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Original Article

Release of soluble yellow components with substances having an absorption peak at 286 nm during the water-soaking process before cooking dried Hijiki.

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Summary　During the water-soaking process before cooking dried Hijiki, materials having a UV-absorption peak at 286±1 nm, were eluted, together with yellow colored materials having broad band between 400 and 520 nm. The former having a sharp absorption peak showed an inflection point at 23 ℃ against the reciprocals of absolute temperatures, and the latter did not show any inflection point. Probable major tissue localization of these materials in Hijiki plants was discussed in relation with their elution patterns.

Keywords: 286 nm materials; yellow colored materials; dried Hijiki; *Sargassum fusiforme;* water-soaking;

Introduction

The seaweed Hijiki, *Sargassum fusiforme*, belongs to a family of *Phaeophyta*. The dried Hijiki is a typical foodstuff used for traditional Japanese dishes[1)]. Hijiki contains rich minerals[2, 3)] and dietary fiber[4)], together with relatively high concentrations of arsenic[3, 5, 6)].

By soaking dried Hijiki in water as a pre-cooking process[6)], 80% of the original arsenic content could be removed[7-10)]. When the temperature of soaking-water was changed, the releasing behaviors of arsenate showed characteristics different from organic arsenic compounds depending on the water temperature, as suggested by an inflection point against the reciprocals of absolute temperatures. During this water-soaking process, nutritionally important minerals were also somewhat lost[7)].

In these water effluents, yellow-colored materials together with substances having an absorption peak at 286 nm (285~287 nm) were released.

Materials and Methods

1. Hijiki plants

The Hijiki plants (*Sargassum fusiforme*) used were commercial products consisting of dried mixtures of leaves, stalks and apexes and they were generously donated from the Tsushima Archipelago-Third Sectional Hijiki Processing Company, Nagasaki Pref. After arrival, they were stored below 4℃ before use.

The average arsenic content of these samples was 89.1±6.4 μg/g dry weight (n = 6) [6)].

2. Treatment for water-soaking

Dried Hijiki samples were cut to pieces of 0.5 to 1.0 cm in length, and mixed with pure water of 30 times their weights at various temperatures (2, 15, 30, 45, 60, and 75℃). The samples in tall beakers were set on a water-bath kept shaking slowly for 20 min. The effluents were separated from their residues by centrifugation at 3,500 rpm at 0℃ by using polyethylene mesh. Fine particles contaminating the effluents were centrifugally removed. The optical density of the supernatants was determined spectrophotometrically.

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3. Measurement of photometric quantities

Relative photometric quantities of the broad bands were determined by measuring the space areas of the spectrum.

4. Instruments

To determine the optical absorption density of the effluent, a spectrophotometer, Bio Spec 1600 (DNA/Protein/Enzyme Analyzer), Shimadzu Co., Japan was used.

5. Reagents

Reagents were Special Grade Reagents of JIS or its equivalents grades. MilliQ water or its equivalent grade[11) was used.

Results

1. Water contents in the Hijiki tissues after water-soaking

The water contents in the respective samples were obtained from the difference between the dry weight and the wet weight. The water content increment versus reciprocal values of the absolute temperature (T°K) gave an inflection point at 18.4℃ (Fig. 1).

2. Absorption between 400 nm to 520 nm

The effluent showed a yellow color, owing to a broad absorption band between 400 nm and 520 nm. The integrated values of the space of the broad absorption band plotted against the reciprocal absolute temperature (T°K) showed no inflection point (Fig. 2).

3. The materials having an optical density peak at 286±1 nm

(1) The optical density of the peak at 286±1 nm changed according to the water-temperature. Its values plotted against the reciprocal absolute temperature (T°K) showed an inflection point at 23℃ (Fig. 3).

(2) To know the behavior of the materials showing a broad band having an optical-density peak at 286±1 nm, the relative values of the integrated area of the broad band from 280 nm to 400nm were obtained and plotted in the log scale on the ordinate axis. The abscissas axis representing the reciprocal of the absolute temperature (T°K) did not showed an inflection point (Fig. 4).

Discussion

In the tissues of Hijiki plants, the levels of elements identified as Mg, Mn, Fe, As, and Ca accumulated through active transport channels at higher levels than their concentrations in ocean sea water[12)], and the strong barrier surrounding the outside of fresh tissues of Hijiki plants may have helped maintain high concentrations of these elements inside the cells.

