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Distribution of Selenium Contents in Human Blood and Foods Produced in Korea

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= ABSTRACT =

한국인과 한국산 가축의 selenium 영양상태를 파악하기 위하여 남한의 selenium 분포조사를 실시한 결과 전국 45개 지역 토양중 selenium 함량은 0.03 내지 0.24 ppm 이였으며 중앙 동북 고산지대는 0.14-0.24 ppm으로 높았고 서해안 그리고 남해안은 0.03-0.06 ppm으로 비교적 낮았다. 전국 42개 지역에서 채취한 목초 (억새, 크로바) 는 0.036 ppm (0.02-0.13 ppm) 을 함유하고 있으며 콩, 보리, 쌀은 0.047, 0.033 그리고 0.033 ppm selenium을 각각 함유하고 있었다.

전국 23개 도시에 거주하는 204명의 사람에서 채취한 혈액에는 평균 0.16 ± 0.06 μg/ml (0.05-0.35 μg/ml) 의 selenium 함량을 갖었고 glutathione peroxidase 활성도는 평균 13.0 ± 1.7 EU/mg homoglobin이었다.

남한에서 생산되는 곡류와 채소류에는 0.02 내지 0.04 ppm의 selenium을 함유하고 육류인 쇠고기, 돼지고기에는 0.11 ± 0.05와 0.14 ± 0.03 ppm을 그리고 참치, 조기, 숭어, 마른멸치등에는 0.50 ± 0.02, 0.42 ± 0.09, 0.20 ± 0.02 그리고 0.55 ± 0.04 ppm selenium을 각각 함유하고 있었다. 국민 1인당 하루 selenium 섭취량은 42.3 μg 이며 이중 71%는 주로 곡류와 채소에서 충당하고 있다.

INTRODUCTION

Since the discovery of selenium (Se), atomic No. 34, as an essential element for animal life[1], selenium deficiency has become increasingly recognized as a practical problem in animal production. For many years, selenium supplementation to animals

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has been shown to be benefitial for the prevention of liver necrosis in pigs[2], exudative diathesis in chicks[3] and white muscle disease in lambs[4].

In some areas where no clinical symptoms were observed, selenium treatment often caused a marked increase in weight gain and fertility of ewes[5][6][7]. In early of 1960's, a survey of selenium levels in America, Australia and some of Europian countries were initiated to investigate the potential significance of selenium supplementation in livestock production. It has been found that selenium is present in most soils and its levels are dependent on the type of soil and geographic location. They have reported that selenium contents in forages and grains were reflected from selenium levels of soils where they grew[8].

In considering the importance of selenium in relation to animal production and human health, an investigation of selenium status in Korea was necessary. Therefore, a survey of selenium distribution in Korea was conducted, and selenium concentrations in soil, forages, grains, meats, fishes, vegetables and whole human blood were measured to examine the geographic distribution of selenium in Korea.

In addition, glutathione peroxidase, a selenoenzyme, in human bloods were measured to evaluate the selenium status of man.

MATERIALS AND METHODS

Materials

2, 3 diaminonaphthalene, hydroxylamine HCl, and EDTA (ethylendiamino tetra acetic acid) were purchased from Sigma Chem. Co. U.S.A. Sulfuric acid, nitric acid, perchloric acid, hydrogen peroxide and cyclohexane were supplied by local supplier. All these reagents were reagent grade.

Sample collections

Soil samples were obtained from 20-30 cm deep from the surface of uncultivated earth by soil sampler and were collected from 3 different places in each 45 areas. Collected soil samples were dried in oven at 110 ℃ for 24 hours and ground in powder form using mortar grinder. Forages (miscanthns purascens, white clower) and grains (soybean, barley, rice) were collected from 3 to 4 different farms in each 42 districts in the country. Leaves and stems (forage) were cut in small pices and dried in the oven in the same way. Grains were also dried by the same method. Human whole blood were obtained from normal person residing in 23 cities around the country. The collected whole blood were preserved at 4 ℃ after addition of EDTA as an anticoagulant until analysis.

Food samples (rice, barley, soybean, radish, chinese cabbage, garlic, beef pork, tuna, yellow corvina, greymullet, dried anchovy) were obtained from markets of 6 major cities (Seoul, Busan, Daegu, Chunchun, Kwangju, Jaeju). All these foods except sea foods were produced in Korea. Vegetables, meats and fishes were preserved at -10 ℃ until analysis.

Selenium analysis

Selenium was determined by the fluorometric method. Samples were pre digested in conc. nitric acid over night at room tamperature and digested for 45 minutes with nitric - sulfuric - perchloric acid mixture (6.0 : 1.5 : 0.5) under mild condition (200℃) Selenium in the digest was complexed with 2, 3 - diamino - naphthalene at 60℃ for 45 min, followed by the extraction of the complex into cyclohexane. The selenium - 2, 3 diaminonaphthalene complex were measured at 360 nm excitation and 525 nm emission using Turner Model 110 Photo - fluorometer. The detailed method is described in the method published[9].

