The available utilization of selenium from some inedible tissues of marine products-IV:
The distribution of selenium in several species of shrimps

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Abstract

The selenium distribution in the exoskeleton (abdominal pleuron) as an inedible tissue and the ordinary muscle of several species of shrimps (Kuruma prawn *Marsupenaus japonocas*, Northern shrimp *Pandalus eous*, Whiskered velvet shrimp *Pleoticus muelleri* and Black tiger prawn *Penaeus monodon*) in clustacea, which have been known to be useful as the scavenger of heavy metals, was investigated in order to clarify the possibility of the available utilization of selenium from those tissues, in relation with the mercury distribution involving the tissues. As a result, each selenium and mercury level in the exoskeleton of all subjected species, except Black tiger prawn, was about the same and low compared with that involving muscle, respectively. Moreover, from the selenium molar fraction involving exoskeleton, the low oxidation states of selenium species was almost predominant in all subjected species, as not in the case of involving ordinary muscle, suggesting that a little Se(VI) species as metabolized in living body after eating exists in the exoskeleton. On the other hand, the Se/Hg (the molar ratio of selenium to mercury) as an indicator of the safety of marine products was also extremely high compared with that involving ordinary muscle, except Black tiger prawn, suggesting that the exoskeleton will be usually inedible but significantly safe tissue in which low levels of heavy metals such as mercury will tend to accumulate, as in the case of a preceding paper. These findings suggest that the available utilization of selenium will not be expected from the exoskeleton, including the improvement of the environment.

Key words
selenium, mercury, distribution, shrimp, exoskeleton

1. Introduction

The scales or the skin of fish are usually discarded as an inedible tissue. Therefore, if the selenium level of such discarded tissues is about the same or higher compared with that of the ordinary muscle as an edible tissue, in addition to no mercury accumulation, the available utilization of selenium will be expected as an essential element (not only detoxification of mercury) from the inedible tissues of marine products, including the improvement of the environment. The selenium distribution in the scales or skin as inedible tissues of several species of fish in relation with the mercury distribution involving tissue has already been reported (Kai et al., 2013; 2014). As a result, each selenium level in the scales or skin and pectoral fin was about the same or somewhat higher than that involving muscle of those fish, but the mercury level was surprisingly low or nearly zero, as not in the cases of midgut grand of shellfish (Kai et al., 2017).

In recent years, it has been well known that the exoskeleton as inedible tissue of several species of shrimps are a very important substance in daily life from the existence and the application of a large amount of chitin or chitosan as one of detoxicants or scavengers against heavy metals such as mercury (Chibu and Shibayama, 2002). On the other hand, the distributions of selenium and mercury in these exoskeletons are little known. Then, it will be very noteworthy to investigate if the selenium level of such discarded tissues is about the same or higher compared with that of the ordinary muscle, in addition to lower or little mercury accumulation, because the available utilization of selenium may be newly found from the inedible tissues, in addition with that of detoxicants such as chitin or chitosan etc.

In the present paper, the selenium distribution in the exoskeleton as one of inedible tissues of the several species of shrimps was investigated in order to clarify the possibility of the utilization of selenium from that discarded tissue, in relation with the mercury distribution involving tissue.

2. Materials and methods

2.1 Materials

Two kinds of cultured Kuruma prawn *Marsupenaus* and wild Northern shrimp *Pandalus eous* as domestic species and two kinds of wild Whiskered velvet shrimp *Pleoticus muelleri* and cultured Black tiger prawn *Penaeus monodon* as outside domestic species were submitted in the present study, respectively. Each five individual ranges of body length of Kuruma prawn, Northern shrimp, Whiskered velvet shrimp and Black tiger prawn were 13.5 to 15.3, 11.2 to 12.8, 12.5 to 14.0, 15.3 to 16.5 cm, respectively.

There was little difference of the degree of growth between the same species in each sampled fish.

In the present study, the ordinary muscle and the exoskeleton as inedible tissues were removed from these fish bodies, and stored in a freezer at –30 ℃ until analyzed.

2.2 Methods

2.2.1 Determination of selenium

The oxidation number of selenium exists as –2, +4, and +6 in aquatic organisms. The minus divalent selenium exists as an organic form, and this form will be the selenide species assigned to the selenohydryl groups (–SeH or SeHg and SeCd) substituting for sulfur of the thiol group or bonding to heavy metals such as Hg and Cd. The chemical forms of the plus tetravalent and hexavalent seleniums will be selenite and selenate species joined to two neighboring thiol groups in the protein, respectively (Gasiewicz and Smith, 1978; Cappon and Smith, 1981; Iwata et al., 1982).