However, in the production processes of commercial dried Hijiki, fresh Hijiki plants were simply dried at first under the sunshine; and then the lots are put in boiling-water and dried in a factory. During these processes, the outer surface and cell walls of fresh Hijiki might have been altered to affect their barrier to the transport of cell contents such as arsenic and 286±1 nm materials or other yellow materials. Thus, the dried samples (dried Hijiki) may have easily released their inner components[7)] during the water-soaking process. Various temperatures of the soaking-water brought about some different elution patterns of the components. The concentrations of the released components at various solution temperatures may suggest characteristics of the surrounding barriers.

In the water-soaking process, the appearance of an inflection point at a certain reciprocal value of absolute temperature may suggest occurrence of some changes in the characteristics of the surrounding barriers outside the tissues of dried Hijiki. The barrier to the materials having the 286±1 nm-peak was changed at 23℃ (Fig 3), which is a higher temperature than that of arsenic release[9)] (Fig. 5)*, i.e. 15℃ .

The yellow-colored materials, corresponding to the space area of light absorption between 400 nm and 520 nm, did not show any inflection point in contrast to the 286±1 nm-peak materials. The former may include many kinds of compounds.

The 286±1 nm-peak materials might be derived from denatured proteins and peptides, or amino acids.

The inflection points of water contents were at 18℃ .

The various values of the inflection points of the inside materials may also suggest differences of their localization in the tissues.

The yellow-colored materials, showing no inflection point, might exist mostly in the palisade cells under the assumption discussed in the previous report[10)].

Footnote:

* The data in the reference 9 were recalculated to express the ratio.

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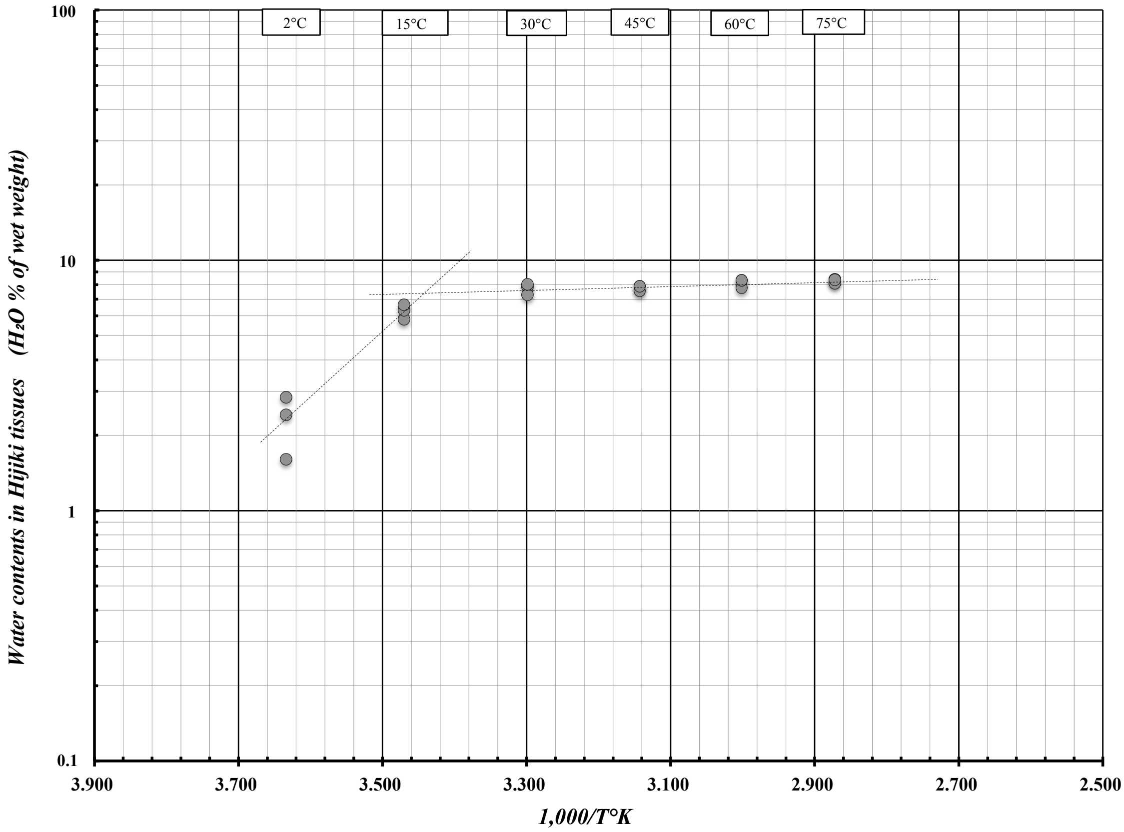

Fig. 1. Water contents in Hijiki tissues after water-soaking at various temperatures.
The ordinate axis represents the log of the water content after water-soaking at various temperatures for 20 min.
The abscissas axis represents the reciprocals of absolute temperatures (*T°K*).
The inflection point was at 18°C.

