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ON THE ACCUMULATION OF RADIOACTIVE MATERIALS IN MARNE ORGANISMS ALONG THE COAST OF KOREA

3. Cesium-137 Activities in Several Edible Marine Algae

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ABSTRACT

Continued to the previous papers, the present investigation is carried out to clarify cesium-137 activities and potassium contents among 54 samples of edible marine algae collected along the coast of Korea during September, 1973 and April, 1974.

The potassium contents are variable, *1.5—29.6%*, and *11.36%* on an average, while most of the members contain them about 10—16% generally. Among the algal phyla, they are 13.49% in green, 10.82% in brown and 16.46% in red algae, respectively.

Cesium-137 activities are variable, 0.19—8.13 $pCi^{137}Cs/g\text{-}K$, and 2.35 $pCi^{137}Cs/g\text{-}K$ on an average in the samples investigated. Among the algal phyla they are 4.35 in green, 2.17 in brown and 0.89 $pCi^{137}Cs/g\text{-}K$ in red algae, respectively. Green algae contain especially higher activities compared with the other two groups. The brown alga, *Myelophycus caespitosus* shows the highest activites, 8.13 $pCi^{137}Cs/g\text{-}K$, among the members investigated. Considering the concentration factor, this plant would be an indicator plant of cesium-137 among the marine algae along the coast of Korea.

INTRODUCTION

In the previous papers(Yang *et al.*, 1975a, 1975b), the accumulation of radioactive materials in the edible marine algae was detected in order to analyse the contamination of manine organisms. In addition to the analysis of gross alpha and beta activities, and strontium-90 activities, the present paper deals with the cesium -137 activities among the edible marine algae in Korea, for the same purpose.

MATERIALS AND METHODS

Materials

In this investigation, about 54 seaweed samples, used in the previous two papers mentioned above, were also used for the analysis of potassium contents and cesium-137 activities. The sampling dates, sites, and the materials collected along the coast of Korea are summarized in the authors' previous paper(Yang *et al.*, 1975).

Methods

The materials are washed in water for several times in order to purify and are ashed under the temperature regulated at 400°C. After ashing, grinding and blanding, a suitable aliquot of the ash is taken for analysis. The seaweed ash is treated with dilute nitric acid in presence of cesium carrier, and dissolved as completely as possible by heating on the hot plate. The solution should be complete except for traces of carbon and silica by means of filtering through Toyo No 5B paper to remove traces of insoluble material. The filtrate is transferred

to a 250 ml centrifuge tube and then a few ml of phosphoric acid and ammonium hydroxide are added.

The supernates, after strontium is precipitated as phosphate, contain radiocesium. Cesium, rubidium and potassium are precipitated from the solution with ammonium phospomolybdate by adding ammonium molybdate in nitric acid. Cesium is separated as the cobaltinitrate complex after adjusting the acidity. And then, purified cesium is finally precipitated as a cesium platinic chloride.

The counting system used is a low background beta counter, LOW BETA II, Beckman. The background count rates of the counting system are less than 1 count per minute at 1 inch planchet. The counting efficiency of cesium-137 is about 30% (Suschny, 1967, Harley, 1972, Yang, 1973).

In the atomic absorption method for potassium determination, on the other hand, light is emitted by a potassium hollow cathode lamp and pass through a flame into the spectrometer to isolate a resonant wavelength. When the sample is atomized into the flame the ground state potassium atoms absorb this wavelength and reduce the light intensity. The degree of absorption is proportional to the concentration of potassium atoms in the flame(Harley, 1972).