Enzyme assay

Glutathione peroxidase activity was measured by the method of Paglia and Valentine[10]. Whole blood was hemolyzed by 50 - fold dilution with cold distilled water and 0.1 ml of diluted hemolysate was used for enzyme assay. Hemoglobin content in hemolysate was determined by the method of Crosby et al[11].

RESUITS AND DISCUSSION

Selenium distribution in soil.

Geographic distribution of soil selenium levels in S. Korea is shown in Figue 1. The values ranged from 0.03 ppm to 0.24 ppm Se.

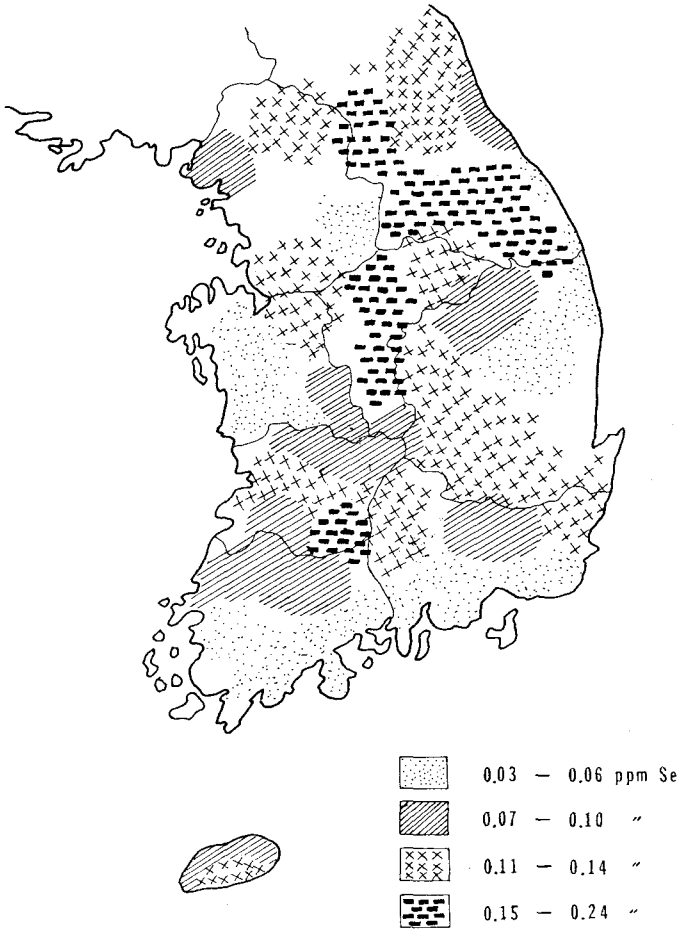

Fig. 1. Selenium distribution in soil.

The central and Northeast parts of S. Korea contain relatively higher Se levels and Southern coastal and central west areas contain relatively lower levels. The overall soil selenium levels in S. Korea belong to normal range and no seleniferous area was observed[12] when compared with the Se level in soils in Midwestern and South eastern United States which ranged from 0.01 to 2.50 ppm. Watkinson[13] has reported that most New Zealand soils contain selenium of 0.1 and 2.0 ppm range and soils from some area contained as much as 4 ppm Se, but no toxic effect he had observed. Selenium contents of many soils in central Western States of U.S.A. and Hawaii are 1 – 10 ppm, but no toxic effect had been found[14]. Therefore, soil selenium levels of S. Korea (0.03 ppm – 0.24 ppm) are considered to be in safe level in terms of toxicity.

Selenium contents in forages and grains.

Selenium concentration in miscanthus purascens, white clover, soybean, barley and rice produced in 42 different districts in S. Korea were shown in Table 1. The importance of selenium as a trace element to the ruminant is well recognized[15] and many investigations[4][16] supported its recognition.

White muscle disease in lambs has been produced by feeding on an alfalfahayoats diet containing 0.02 ppm Se and it could be prevented by raising the dietary selenium level to 0.06 ppm or more[16].

In the present study, selenium contents in forages

Table 1. Distrubution of selenium contents in grasses and grains produced in S. Korea

