, *i.e*. location. By seeing the results, it can be said that Kuala Tungkal, Jambi coastal waters have less Mg and more Na, K and Ca in a bioavailable form.

Regarding the mantis shrimp as a source of minerals for human consumption, Table 3 shows some mineral contents of various types of crustaceans. The table indicates that the mantis shrimps for both locations can be a good source of macro minerals (Na, K, Ca and Mg) and of micro mineral (especially Zinc) for human health.

Mineral solubility

The results of the influence of boiling on the solubility of minerals (Na, Ca, Zn and Fe) on various types of media (water, 1% NaCl and 0.5% acetic acid) are presented in Figure 2. The results show that media and processing (with and without

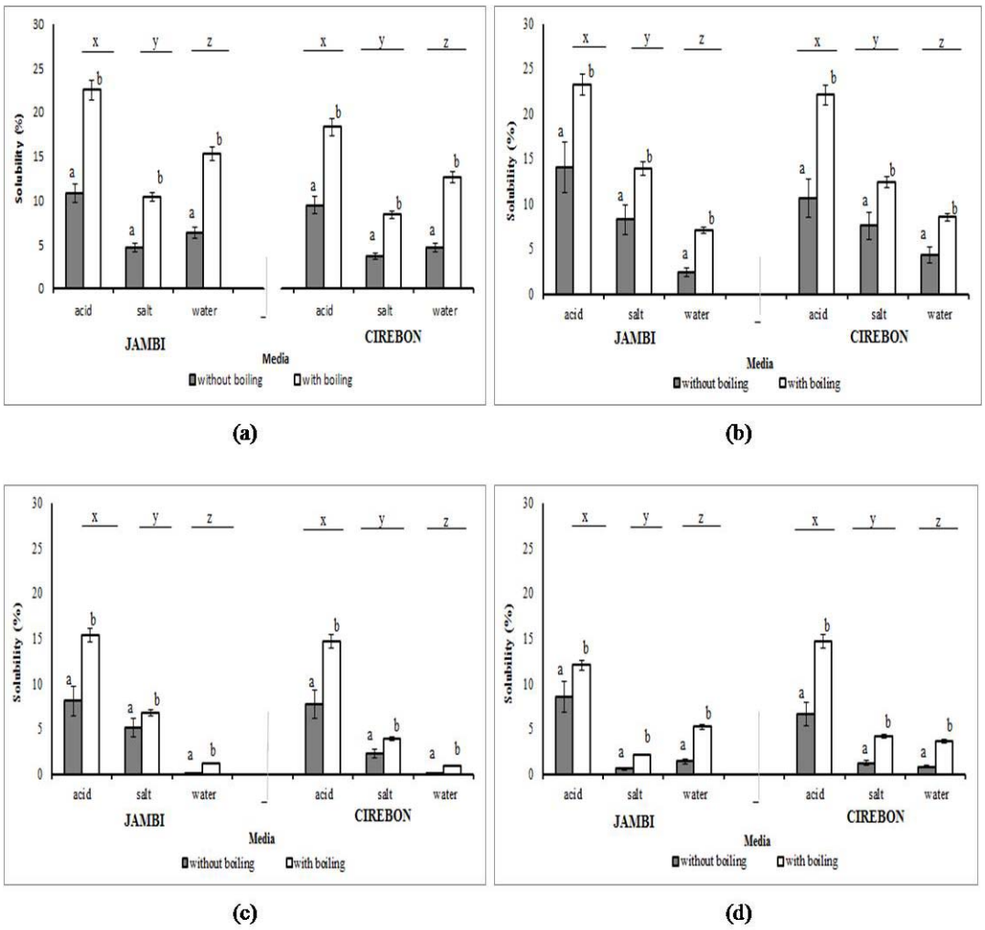

Figure 2. The mean of solubility of sodium (a), calcium (b), zinc (c) dan iron (d) due to boiling process with different media in the mantis shrimp (*Harpiosquilla raphidea*) collected from Jambi and Cirebon. (Note: letters a and b are the results of Duncan test for factors that indicate boiling significantly different ($p < 0.05$). Letters x, y and z are the results of Duncan test on the media treatment of boiling that show significantly different ($p < 0.05$).)

boiling) affected the solubility of the four mineral in the same patterns for samples of the two locations. The best media for getting the highest solubility was the acid, and it would be even better to boil the shrimp in acid. Location seems not to influence the solubility level of the four minerals.

Santoso *et al*. (2006[b]) and Santoso *et al.* (2007) reported that pH can affect the solubility of minerals. The used of 0.5% acetic acid could enhance the solubility of minerals such as calcium and magnesium both in seaweed and invertebrate organism. Mineral solubility of Fe in the three types of seaweed from Japan, namely *Porphyra yezoensis*, *Enteromorpha intestinal* and *Hiziki fusiformis* at pH 2 was higher than at pH 6 (Yoshie *et al*., 1999). Mineral solubility of Fe in cod, mussels and shrimp also increases with increasing degree of acidity (Yoshie *et al*., 1997), and the percentage of Fe solubility at pH 2.5 to 3.1 were also higher than at pH 5.5 in model studies with using organic acids and lignin (Suzuki *et al*., 1992). For protein, solubility is usually considered the premier functional properties of protein because of its relevance to other properties such as viscosity, gelation, foaming and emulsification (Hall, 1992), and the pH-solubility relationship for proteins has been well-studied (Geirsdottir *et al*., 2007; Emmanuel *et al*., 2008; Bourtoom *et al*., 2009). Omotoso (2005) also found the similar thing. He found that the protein solubility of the land crab (*Cardisoma armatum*) was affected by pH.

Minerals in foods can change their chemical structure during the cooking process or by interactions with other material. Mineral solubility can be increased or decreased depending on the process. Heating is known to cause the protein to be denatured; it can interact with the minerals that cause the mineral is difficult to dissolve (Santoso *et al*., 2006[a]). Cooking of food can have a positive effect because the cooking process can damage the inhibitor and change the mineral components of food into the complex nature of ligands that can increase its bioavailable (Niamnuy *et al*., 2008). Cooking may also have a negative impact, *i.e.* when there is activation of enzymes that inhibit and make a difficult mineral to be dissolved component (Watzke, 1998). This is what can lead to increase or decrease the solubility of minerals.

Conclusions

The research concludes that the macro minerals such as Na, K, Ca of mantis shrimp collected from Kuala Tungkal, Jambi waters are higher than those of mantis shrimp collected from Cirebon, but having smaller Mg. This indicates that Kuala Tungkal, Jambi coastal waters have less Mg and more Na, K and Ca in the form of bioavailable. Mantis shrimp is a good food source for macro- and micro mineral essential. Boiling with the acetic acid 0.5% would be the best to get high solubility of minerals Na, Ca, Zn and Fe.

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