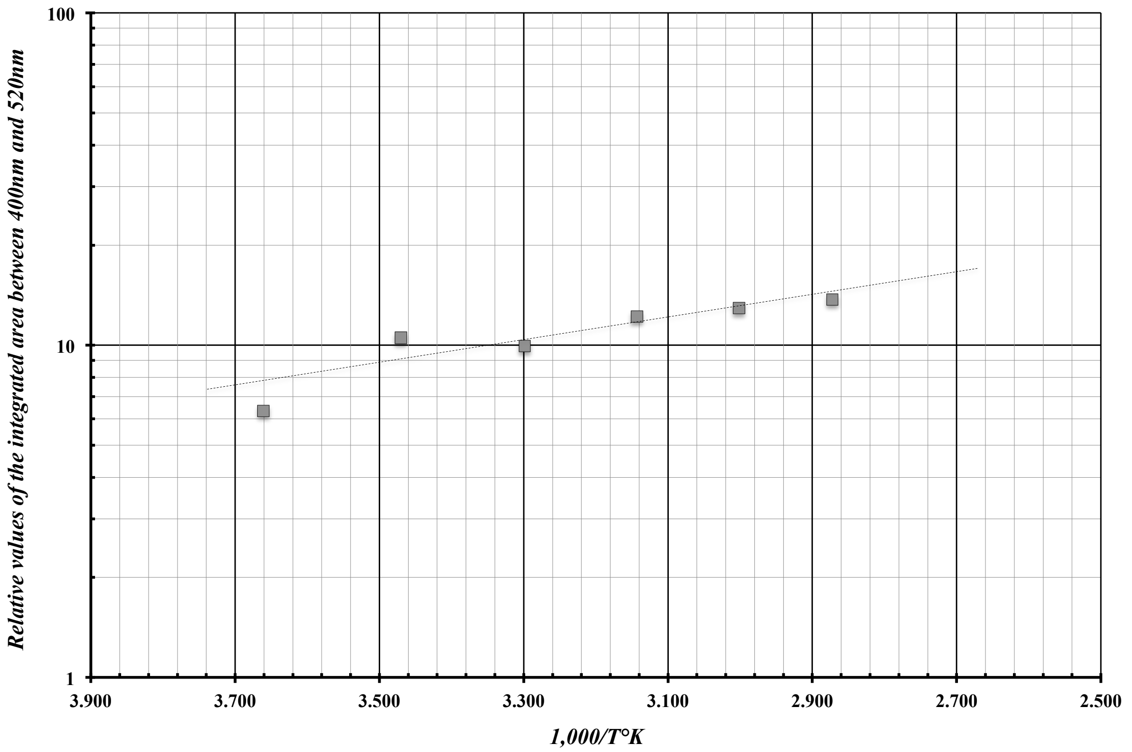

Fig. 2. Relative values of the integrated area of the broad band between 400 nm and 520 nm.
Areas of the materials in the effluent having optical absorption between 400nm and 520nm were integrated, and plotted in the log scale on the ordinate axis. The abscissas axis represents the reciprocals of absolute temperatures (T°K).

