The available utilization of selenium from some inedible tissues of marine products-II: The distribution of selenium in several species of fish at lower trophic level in the marine ecosystem

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Abstract
The selenium distribution in the scales or skin as the some inedible tissues and the ordinary muscle of several species of fish at lower trophic levels in marine ecosystem (Japanese sardine Sardinops melenostictus, Silver-stripe herring Spratelloides gracilis, Japanese horse mackerel Trachurus japonicas, Chub mackerel Scomber japonicas, Pacific saury Cololabis saira and Flying fish Cypselurus agoo agoo), generally called “Aomono” in Japanese, containing a small amount of mercury with a large amount of polyunsaturated fatty acid, 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 level in the scales or skin in all subjected fish was about the same or somewhat higher than that involving muscle. On the other hand, the mercury level was extremely low compared with the muscle and Se/Hg (the molar ratio of selenium to mercury) as an indicator of the safety of marine products was extremely high compared with that involving muscle, suggesting that the scale or skin will be usually expected as an essential element (not only detoxification of mercury) from the inedible tissues of marine products, in addition with that of PUFA such as EPA, DHA etc. from the edible tissue. Therefore, if the selenium level of such discard involved fish was about the same or somewhat higher than that involving muscle of those fish, but the mercury level was surprisingly low or nearly zero.

Key words
selenium, mercury, distribution, inedible tissue, lower trophic level

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 environment. The selenium distribution in the scales or skin as inedible tissues of several species of fish (Yellow tail Seriola quinqueradiata, Red sea bream Pagrus major and Puffer Takihugu rubripes) in relation with the mercury distribution involving tissue has already been reported (Kai et al., 2013). As a result, each selenium level in the scales or skin was about the same or somewhat higher than that involving muscle of those fish, but the mercury level was surprisingly low or nearly zero.

In recent years, it has been well known that several species of fish generally called “Aomono” in Japanese are a very important diet in daily life due to the existence of a large amount of polyunsaturated fatty acid (PUFA) as one of antioxidants (Kimura and Miyashita, 2003; Ulven et al., 2014). On the other hand, it is also known that there will be low mercury accumulation in these fish bodies, because these fish are located at lower trophic levels in the marine ecosystem. This suggests that the mercury levels of these low cost fish are significantly lower than those of the usually tasted and consumed fish in our preceding study (Kai et al., 2013). 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 PUFA such as EPA, DHA etc. from the edible tissue.

In the present paper, the selenium distribution in some inedible tissues of the several species of fish at lower trophic levels in marine ecosystem was investigated in order to clarify the possibility of the utilization of selenium from those discarded tissues, in relation with the mercury distribution involving tissue.

2. Materials and methods
2.1 Materials
Five kinds of Japanese sardine Sardinops melenostictus from Mie Prefecture, Japanese horse mackerel Trachurus japonicas from Oita Prefecture, Chub mackerel Scomber japonicas from...
Yamaguchi Prefecture, Pacific saury Cololabis saira from Hokkaidou, Silver-stripe herring Spratelloides gracilis, and Flying fish Cypselurus aogo aogo from Kagoshima Prefecture were submitted in the present study, respectively. The ranges of body length of Japanese sardine, Silver-stripe herring, Japanese horse mackerel, Chub mackerel, Pacific saury and Flying fish were 14.6 to 15.4, 4.5 to 5.6, 17.3 to 21.5, 31.8 to 35.4, 30.0 to 31.5 and 27.5 to 30.0 cm (14.9, 5.0, 19.4, 34.0, 31.0 and 29.2 cm (as each mean concentration). 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 scale or skin (plus pectoral fins only in the case of Flying fish) as inedible tissues were removed from these fish bodies, and stored in a freezer at −30 °C 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 Japanese sardine

The ranges of [Org.Se + Se (IV)], Se (VI) and T-Se in the ordinary muscle were 0.29, to 0.49, to 0.11, and to 0.37, to 0.50, µg/g (0.38, ± 0.03, ± 0.06, ± 0.02, and ± 0.02, µg/g as each mean concentration), respectively. Those in the skin were 0.52, to 0.94, 0.08, to 0.17, and 0.64, 1.06, µg/g (0.64, ± 0.07, ± 0.12, ± 0.01, and 0.76, ± 0.08, µg/g as each mean concentration), respectively.

3.1.2 Silver-stripe herring

The ranges of [Org.Se + Se (IV)], Se (VI) and T-Se in the ordinary muscle were 0.25, to 0.39, to 0.13, and to 0.29, to 0.52, µg/g (0.31, ± 0.02, ± 0.08, ± 0.01, and 0.40, ± 0.03, µg/g as each mean concentration), respectively. Those in the skin were 0.80, 0.89, and 1.70, µg/g as each mean concentration of one specimen combined with five individuals because the sample size was very small as described above, respectively.

3.1.3 Japanese horse mackerel

The ranges of [Org.Se + Se (IV)], Se (VI) and T-Se in the ordinary muscle of cultured species were 0.13, to 0.26, 0.03, to 0.16, and 0.23, to 0.41, µg/g (0.22, ± 0.03, 0.10, ± 0.05, and 0.32, ± 0.03, µg/g as each mean concentration), respectively. Those in the scales were 0.15, to 0.29, 0.03, to 0.54, and 0.23, to 0.81, µg/g (0.23, ± 0.02, 0.18, ± 0.09, and 0.42, ± 0.11, µg/g as each mean concentration), respectively.