The abbereviations used in this paper are as follows:

Kangnung	: Ka	Sept. 1973	: 9
Samchuck	: S	Dec. 1973	:12
Kizang	: Ki	Jan. 1974	: 1
Yeosu	: Y	Mar. 1974	: 3
Anmyundo	: A	Apr. 1974	: 4
Cheju isl.	: C		
Zindo	: Z		
Kunsan	: Ku		

RESULTS AND DISCUSSIONS

Potassium contents

Potassium contents obtained from the present investigation are summarized in Table 1. As shown in the table, potassium contents in edible seaweeds experimented are variable from species to species. In potassium the fluctuation of mean value of the content is from 1.5% of *Codium fragile* to 29.6% of *Porphyra yezoensis*, and individually *C. fragile* (A-3) is the lowest, 0.9%, and *P. yezoensis* (Ku-3) is the hightest, 30.8%. Most of the members contain about 10—16% generally, while the mean value of the members of green algae is 13.49%, brown algae 10.82%, and red algae 16.46%, respectively. The result shows about 10 times higher in contents compared with the other data referred (Lee *et al.*, 1970, Ishibashi and Yamamoto, 1958).

Even in a single species, the potassium content is generally different from one another among the materials collected at different places in the same season. For example, in *Capsosiphon-Enteromorpha* complex, it is 3.9%(Ku-3), 10.2%(Ki-3), and 13.8%(Y-3), and in *Sargassum thunbergii*, 7.7%(Ku-3), 25.3%(Ki-3), 9.2%(Ka-3), and 14.2%(Y-3), etc. It is presumed that the potassium content in the algae is rather variable owing to the habitat condition. It is interesting to notice that the potassium content is higher in *Porphyra* among the algae experimented.

Cesium-137 activities

The cesium-137 activities, on the other hand, are variable from 0.19 $pCi^{137}Cs/g\text{-}K$ of *Gelidium amansii* to 8.13 $pCi^{137}Cs/g\text{-}K$ of *Myelophycus caespitosus*, and 2.35 $pCi^{137}Cs/g\text{-}K$ on an average, as shown in Table 2 and Figure 1. The average value of the activities is 4.35 $pCi^{137}Cs/g\text{-}K$ in green algae, 2.17 $pCi^{137}Cs/g\text{-}K$ in brown algae and 0.89 $pCi^{137}Cs/g\text{-}K$ in red algae, respectively. Therefore, the activities of

Table 1. Potassium content of edible seaweeds in Korea

Materials	Mean	Potassium Percentage(%)
Green Algae *Capsosiphon fulvescens-Enteromorpha clathrata*	10.92	3.4(Ku-12), 3.9(Ku-3), 23.3(A-1), 10.2(Ki-3), 13.8(Y-3).
Enteromorpha-complex	10.60	10.9(Ku-12), 10.3(Ku-3).
Enteromorpha linza	9.30	15.6(Ki-3), 3.0(Y-3).
Ulva pertusa	4.57	4.5(Ki-3), 6.6(Y-3), 3.6(C-4).
Codium fragile	1.50	2.0(Ki-12), 0.9(A-3).
Brown Algae *Scytosiphon lomentaria*	8.25	11.0(S-3), 12.3(Ka-3), 6.7(Y-3), 6.1(C-4).
Myelophycus caespitosus	3.20	3.20(C-4).
Ishige okamurai	10.00	10.00(C-4).
Undaria pinnatifida	13.34	14.2(Ku-12), 15.3(Ki-3), 20.8(Ka-12), 13.2(Ka-3), 9.6(C-4).
Ecklonia cava	11.70	11.7(C-4).
Costaria costata	15.90	14.7(Ka-3), 17.1(S-3).
Laminaria japonica	15.55	12.1(Y-3), 19.0(Z-3).
Kjellmaniella crassifolia	13.60	13.6(Ka-3).
Hizikia fusiforme	14.25	13.7(Y-3), 14.8(C-4).
Pelvetia wrightii	10.00	10.1(Ku-12), 9.9(Ku-3).
Sargassum thunbergii	9.60	7.7(Ku-3), 25.3(Ki-3), 9.2(Ka-3), 14.2(Y-3), 7.3(C-4).
Sargassum fulvellum	7.67	7.9(Ku-12), 6.9(Ku-3), 7.9(Y-3).
Sargassum confusum	12.80	12.80(C-4).
Sargassum horneri	5.40	5.8(A-3), 5.0(Y-3).
Red Algae *Porphyra tenera*	26.40	29.3(Ku-12), 21.3(Ku-3), 28.6(A-1).
Porphyra yezoensis	29.60	28.3(Ka-3), 30.8(Ku-3).
Gelidium amansii	10.30	10.3(C-4).
Chondrus pinnulatus	7.00	7.0(Ka-3).
Enteromorpa-Porphya complex	16.00	16.0(A-1).