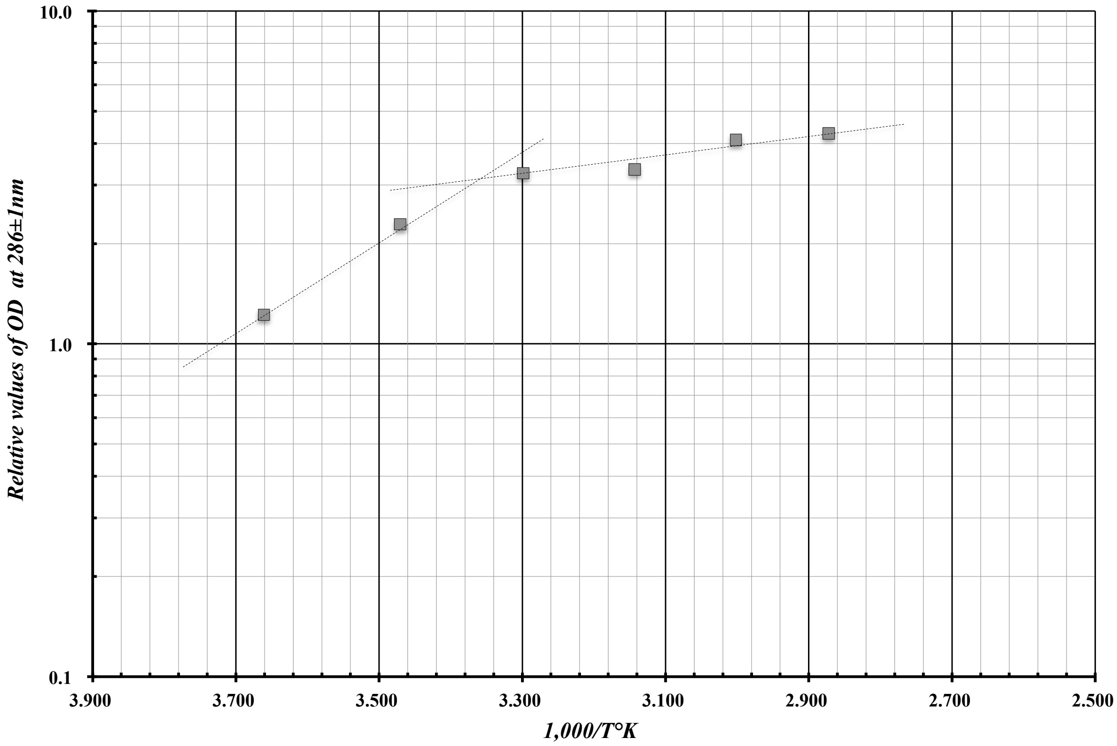

Fig. 3 Relative values of the peak at 286±1 nm.

Relative values of the materials in the effluent showing optical absorption at 286±1nm were plotted in the log scale on the ordinate axis. The abscissas axis represents the reciprocals of the absolute temperatures *(T°K)*.
The inflection point of the curve was at 23°C.

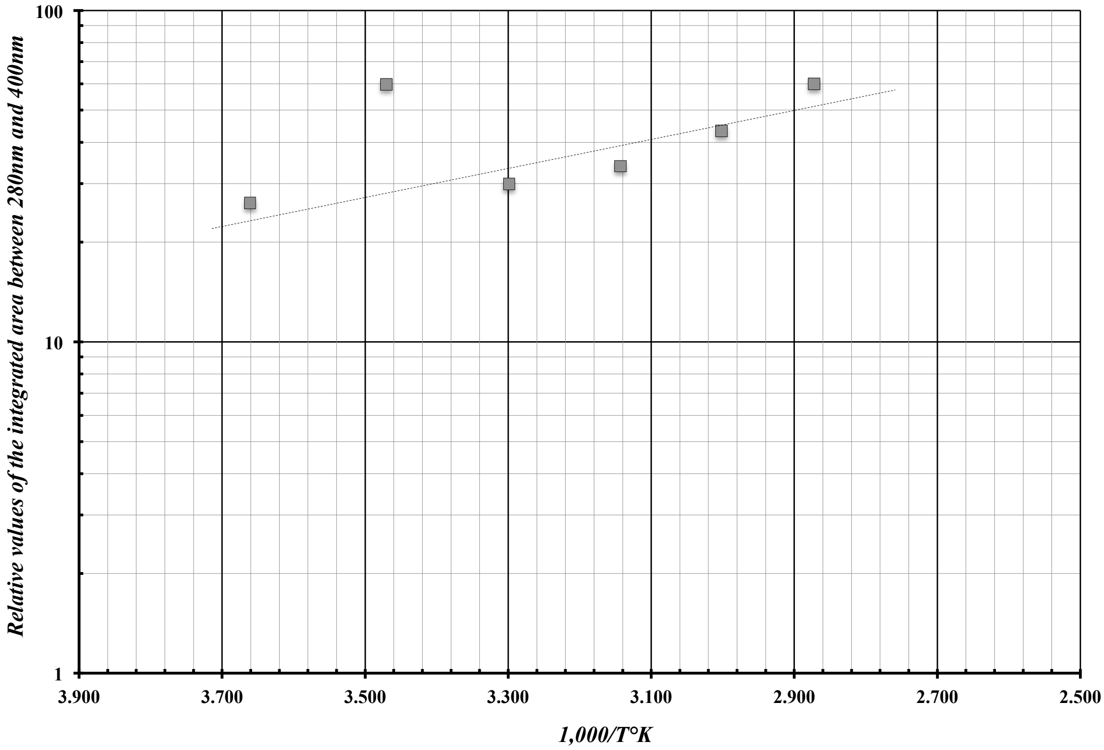

Fig. 4. Relative values of the integrated area of the broad band showing optical absorption between 280 nm and 400 nm.

