Selenium Content of Seed Crops Consumed in Japan

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SUMMARY

Selenium contents in rice, wheat and soybean consumed in Japan were determined by a fluorometrical analysis. Brown rice samples, collected from various sites in Japan, showed a mean value of 0.04 μg Se/g (n=69). Wheat and soybean samples, grown at various sites of Japan, also showed low selenium values. The mean values were 0.02 (wheat, n=5) and 0.03 (soybean, n=18) μg Se/g, respectively. High selenium values (0.03 to 1.15 μg Se/g) were found in imported American or Canadian hard or durum wheats. Australian wheat showed moderate levels (0.05 to 0.13 μg Se/g) of selenium, and American soft wheat showed the lowest levels (0.01 to 0.03 μg Se/g) of selenium. Selenium in commercial wheat products were also determined. The hard type of wheat flour, bread and Japanese spaghetti, produced from the American or Canadian hard or durum wheats, showed high selenium values (0.19 to 0.39 μg Se/g). These results indicate that wheat products, produced from the imported American or Canadian hard or durum wheat, is one of the principal selenium source in Japanese diet.

INTRODUCTION

Recent epidemiological studies have suggested a relation of incidence of certain types of cancer to selenium status [1-3]. Schrauzer *et al.*[4] have observed an inverse correlation between age-corrected mortalities of female by breast cancer and estimated dietary selenium intakes in 27 countries. Geographic comparisons of human tissue selenium levels have demonstrated a distinct variation in selenium status, which correlates with the dietary selenium intakes[5]. The dietary intakes of selenium are calculated to be deficient in New Zealand[6], Finland[7], and areas of China where Keshan Disease is endemic[8] (below 30 μg/day/capita). On the other hand, dietary selenium intakes of Japanese adults are estimated at around 100 μg/day/capita[9], which is quantitatively sufficient to fulfill the daily intake recommended by the U.S. National Academy of Science[10].

The principal dietary source of selenium for Japanese was previously reported to be fish, followed by seed crops, and then meat and eggs[11]. Recently, it has been recognized that bioavailability of selenium varies by dietary sources; selenium in most animal products is poorly or moderately available, while selenium of plant origins is highly available[5,12,13]. It thus appears that seed crops rank the more important than fish, as the dietary source of "available selenium" for Japanese. In the present study, we measured the selenium contents of rice, wheat and soybean products used in Japan, and confirmed an importance of imported seed crops as the available selenium source in Japanese diet.

EXPERIMENTAL

Brown rice samples were collected from national or prefectural agricultural experiment stations located in various sites of Japan. Imported whole wheat grain samples were supplied by the Food Agency, Japan. The classes in the samples included Durum (USA), Hard Red Winter (high protein and semi-hard) (USA), Hard Red Spring (Dark Northern Spring) (USA), Western White (USA), No1 Canadian Western Red Spring (Canada), Australian Standard White (Australia) and Australian Prime Hard (Australia). Domestic wheat samples, cropped at different sites of Japan, were kindly supplied by the Agricultural Technical Center, Japan, Soybean samples imported from USA, Brazil and Argentina were kindly supplied by Honen Oil Co., Yoshihara Oil Co. or Showa Sangyo Co. Ltd. Imported Chinese soybean samples were purchased in Tokyo Metropolitan area. Japanese domestic soybean samples were kindly supplied by Obihiro University of Agriculture and Veterinary Medicine and by the Agricultural Technical Center, Japan. Commerical wheat and soybean products were randomly purchased from local retail shops in Osaka and Kyoto city areas.

Selenium was determined fluorometrically by the method of Watkinson[14]. Four-times repeated measurements of selenium by this analytical procedure in our laboratory gave the values (means ± SD) of 0.66 ± 0.04 μg/g and 0.028 ± 0.004 μg/g for bovine liver (NBS SRM 1577a, the certified value is 0.71 ± 0.07 μg Se/g) and for citrus leaves (NBS SRM 1572, the information value is 0.025 μg Se/g), respectively.

RESULTS AND DISCUSSION

Table 1 shows the selenium contents in the seed crops used in Japan. The American and Canadian hard wheats were found to be high selenium levels; values in the hard or durum wheats ranged from 0.30 to 1.15 μg/g. However, the selenium levels in the American soft wheats averaged 0.02 μg/g, comparable to low values reported on wheat grown in a selenium deficient area, New Zealand[15]. These values fall within the range of value in a previous report on the American wheats[16]. The variation of the selenium level among the American wheats is considered to be caused by a difference of their producing districts within USA; the soft wheat is grown on Washington or Oregon State, which have been known to include low-selenium areas[17], while the other American hard wheats are grown on adequate- or high-selenium areas (e.g., northern Great Plains States). Similarly to the wheats, the imported American soybean contained significantly higher selenium levels than the other samples. On the other hand, the selenium levels in the seed crops grown on Japan were comparatively low values (0.02–0.04 μg Se/g).