The total selenium concentration and the concentration of the low oxidation states of selenium (selenide and selenite species) (abbreviated as T-Se and [Org.Se+Se(IV)], respectively) in each specimen were then measured using gas chromatography with an electron capture detector (Toei and Shimoishi, 1981). The concentration of the selenate species was estimated by the difference between T-Se and [Org. Se+Se(IV)], and abbreviated as Se(VI).

2.2.2 Determination of mercury

The total mercury concentration in each specimen was measured by a flow injection analysis system using cold vapor atomic absorption spectrometry (FIAS-CV-AAS) preceded by a wet digestion in a microwave oven, and abbreviated as T-Hg (Aduna de Paz et al., 1997).

3. Results and discussion

3.1 Selenium distribution

3.1.1 Kuruma prawn

The ranges of [Org.Se+Se(IV)], Se(VI) and T-Se in the ordinary muscle were 0.11_8 to 0.19_4, 0.12_0 to 0.17_2 and 0.23_5 to 0.36_6 μg/g ($0.15_0 \pm 0.01_5$, $0.14_5 \pm 0.00_9$ and $0.29_5 \pm 0.02_1$ μg/g as each mean concentration), respectively. Those in the exoskeleton were 0.13_3 to 0.37_7, 0.02_1 to 0.05_8 and 0.15_9 to 0.42_4 μg/g ($0.28_0 \pm 0.04_2$, $0.04_1 \pm 0.00_7$ and $0.32_1 \pm 0.04_6$ μg/g as each mean concentration), respectively.

3.1.2 Northern shrimp

The ranges of [Org.Se+Se(IV)], Se(VI) and T-Se in the ordinary muscle were 0.05_4 to 0.07_0, 0.10_4 to 0.17_8 and 0.15_8 to 0.23_7 μg/g ($0.06_1 \pm 0.00_2$, $0.14_5 \pm 0.01_7$ and $0.20_6 \pm 0.01_6$ μg/g as each mean concentration), respectively. Those in the exoskeleton were 0.17_1 to 0.19_2, 0.00_5 to 0.35_7 and 0.194 to 0.44_1 μg/g ($0.16_2 \pm 0.01_9$, $0.11_1 \pm 0.06_4$ and $0.27_3 \pm 0.04_5$ μg/g as each mean concentration), respectively.

3.1.3 Whiskered velvet shrimp

The ranges of [Org.Se+Se(IV)], Se(VI) and T-Se in the ordinary muscle of cultured species were 0.15_2 to 0.23_9, 0.18_0 to 0.25_0 and 0.38_8 to 0.43_7 μg/g ($0.19_6 \pm 0.01_5$, $0.22_0 \pm 0.01_3$ and $0.41_6 \pm 0.00_9$ μg/g as each mean concentration), respectively. Those in the exoskeleton were 0.05_5 to 0.34_4, 0.06_2 to 0.22_7 and 0.28_5 to 0.40_6 μg/g ($0.22_0 \pm 0.05_2$, $0.14_6 \pm 0.03_4$ and $0.36_2 \pm 0.04_4$ μg/g as each mean concentration), respectively.

3.1.4 Black tiger prawn

The ranges of [Org.Se+Se(IV)], Se(VI) and T-Se in the ordinary muscle were 0.09_2 to 0.15_8, 0.08_4 to 0.24_6 and 0.17_6 to 0.39_6 μg/g ($0.12_4 \pm 0.01_1$, $0.17_3 \pm 0.03_3$ and $0.29_7 \pm 0.04_1$ μg/gas each mean concentration), respectively. Those in the exoskeleton were 0.07_7 to 0.16_2, 0.01_0 to 0.10_5 and 0.10_9 to 0.23_9 μg/g ($0.12_2 \pm 0.01_4$, $0.05_4 \pm 0.01_6$ and $0.17_6 \pm 0.02_1$ μg/g as each mean concentration), respectively.

3.2 Mercury distribution

3.2.1 Kuruma prawn

The ranges of T-Hg in the ordinary muscle and exoskeleton were 0.00_8 to 0.04_1 and 0.005 to 0.00_7 μg/g ($0.02_4 \pm 0.00_7$ and $0.00_7 \pm 0.00_1$ μg/g as each mean concentration), respectively.

3.2.2 Northern shrimp

The range of T-Hg in the ordinary muscle was 0.04_0 to 0.06_8 ($0.05_5 \pm 0.00_6$ μg/g as mean concentration. T-Hg of the exoskeleton was 0.02_1 μg/g as mean concentration of one specimen combined with five individuals because the sample size was very small.

