Diminution of the Arsenic Level in Hijiki, *Sargassum fusiforme* (Harvey) Setchell[+], through Pre-cooking Treatment

Yohko SUGAWA-KATAYTAMA[1, 2)]*, Masayuki KATAYAMA[1, 3)], Yoko ARIKAWA[2)], Yuko YAMAMOTO[1)], Rie SAWADA[1)] and Yukihiro NAKANO[4)].

[1)] *Gifu Women's University***, [2)] *Fukuoka Women's University****, [3)] *Osaka Prefecture University*****, [4)] *Research Reactor Institute, Kyoto University******

Summary

The seaweed Hijiki, *Sargassum fusiforme* (Harvey) Setchell, has been traditionally eaten by Japanese. However, a rather high concentration of arsenic is sometimes detected in dried Hijki. Thus, it is necessary to find a pre-cooking process to diminish its arsenic level. The arsenic level in commercial products of dried Hijiki harvested in Japan was diminished more than 50 percent by soaking them in water for several hours at room temperature.

Key words: Arsenic, *Sargassum fusiforme* (Harvey) Setchell, Neutron activation analysis, Hijiki, Water soaking, *Phaeophyta* Family.

Introduction

Japanese people traditionally eat a high amount of seaweeds of the *Phaeophyta* Family, some of which have sometimes been reported to contain rather higher amounts of arsenic[2, 3, 4)]. Hijiki, *Sargassum fusiforme* (Harvey) Setchell, a member of the Family, contains significant amounts of arsenic in the whole plant[3, 4)]. We aimed to elucidate the arsenic distribution in Hijiki plants, harvested for commercial products at several points of the Japanese coast line[5, 6, 7, 8, 9)].

To obtain safe foodstuffs, it is necessary to find a pre-cooking process which would diminish their arsenic contents. In this research, we arrived at the conclusion that the arsenic level in commercial dried Hijiki samples was diminished more than 50 percent by soaking them in water for several hours at room temperature before cooking.

Experimental

Hijiki, *Sargassum fusiforme* (Harvey) Setchell

Commercial products of dried Hijiki were obtained from several local markets in Fukuoka and Tsu City. The Hijiki plants were dried under the sun on the seashore after harvest. The dried plants were gathered, heated in boiling water and air-dried for the commercial products.

Water-soaking of dried Hijiki samples

Measured portions of dried Hijiki were soaked in 20 volumes of pure water (MiliQ or another grade of water) for

---

[+]Newly proposed taxonomic name[1)] of *Hizikia fusiforme* Okam.

*To whom the correspondence should be sent.

**Address : 80 Taromaru, Gifu City, 501-2592, Japan

***Address : 1-1-1 Kasumigaoka, Higashi-ku, Fukuoka City, 813-8529, Japan

****Professor Emeritus (2-33-10 Shiroyamadai, Hashimoto City, 648-0054, Japan)

*****Address : 2, Asashirodai-Nishi, Kumatoricho, Sennan-gun, Osaka Pref., 590-0494, Japan

20 min, 1 hr or 6 hr at room temperature as a pre-cooking process.

The soaked plants were separated from the extracts by filtration. Aliquots of the extracts were concentrated and spotted onto pieces of filter paper, Toyo Roshi, No.51A, and dried. The separated Hijiki residues were lyophilized in small polyethylene bags.

Arsenic determination[6)]

The extracts on the filter paper and the residues of Hijiki plants were separately packaged in small polyethylene bags for neutron activation analysis.

The amount of arsenic in each sample was determined in duplicate in comparison with an arsenic standard. To determine the arsenic concentration in the samples, 40 of these bags were put together in a polyethylene Neuma-capsule, with 10 bags of various amounts of a standard arsenic compound; two of the standard specimens were arranged for every 8 specimens of the Hijiki samples.

Thermal neutron activation analysis[6)]

The samples in the Neuma-capsules were irradiated in a flux of 10^{13} neutrons・cm^{-2}・sec^{-1} for 20 min in the center position of the nuclear reactor of the Research Reactor Institute, Kyoto University. After the cooling time of 72 hr, the arsenic contents in the samples were determined by gamma radiation from ^{76}As using a pure Ge gamma-detector at 559.1 keV. The energy levels of ^{60}Co and ^{137}Cs were used for the calibration.

Results and Discussion

Levels of arsenic in the various samples

When the whole plant of Hijiki is cut and divided into several parts, the arsenic concentration on the dry weight basis in the leaves, stalks and the filamentous holdfast was not uniform along the stem of Hijiki, suggesting that arsenic accumulated depending on the ocean conditions as well as on the plant physiological conditions[5, 6, 7, 8, 9)]. For preparing the commercial products, the dried Hijiki plants are gathered from more than one harvesting seashore and mixed. Therefore, the arsenic concentrations in the commercial products are likely to be variable according to the individual origin differences of Hijiki plants as well as their differences in production lot. The arsenic levels in the dried samples varied from 37ppm to 146ppm on the dry weight basis (Table 1).

