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

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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 arsenic2,3,4). Hijiki, *Sargassum fusiforme* (Harvey) Setchell, a member of the Family, contains significant amounts of arsenic in the whole plant3,4). We aimed to elucidate the arsenic distribution in Hijiki plants, harvested for commercial products at several points of the Japanese coastline.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 (MilliQ or another grade of water) for

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*Newly proposed taxonomic name*1) of *Hizikia fusiforme* Okam.
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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 Hijiiki residues were lyophilized in small polyethylene bags.

**Arsenic determination**

The extracts on the filter paper and the residues of Hijiiki 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 Hijiiki samples.

**Thermal neutron activation analysis**

The samples in the Neuma-capsules were irradiated in a flux of \(10^{13}\) neutrons \(\cdot\ \text{cm}^{-2} \cdot \text{sec}^{-1}\) 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 \(^{75}\)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 Hijiiki 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 Hijiiki, 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 Hijiiki 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 Hijiiki 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 Hijiiki in water, a significant amount of arsenic can be extracted. With the lapse of time, the arsenic content in Hijiiki decreased rapidly as shown in Table 2 and 3. The time course of change in the percentage of the arsenic content remaining in the Hijiiki plants suggested that the longer the time of soaking, the lesser retention of arsenic in the Hijiiki plants.

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

<table>
<thead>
<tr>
<th>Products, harvested at*</th>
<th>Sample No.**</th>
<th>Grade</th>
<th>Harvest Year</th>
<th>Tissues</th>
<th>As µg/g Dry Weight of Hijiiki</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ie</td>
<td>Ie-1-1</td>
<td>Nagahijiiki</td>
<td>2003</td>
<td>Stalks</td>
<td>37.4</td>
</tr>
<tr>
<td>Ie</td>
<td>Ie-2-1</td>
<td>Nagahijiiki</td>
<td>2000</td>
<td>Stalks</td>
<td>107.8</td>
</tr>
<tr>
<td>Ie</td>
<td>Ie-3-1</td>
<td>Mehijiki</td>
<td>2000</td>
<td>Leaves</td>
<td>59.8</td>
</tr>
<tr>
<td>Ts</td>
<td>Ts-1-1</td>
<td>Nagahijiiki</td>
<td>2000</td>
<td>Stalks</td>
<td>75.2</td>
</tr>
<tr>
<td>Ts</td>
<td>Ts-2-1</td>
<td>Mehijiki</td>
<td>2000</td>
<td>Leaves</td>
<td>88.0</td>
</tr>
<tr>
<td>Ts+Ik+G</td>
<td>Ts+Ik+G</td>
<td>-</td>
<td>2003</td>
<td>Leaves+Stalks</td>
<td>146.3</td>
</tr>
</tbody>
</table>

*: 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.

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

*: 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.

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

<table>
<thead>
<tr>
<th>Products, harvested at *</th>
<th>Soaking time (hours)</th>
<th>Tissues</th>
<th>As μg/g Dry Weight of Hijiki, after soaking</th>
<th>Ratio of the retained As in the soaked plants (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ts+Ik+G</td>
<td>0</td>
<td>Leaves</td>
<td>146.3</td>
<td>100.0</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>+</td>
<td>73.7</td>
<td>50.4</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Stalks</td>
<td>320</td>
<td>35.6</td>
</tr>
</tbody>
</table>

*: 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