3.1.4 Chub mackerel

The ranges of [Org.Se + Se (IV)], Se (VI) and T-Se in the ordinary muscle were 0.32, to 0.69, 0.06, to 0.24, and 0.46, to 0.75, µg/g (0.43, ± 0.06, 0.15, ± 0.03, and 0.58, ± 0.05, µg/g as each mean concentration), respectively. Those in the skin were 0.08, to 0.22, 0.03, to 0.23, and 0.13, to 0.39, µg/g (0.14, ± 0.02, ± 0.09, ± 0.03, and 0.23, ± 0.04, µg/g as each mean concentration), respectively.

3.1.5 Pacific saury

The ranges of [Org.Se + Se (IV)], Se (VI) and T-Se in the ordinary muscle were 0.07, to 0.11, 0.06, to 0.19, and 0.17, to 0.29, µg/g (0.09, ± 0.00, 0.13, ± 0.02, and 0.23, ± 0.02, µg/g as each mean concentration), respectively. Those in the skin were 0.06, to 0.17, 0.07, to 0.39, and 0.22, to 0.51, µg/g (0.12, ± 0.04, 0.23, ± 0.09, and 0.35, ± 0.10, µg/g as each mean concentration), respectively.

3.1.6 Flying fish

The ranges of [Org.Se + Se (IV)], Se (VI) and T-Se in the ordinary muscle were 0.10, to 0.16, 0.10, to 0.29, and 0.22, to 0.40, µg/g (0.12, ± 0.01, 0.17, ± 0.03, and 0.30, ± 0.03, µg/g as each mean concentration), respectively. Those in the scale were 0.08, to 0.15, 0.08, to 0.14, and 0.19, to 0.23, µg/g (0.10, ± 0.01, 0.11, ± 0.01, and 0.22, ± 0.02, µg/g as each mean concentration), respectively. Those in the pectoral fins were 0.10, to 0.19, 0.07, to 0.08, and 0.18, to 0.26, µg/g (0.14, ± 0.04, 0.08, ± 0.00, and 0.22, ± 0.04, µg/g as each mean concentration), respectively. The results on the selenium data described above are shown in Figure 1.

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3.2 Mercury distribution

3.2.1 Japanese sardine
The range of T-Hg in the ordinary muscle and skin were 0.016 to 0.02, and 0.008 to 0.014 µg/g (0.02 ± 0.00, and 0.01 ± 0.00, µg/g as each mean concentration), respectively.

3.2.2 Silver-stripe herring
The range of T-Hg in the ordinary muscle and skin were 0.007 to 0.01, and 0.005 to 0.011 µg/g (0.01 ± 0.00, and 0.00 ± 0.00, µg/g as each mean concentration), respectively.

3.2.3 Japanese horse mackerel
The range of T-Hg in the ordinary muscle and scales were 0.027 to 0.031, and 0.002 to 0.004 µg/g (0.01 ± 0.00, and 0.00 ± 0.00, µg/g as each mean concentration), respectively.

3.2.4 Chub mackerel
The range of T-Hg in the ordinary muscle and skin were 0.005 to 0.011, and 0.00 to 0.005 µg/g (0.01 ± 0.01, and 0.00 ± 0.00, µg/g as each mean concentration), respectively.

3.2.5 Pacific saury
The range of T-Hg in the ordinary muscle and skin were 0.001 to 0.013, and 0.00 to 0.001 µg/g (0.01 ± 0.01, and 0.00 ± 0.00, µg/g as each mean concentration), respectively.

3.2.6 Flying fish
The range of T-Hg in the ordinary muscle, scales and pectoral fins were 0.001 to 0.015, 0.00, to 0.00, and 0.002 to 0.005 µg/g (0.07 ± 0.02, 0.00 ± 0.00, and 0.00 ± 0.00, µg/g as each mean concentration), respectively. The results on the mercury data described above are shown in Figure 2.

Then, Se/Hg (the molar ratio of selenium to mercury) of the ordinary muscle and the scales or the skin in all sampled fish species were estimated at molar basis as the indicator on the safety of marine products, from the point of the toxicological view of a trace amount of heavy metals such as mercury.

Each mean value of Se/Hg in the ordinary muscle and the scales or the skin of Japanese sardine, Silver-stripe herring, Japanese horse mackerel, Chub mackerel, Pacific saury and Flying fish were 57.79 and 188.98, 108.64 and 283.83, 10.95 and 123.38, 38.21 and 83.36, 10.88 and 59.30 and 18.02 and 141.33, respectively. On the other hand, the mean value of Se/Hg in the pectoral fins of Flying fish was 250.45. The results on the estimated value described above are shown in Figure 3.

4. Conclusion
From the profiles of selenium and mercury distribution shown in Figures 1 and 2, it is clear that those of fish at lower trophic levels in the marine ecosystem are about the same as the cases of Yellow tail, Red sea bream and Puffer described...
in a preceding paper (Kai et al., 2013), that is, that the selenium levels of the discarded tissues are about the same or higher compared with those of the ordinary muscle, in addition to lower or little mercury accumulation. Furthermore, from the profile of estimated value shown in Figure 3, each distribution profile of the value of Se/Hg in the ordinary muscle and the scales or the skin was also about the same, and those mean values were larger than 1, suggesting that those sampled marine products are generally safe against toxicity due to the accumulation of mercury. Especially, it will be also very noteworthy that that value in the inedible tissue such as pectoral fins of Flying fish in addition with scale or skin was extremely high compared with those in the ordinary muscle. These findings mean that the new utilization of selenium as an essential element will be expected using discarded tissues containing the present inedible tissues as in the case of previous reported fish (Kai et al., 2013), and moreover that the improvement of the environment will be performed by such utilization.

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

References


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