Arsenic contents in the residues after extraction with water

By soaking dried Hijiki in water, a significant amount of arsenic can be extracted. With the lapse of time, the arsenic content in Hijiki decreased rapidly as shown in Table 2 and 3. The time course of change in the percentage of the arsenic content remaining in the Hijiki plants suggested that the longer the time of soaking, the lesser retention of arsenic in the Hijiki plants.

The diminution of arsenic in the Hijiki will thus be easily attained, since a process as simple as soaking in water

Table 1 Arsenic concentration in commercial products of Hijiki plants.

Products, harvested at*	Sample No.**	Grade	Harvest Year	Tissues	As μg/g Dry Weight of Hijiki
Ie	Ie-1-1	Nagahijiki	2003	Stalks	37.4
Ie	Ie-2-1	Nagahijiki	2000	Stalks	107.8
Ie	Ie-3-1	Mehijiki	2000	Leaves	59.8
Ts	Ts-1-1	Nagahijiki	2000	Stalks	75.2
Ts	Ts-2-1	Mehjiki	2000	Leaves	88.0
Ts+Ik+G	Ts+Ik+G	-	2003	Leaves+Stalks	146.3

* : The harvest places are designated in abbreviated marks.
** : The last number -1 means the different lots from those with -2 in Table 2.

Table 2 Arsenic concentration in Hijiki plants, after soaking in water for 20 min.

Products, harvested at *	Sample No.**	Tissues	As μg/g Dry Weight of Hijiki, after soaking	Extracted As μg	Ratio of the retained As in the soaked plants (%)***
Ie	Ie-1-2	Stalks	-	-	-
Ie	Ie-2-2	Stalks	76.2	30.2	71.6
Ie	Ie-3-2	Leaves	49.0	18.0	73.1
Ts	Ts-1-2	Stalks	77.0	27.2	73.9
Ts	Ts-2-2	Leaves	71.4	24.2	74.7

*: The harvest places are designated in abbreviated marks, as Table 1.
**: The last number -2 means the different lots from those with -1 in Table 1.
***: Arsenic retained in soaked Hijiki plus extracted one was 100%.
- : Not determined.

Table 3 Arsenic concentration in Hijiki plants, after soaking in water for 1 hour or 6 hours.

Products, harvested at *	Soaking time (hours)	Tissues	As μg/g Dry Weight of Hijiki, after soaking	Ratio of the retained As in the soaked plants (%)
Ts+Ik+G	0	Leaves + Stalks	146.3	100.0
	1		73.7	50.4
	6		52.0	35.6

*: The harvest places are designated in abbreviated marks, as Table 1.

would diminish the arsenic level more than 50% in several hours. We are investigating more details of the effective diminution process for the arsenic level in Hijiki.

Acknowledgements

The authors express their appreciation to Prof. M. Amano, Mie University, for his valuable suggestions and support to the research.

References

1) Yoshida, T., K. Yoshinaga and Y. Nakajima (2000) Jpn. J. Phycol. (Sorui), 48: 113-166.
2) Suzuki, Y. and S. Tanushi (1993) 15th Group-ALGAE, in Table of Trace Element Contents in Japanese Foodstuffs, ed. by Y. Suzuki, and S. Tanushi, Daiichi Shuppan Publ. Co. Ltd., Tokyo: pp.152-153.
3) Kawashima, T., T. Yamamoto and Y. Koda (1983) J. Chem. Soc. Jpn., 1983: 368-379.
4) Jin, K. (1983) Rep. Hokkaido Inst. Publ. Health, 33: 21-27.
5) Katayama, M., C. Sakiyama, Y. Nakano and Y. Sugawa-Katayama (2001) Proceedings of 18th Symposium on Trace Nutrients Research, Kyoto, 18: 29-34.
6) Sugawa-Katayama, Y., M. Katayama, C. Sakiyama and Y. Nakano (2004) Bull. Fac. Human Environment. Sci., Fukuoka Women's Univ., 35: 81-90.
7) Sugawa-Katayama, Y., M. Katayama, C. Sakiyama and Y. Nakano (2004) Bull. Fac. Human Environment. Sci., Fukuoka Women's Univ., 35: 91-100.
8) Sakiyama, C., M. Katayama, Y. Nakano and Y. Sugawa-Katayama (2004) Bull. Fac. Human Environment. Sci., Fukuoka Women's Univ., 35: 101-106.
9) Sugawa-Katayama, Y., M. Katayama, C. Sakiyama, and Y. Nakano (2003) Proceedings of 20th Symposium on Trace Nutrients Research, Kyoto, 20: 73-79.