3.2.3 Whiskered velvet shrimp

The ranges of T-Hg in the ordinary muscle and exoskeleton were 0.00_9 to 0.01_0 and 0.00_1 to 0.02_5 μg/g ($0.01_0 \pm 0.00_0$ and $0.00_9 \pm 0.00_4$ μg/g as each mean concentration), respectively.

3.2.4 Black tiger prawn

The ranges of T-Hg in the ordinary muscle and exoskeleton were 0.00_3 to 0.00_9 and 0.00_6 to 0.02_9 μg/g ($0.00_6 \pm 0.00_1$ and $0.01_6 \pm 0.00_5$ μg/g as each mean concentration), respectively.

4. Conclusion

From the profiles of selenium and mercury distribution shown in Figures 1 and 2, it was clear that those of shrimps are significantly different, as not in the cases of papers previously reported (Kai et al., 2013; 2014; 2017), that is, that the selenium levels of exoskeleton as the discarded tissues are also high compared with those of the whole muscle, in addition to higher mercury accumulation. Furthermore, from the estimated value of selenium molar fraction shown in Figure 3, [Org.Se+Se(IV)]molar fraction of the exoskeleton was about the same or somewhat higher than that of ordinary muscle in the subjected shrimps, suggesting that a little Se(VI) species as metabolized in living body after eating exists in the exoskeleton.

These findings mean that the new utilization of selenium

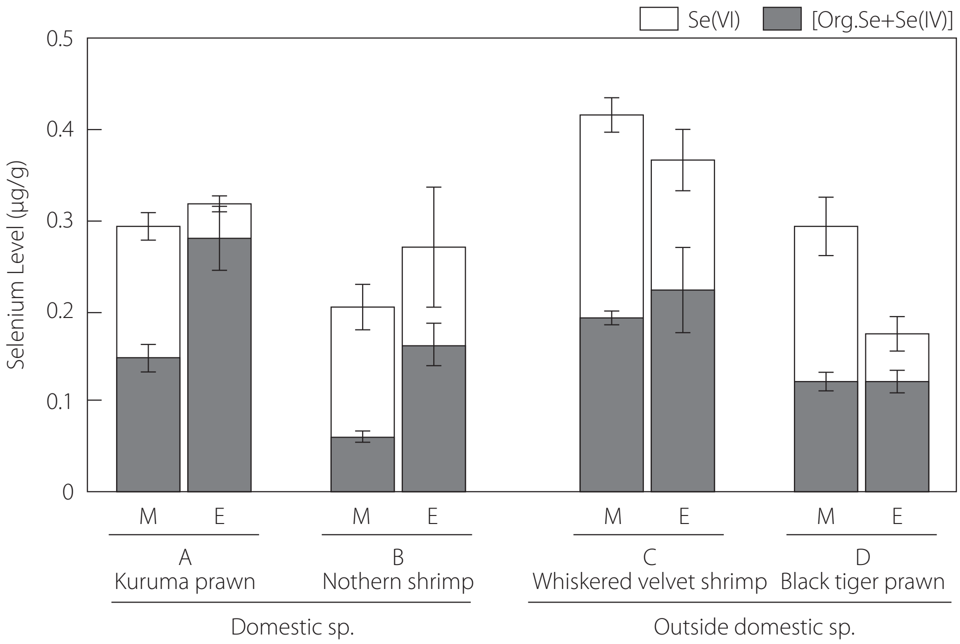

Figure 1: Selenium levels in the subjected shrimps

Note: M = Ordinary muscle; E = Exoskeleton

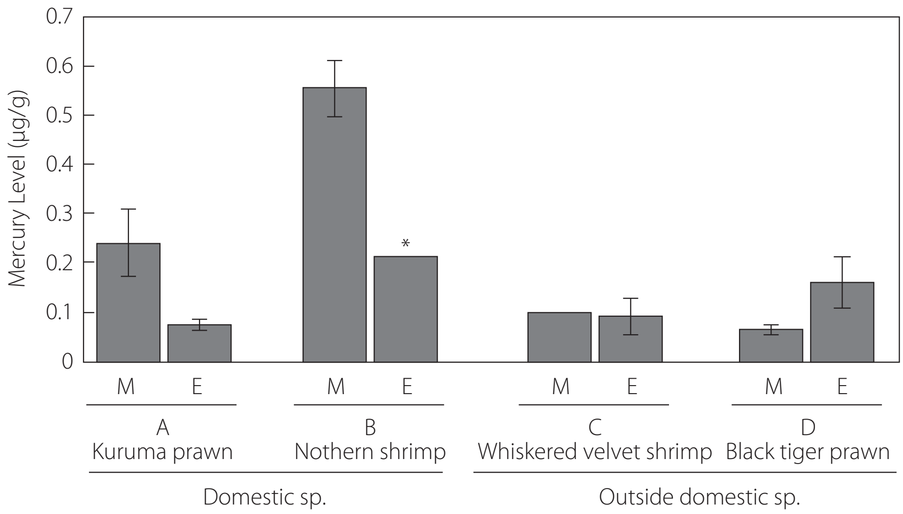

Figure 2: Mercury levels in the subjected shrimps

Note: M = Ordinary muscle; E = Exoskeleton; * = Mean concentration as one specimen combined with five individuals