The selenium levels in the wheat and soybean products are shown in Table 2. The selenium contents of wheat products reflected the selenium levels of wheat classes used in Japan; the hard type of flours, bread and spaghetti, produced from the American or Canadian hard or durum wheats, showed high selenium contents. Defatted soybean flake and soybean protein isolate, which were produced from the American soybean, contained high selenium levels correspondingly to their source materials. In

Table 1. Selenium content in brown rice, whole wheat and soybean used in Japan

Seed crops	Country grown on	Number of samples	Selenium content (μg/g)	
			Mean	Range
Brown rice	Japan	69	0.04	0.01–0.18
Whole wheat:				
Soft	USA	4	0.02	0.01–0.03
Medium	Japan	5	0.02	0.01–0.04
	Australia	4	0.07	0.05–0.09
Hard	Australia	2	0.11	0.08–0.13
	Canada	4	0.72	0.60–0.82
	USA	8	0.44	0.30–0.66
Durum	USA	1	1.15	
Soybean	Japan	18	0.03	0.01–0.08
	China	8	0.06	0.01–0.15
	Brazil	5	0.08	0.02–0.25
	USA	7	0.32	0.12–0.50
	Argentina	1	0.12	

Table 2. Selenium content in wheat and soybean products consumed in Japan

Products	Number of samples	Selenium content (μg/g)			
		Fresh weight basis		Dry weight basis	
		Mean	Range	Mean	Range
Wheat flour:					
Hard	6	0.27	0.21–0.39	0.32	0.25–0.46
Medium	4	0.05	0.02–0.08	0.06	0.02–0.09
Soft	7	0.03	0.01–0.12	0.03	0.01–0.14
Bread:					
White bread	4	0.25	0.19–0.36	0.40	0.30–0.57
Other types of bread	4	0.22	0.20–0.24	0.34	0.31–0.38
Noodles:					
Udon (Japanese noodle), boiled	3	0.02	0.02–0.02	0.08	0.07–0.08
Chinese noodle, boiled	3	0.09	0.06–0.15	0.27	0.16–0.42
Precooked Chinese noodles	4	0.14	0.10–0.18	0.15	0.10–0.19
Spaghetti:					
Produced in Japan	5	0.57	0.31–0.79	0.61	0.36–0.85
Imported from Italy	5	0.05	0.01–0.05	0.06	0.01–0.09
Soybean products:					
Tofu (Soybean curd)	4	0.01	0.01–0.02	0.11	0.09–0.16
Miso (Soybean paste)	3	0.01	0.01–0.02	0.02	0.02–0.03
Defatted soybean flake	3	0.46	0.28–0.57	0.52	0.32–0.65
Soybean protein isolate	5	0.35	0.29–0.45	0.39	0.32–0.50
Other soybean products	4	0.04	0.02–0.05	0.09	0.03–0.22

contrast, most of Japanese traditional soybean products contained less than 0.1 μg/g of selenium on dry weight basis. This low level of selenium will be closely associated with the manufactures' practice of preferring the Chinese or domestic soybeans to the American soybeans. A relatively large proportion of the American soybean is utilized for animal feed as defatted soybean. It thus follows that soybean is an important selenium source not for human but for livestock in Japan.

Based on the present study, daily selenium intake of Japanese was recalculated (fig. 1) and revealed as 127 μg/day/capita.

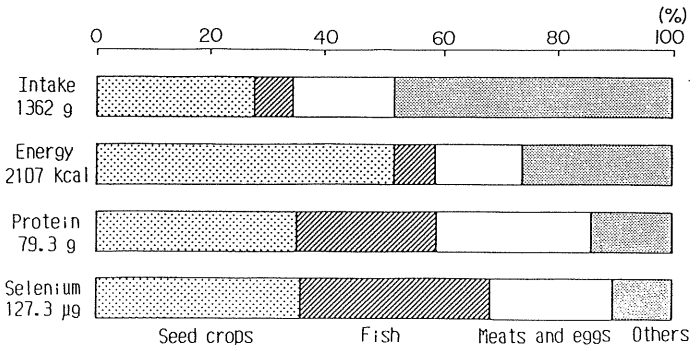

Fig. 1. Daily intake of energy, protein and selenium by Japanese.