Areas of the materials in the effluent having optical absorption between 280 nm and 400 nm were integrated, and plotted in the log scale on the ordinate axis. The abscissas axis represents the reciprocals of the absolute temperatures (*T°K*).

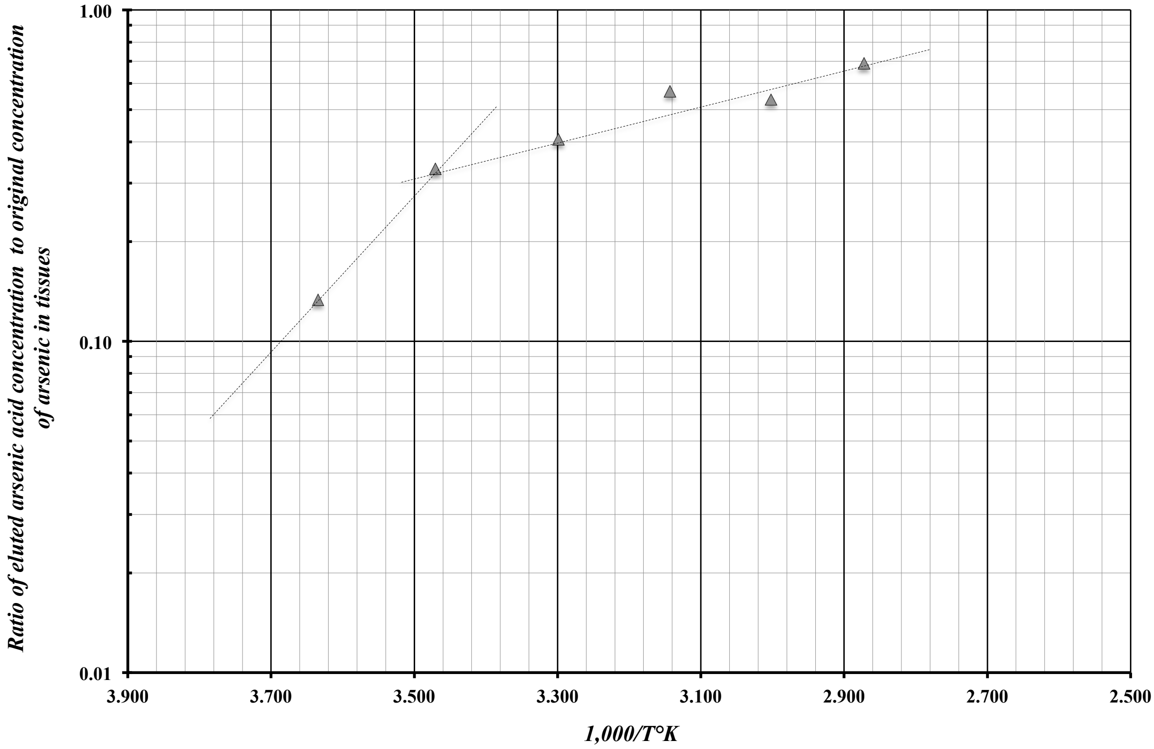

Fig. 5. Elution pattern of arsenate (V) from the water-soaked Hijiki at various temperatures[9].

The ordinate axis represents the log of the ratio of "eluated inorganic arsenic acid concentration" to "the total amount of arsenic existing in the dried Hijiki tissues". The abscissas axis represents the reciprocal of the absolute temperatures (*T*°*K*).

The inflection point was at 15°C.

乾燥ヒジキを水戻し処理するとき溶出される黄色色素および 286±1nm 吸光ピーク物質の溶出様式について

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要　旨

市販乾燥ヒジキは調理前に水戻し操作を行ってから調理されている。この水戻し処理の間に、黄色色素 (400~520 nm) および 286±1nm 光吸収物質が溶出される。溶出温度を変えて溶出量を測定し、縦軸を溶出量の対数値、横軸を溶出絶対温度の逆数値にしてプロットした。水分の吸収量に関しては、18℃に変曲点を持ち無機態ヒ素 (V) の溶出曲線が 15℃に変曲点を持っていたのに対して、286±1nm の吸収ピークは 23℃に変曲点を持っていた。しかし、黄色物質（400~520 nm に吸収）および紫外部吸収物質（280~400 nm）は変曲点を示さなかった。以上のことは、上記物質の各々が組織中で偏在していることを示している。

キーワード：乾燥ヒジキ、*Sargassum fusiforme*、水戻しヒジキ、286±1nm 物質、黄色物質