as an essential element will be not expected using the exoskeleton as inedible tissues of shrimps.

In the present shrimps, each molar ratio of T-Hg to T-Se in both tissues were also calculated as an indicator of safety against toxicity due to the accumulation of mercury (Kai et al., 2013; 2014; 2017). The ranges of each mean molar ratio of ordinary muscle and exoskeleton were 8.35 to 259.39 and 17.16 to 233.11, respectively.

As shown in Figure 4, all of those mean values were larger than 1.00, suggesting that those sampled marine products are generally safe against toxicity due to the accumulation of mercury.

In further studies, using another species of crustaceans or seaweeds etc., the possibility of the overall utilization of selenium from the discarded or inedible tissues in marine products should be clarified.

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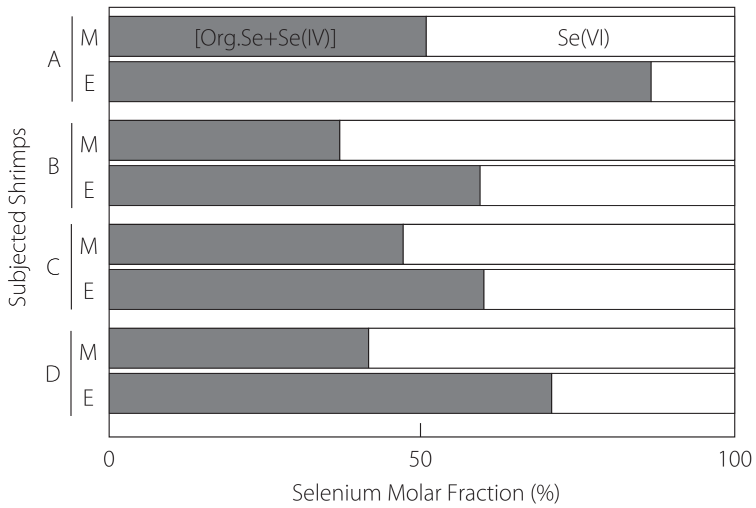

Figure 3: Selenium molar fraction in the subjected shrimps
Note: M = Ordinary muscle; E = Exoskeleton

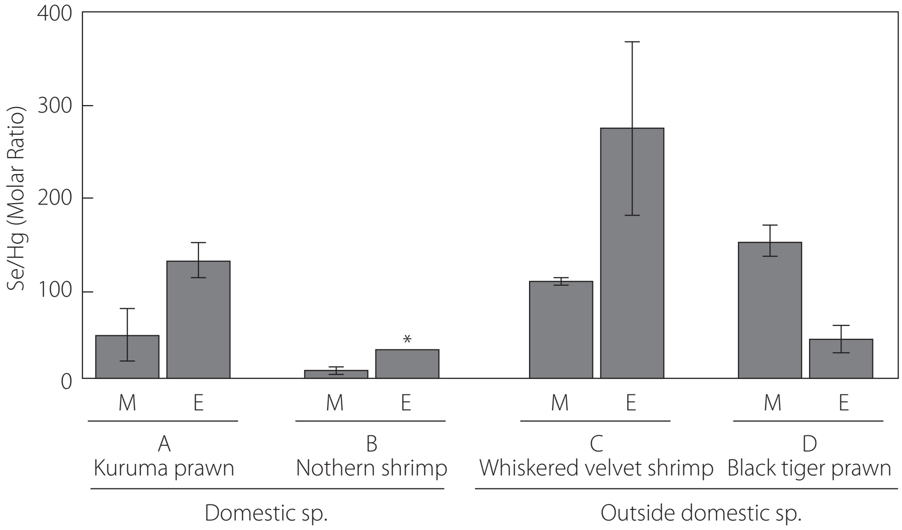

Figure 4: Se/Hg (molar ratio) in the subjected shrimps
Note: M = Ordinary muscle; E = Exoskeleton; * = Mean concentration as one specimen combined with five individuals

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(Received: November 1, 2017; Accepted: April 2, 2018)