We reported previously that the principal source of selenium in Japanese diet was fish, followed by seed crops and then meat and eggs.[11]. The present study revealed that in spite of the low selenium level in Japanese cereals, seed crops have still been ranked as the main selenium source. About 90% of wheat consumed in Japan is imported from USA, Canada and Australia. The American and Canadian wheats of high selenium levels (except the soft wheat) occupy more than 90% of the imported wheat. According to the annual nutrition survey conducted by the Ministry of Health and Welfare, Japan[18], we consume 94 g/day/capita of wheat products and more than half of them as bread. American or Canadian hard wheats amount to consumption of about 60 to 70 g/day/capita; wheat products include spaghettis and noodles. Japanese selenium intake from wheat account for around 20 μg/day/capita. Selenium in wheat is more available than this trace element in animal products, especially fish[5]. It may be allowed to conclude that wheat products are important as an available selenium source in Japanese diet. It is considered that the importation of wheat from USA or Canada plays an important role in the selenium intake from plant products by Japanese.

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REFERENCES

1. Shamberger, R. J., Tytko, S. A. and Willis, C. E. (1976): Antioxidant and cancer. Part IV. Selenium and age-adjusted human cancer mortality. Arch. Environ. Health, 31, 231–235
2. Salonen, J. T., Alfthan, G., Huttunen, J. K. and Puska, P. (1984): Association between serum selenium and the risk of cancer. Am. J. Epidemiol., 120, 342–349.
3. Kok, F. J., Bruijn, A. M., Hofman, A., Vermeeren, R. and Valkenburg, R. (1987): Is serum selenium a risk factor for cancer in men only. Am. J. Epidemiol., 125, 12–16.
4. Schrauzer, G. N., White, D. A. and Schneider, C. J. (1977): Cancer mortality correlation studies Ⅲ: Statistical association with dietary selenium intakes. Bioinorg. Chem., 7, 23–34.
5. Combs, G. F. Jr. and Combs, S. B. (1986): The Role of Selenium in Nutrition, Academic Press, New York.
6. Robinson, M. F. (1976): The moonstone: More about selenium. J. Hum. Nutr., 30, 79–91.
7. Koivistoinen, P. (1980): Mineral element composition of Finnish foods. Acta Agric. Scand. 30, Suppl. 22, 1–171.
8. Xu, G. L., Hong, S. Y., Song, H. B. and Xie, H. K. (1985): Keshan Disease and selenium deficiency. Nutr. Res., 5, Suppl. 1, 187–192.
9. Sakurai, H. and Tsuchiya, K. (1975): A tentative recommendation for the maximum daily intake of selenium. Environ. Physiol. Biochem., 5, 107–118.
10. Food and Nutrition Board (1980): Recommended Dietary Allowances, 9th rev. Ed., National Academy of Sciences, Washington, DC.
11. Yasumoto, K., Iwami, K., Yoshida, M., and Mitsuda, H. (1976): Selenium content of foods and its daily intake in Japan. Eiyo to Shokuryo (J. Jpn. Soc. Food & Nutr.), 29, 511–515.
12 Cantor, A. H., Scott, M. L. and Noguchi, T. (1975): Biological availability of selenium in feedstuffs and selenium compounds for prevention of exudative diathesis in chicks. J. Nutr., 105, 96–105.
13. Yoshida, M., Iwami, K. and Yasumoto, K. (1984): Determination of nutritional efficiency of selenium contained in processed skipjack meat by comparison with selenite. J. Nutr. Sci. Vitaminol., 30, 395–400.
14. Watkinson, J. H. (1966): Fluorometric determination of selenium in biological material with 2, 3–diaminonaphthalene. Anal. Chem., 38, 92–97.
15. Watkinson, J. H. (1981): Changes of blood selenium in New Zealand adults with time and importation of Australian wheat. Am. J. Clin. Nutr., 34, 936–942.
16 Lorenz, K. (1978): Selenium in wheats and commercial wheat flours. Cereal Chem., 55, 287–294.
17. Kubota, J., Allaway, W. H., Carter, D. L., Cary, E. E. and Lazar, V. A. (1967): Selenium in crops in the United States in relation to selenium-responsive disease of animals. J. Agric. Food Chem., 15, 448–453.
18. Ministry of Health and Welfare, Japan (1986): Kokumin Eiyo no Genjo, Daiichi Shuppan, Tokyo.