cesium-137 increase from red to brown and green algae, in turn. The tendency is different from the ones, such as gross alpha and beta activities and also strontium-90 activities (Yang *et al.*, 1975a, 1975b). The activities of cesium-137 are 1/3 times higher than those of strontium-90 in the present investigation. Most of the brown and red algae investigated show 1-3 $pCi^{137}Cs/g\text{-}K$, except for *Scytosiphon lomentaria* (4.16 $pCi^{137}Cs/g\text{-}K$) and *Myelophycus caespitosus*, while some of them, *Ishige okamurai* and *Gelidium amansii*, are less than 0.5 $pCi^{137}Cs/g\text{-}K$.

Table 2. Cesium-137 activities of edible seaweeds in Korea

Materials	Mean	Activities($pCi^{137}Cs/g$-K)
Green Algae		
Capsosiphon fulvescens-Enteromorpha clathrata	6.06	5.79(Y-3), 11.66(Ku-12), 0.38(A-1), 6.41(Ku-3).
Enteromorpha-complex	2.63	1.67(Ku-12), 3.59(Ku-3).
Enteromorpha linza	5.64	10.33(Y-3), 0.96(Ki-3).
Ulva pertusa	3.77	2.78(C-4), 4.89(Ki-3), 3.64(Y-3).
Codium fragile	3.63	2.16(Ku-12), 5.1(A-3).
Brown Algae		
Scytosiphon lomentaria	4.16	1.91(S-3), 6.42(Y-3).
Myelophycus caespitosus	8.13	8.13(C-4).
Ishige okamurai	0.50	0.50(C-4).
Undaria pinnatifida	1.39	1.97(Ku-12), 1.58(Ki-3), 1.46(Ka-12), 0.68(Ka-3), 1.25(C-4).
Ecklonia cava	0.63	0.63(C-4).
Costaria costata	1.33	1.23(S-3), 1.43(Ka-3).
Laminaria japonica	1.14	0.79(Z-3), 1.49(Y-3).
Kjellmaniella crassifolia	1.25	1.25(Ka-9).
Hizikia fusiforme	2.13	0.68(C-4), 3.58(Y-3).
Pelvetia wrightii	1.62	1.13(Ku-12), 2.12(Ku-3).
Sargassum thunbergii	2.43	3.25(Ku-3), 0.59(Ki-3), 2.93(Ka-3), 2.94(Y-3).
Sargassum fulvellum	2.21	1.01(Ku-12), 2.36(Ku-3), 2.28(Y-3).
Sargassum confusum	0.78	0.78(C-4).
Sargassum horneri	2.61	1.03(A-3), 4.20(Y-3).
Red Algae		
Porphyra tenera	1.30	0.24(Ku-12), 0.31(A-1), 0.72(Ku-3), 5.93(Y-3).
Porphyra yezoensis	0.51	0.45(Ku-3), 0.57(Ka-3).
Gelidium amansii	0.19	0.19(C-4).
Chondrus pinnulatus	1.57	1.57(Ka-3).
Enteromorpha-Porphyra complex	0.88	0.88(A-1).

The green algae, on the other hand, show 2-6 $pCi^{137}Cs/g$-K, generally, which is about 2 times higher in activities than those of brown and red algae that show comparatively high activities. It is also a noticeable fact that *Myelophycus caespitosus*, growing on rocks at upper tidal zone and inhabiting commonly along the coasts of Korea, shows especially high activities. Considering the concentration factor of cesium-137, the plant would be an indicator of cesium-137 activities in marine algae along the coast of Korea, as seen in *Sargassum thunbergii* of gross beta activities, and in *Capsosiphon-Enteromorpha* complex of strontium-90 activities, both

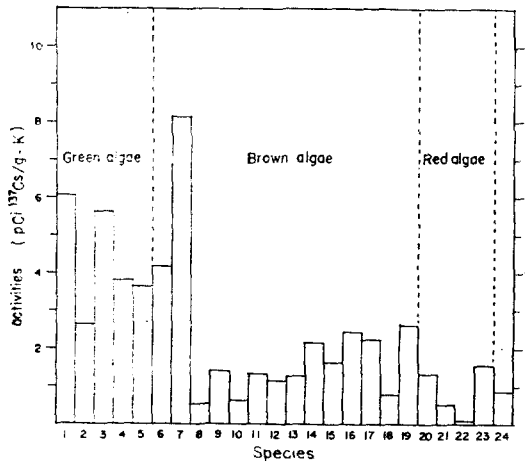

Fig. 1. Cesium-137 activities of edible seaweeds in Korea

1. *Capsosiphon fulvescens-Enteromorpha clathrata* 2. *Enteromorpha*-complex 3. *Enteromorpha linza* 4. *Ulva pertusa* 5. *Codium fragile* 6. *Scytosiphon lomentaria* 7. *Myelophycus caespitosus* 8. *Ishige okamurai* 9. *Undaria pinnatifida* 10. *Ecklonia cava* 11. *Costaria costata* 12. *Laminaria japonica* 13. *Kjellmaniella crassifolia* 14. *Hizikia fusiforme* 15. *Pelvetia wrightii* 16. *Sargassum thunbergii* 17. *Sargassum fulvellum* 18. *Sargassum confusum* 19. *Sargassum horneri* 20. *Porphyra tenera* 21. *Porphyra yezoensis* 22. *Gelidium amansii* 23. *Chondrus pinnulatus* 24. *Enteromorpha-Porphyra* complex

of which grow also at upper tidal zone rather commonly. There is no special significance to compare the activities of cesium-137 with the materials collected from different localities at the same season in a single species.

According to Yang and Pak(1973), cesium-137 activities are 175.78 pCi^{137}Cs/g-K in green laver(an average of 528.28, 1.94 and 0.91), and 58.85 pCi^{137}Cs/g-K in dulse(an average of 115.27 and 2.43). Considering the present results of these seaweeds, 4.14 pCi^{137}Cs/g-K of green laver(=*Enteromorpha linza* and *Enteromorpha*-complex) and 1.39 of dulse (=*Undaria pinnatifida*), the average value of the activities is far higher in the previous data. However, some individual data such as 1.94 and 0.91 of green laver, and 2.43 of dulse show rather a similarity to the present results.

CONCLUSION

The potassium contents of the edible marine algae investigated are variable from 1.5% to 29.6%, and about 11.36% on an average. However, most of the members contain about 10-16% generally, and the mean of the members investigated among the algal phyla is 13.49% in green algae, 10.82% in brown algae and 16.46% in red algae, respectively. The results are about 10 times higher in content compared with the other data referred (Lee *et al.*, 1970, Ishibashi and Yamamoto, 1958).

On the other hand, cesium-137 activities are variable from 0.19 pCi^{137}Cs/g-K to 8.13 pCi^{137}Cs/g-K, and 2.35 pCi^{137}Cs/g-K, on an average in the edible marine algae investigated. The average value of the activities among the algal phyla is 4.35 pCi^{137}Cs/g-K in green, 2.17 pCi^{137}Cs/g-K in brown, and 0.89 pCi^{137}Cs/g-K in red algae, respectively. The green algae show about 2 times higher in activities than the members of brown and red algae that show comparatively high activities.

It is also a noticeable fact that *Myelophycus caespitosus*, a member of brown algae, shows especially high activities, 8.13 pCi^{137}Cs/g-K. Considering the concentration factor, the plant would be an indicator of cesium-137 activities among the marine algae in Korea, as seen in *Sargassum thunbergii* of gross beta activities and *Capsosiphon-Enteromorpha* complex of strontium-90 activities(Yang *et al.*, 1975 a, 1975b). *Myelophycus caespitosus* inhabits alsoa, upper tidal zone rather commonly along the coast of Korea.

There are no significant tendency on the cesium-137 activities among the eastern, western and southern coasts of Korea, comparing with the materials of a single species collected at the same season, as seen in strontium-90 activities (Yang *et al.*, 1975b).

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