Province	District	Miscanthus purascens	White clover	Soy bean	Barley	Rice
Kyung Gi Do	Song tan	13.0±2.4	7.0±3.4	11.3±3.4	4.0±1.2	2.2±1.0
	Yeo Ju	5.0±0.3	3.0±0.3	8.8±2.1	4.0±0.5	2.0±0.8
	Yean chon	8.6±1.3	7.1±2.0	5.0±2.2	3.5±1.0	3.0±0.5
	Kang Hwa	7.0±1.3	6.2±1.4	4.4±1.8	4.0±1.2	2.5±1.0
Kang Won Do	Chun Cheon	7.6±1.4	4.7±0.6	7.5±2.9	2.9±0.3	5.1±0.9
	Ko Sung	8.0±0.7	5.4±0.3	6.5±2.2	4.9±0.5	5.6±2.6
	In Jae	7.0±1.4	4.5±1.4	4.2±0.8	3.5±1.0	2.4±0.6
	Yang Yang	4.8±0.5	5.0±3.1	6.7±1.8	3.8±0.7	2.2±0.4
	Do Gye	10.3±0.1	5.6±2.2	2.9±0.5	2.9±0.4	2.0±0.3
	Dae Gwan Ryung	8.0±1.3	5.1±0.8	6.8±1.9	4.0±1.3	3.2±0.4
Chung Chung Buk Do	Bo Eun	9.2±2.4	7.2±0.9	4.1±1.3	2.0±0.5	2.5±0.3
	OK Cheon	4.7±0.9	5.1±1.4	4.2±0.8	2.4±0.7	2.7±0.5
	Young Dong	11.3±2.4	10.6±2.8	4.0±1.2	3.8±0.8	3.6±0.4
	Goe San	5.6±1.8	6.8±2.2	3.5±1.0	3.0±0.7	2.5±1.0
	Oh Gun Jang	7.3±2.0	7.8±2.2	4.2±1.0	3.8±0.4	3.0±1.1
Chung Chung Nam Do	Sung Hwan	5.0±1.4	10.3±2.0	2.7±1.1	2.8±0.9	1.4±0.5
	You Sung	8.2±1.7	8.9±2.0	10.8±2.1	3.5±0.3	5.4±2.1
	Sap Kyo	4.7±1.2	5.6±1.5	4.7±2.0	2.6±1.0	3.0±0.8
	Chung Yang	6.8±2.2	8.0±1.1	3.1±1.4	2.8±1.0	1.7±0.4
	Bu Yo	6.3±2.0	7.7±1.6	2.1±0.8	1.0±0.4	4.4±1.2
Kyung Sang Buk Do	Kyung San	2.9±1.1	9.9±1.0	2.8±1.1	2.2±1.1	1.5±0.5
	Sang Ju	4.4±0.8	3.3±1.1	4.6±0.1	3.5±0.9	3.5±1.2
	Ahn Dong	3.4±0.7	4.0±1.1	2.7±0.5	4.0±0.7	2.3±0.4
	Ul Jin	5.9±1.9	3.3±0.3	3.4±0.8	4.7±1.3	4.0±1.4
Kyung Sang Nam Do	Ul San	6.8±1.0	7.7±0.7	10.0±2.1	5.2±1.5	5.2±1.8
	Kim Hae	22.5±1.0	4.4±0.5	3.0±0.8	4.0±1.3	1.9±0.7
	Chang Young	5.9±1.4	4.1±1.3	4.0±0.6	3.0±0.5	3.3±1.0
	Ham Yang	5.0±0.4	8.0±1.8	3.5±0.7	3.5±1.3	5.0±1.2
Jeon La Buk Do	Jung Ju	2.4±0.5	7.9±3.4	3.5±1.2	1.0±0.3	4.0±1.8
	Nam Won	8.5±0.5	3.4±0.6	4.0±1.1	1.4±0.6	3.0±1.0
	Kim Jae	8.0±3.2	6.0±2.8	2.5±0.7	6.0±1.3	2.0±0.4
	Ik San	9.8±1.5	8.3±1.2	2.9±0.6	3.8±0.7	3.3±0.8
	Mu Ju	7.3±0.9	14.1±1.5	3.5±0.4	4.0±1.2	5.6±1.0
Jeon La Nam Do	Kwang Yang	5.3±1.8	8.0±1.4	7.0±2.2	4.5±1.3	3.0±0.6
	Na Ju	5.7±2.0	4.0±1.2	5.7±1.5	2.0±0.4	4.1±1.2
	Mu Ahn	4.0±1.2	7.0±2.4	5.5±0.9	3.0±1.0	3.3±1.0
	Young Kwang	2.9±0.4	7.3±0.4	2.0±0.5	4.3±0.4	5.0±1.4
	Gok Sung	8.0±1.5	4.5±1.3	3.0±0.4	2.0±0.2	4.5±1.2
	Jang Hung	3.7±0.9	4.1±2.0	2.0±0.2	3.1±1.1	5.0±1.4
Jae Ju Do	Jae Ju	4.4±1.6	4.8±1.2	3.0±1.0	3.8±0.4	1.0±0.3
	Han Lim	2.0±0.5	4.0±0.8	6.5±1.4	2.5±0.3	3.0±1.1
	Suh Kuy Po	6.0±1.8	4.0±1.2	5.0±0.6	2.0±0.3	3.4±0.4
Over all	42 districts	6.3±2.6	6.3±2.4	4.7±2.3	3.3±1.0	3.3±1.2

* All values are mean±S.D. (n = 3-4) (ug Se per 100g dry matter).
* Samples were obtained from 4 different places in each district.

and grains (soybean and barley) which are considered as major feed stuffs for the ruminant, are in the range between 0.02 and 0.13 ppm with average valves of 0.063 ppm Se for forage, 0.047 ppm Se for soybean – grain and 0.033 ppm Se for barley and rice. These values are comparable with the values reported by Alloway et al.[9], but selenium content in forages and grains are not sufficient to meet the requirement for growing lambs recommended by Oh et al.[17] Kubota et al.[18] reported selenium deficient regions of the United States (Northwest coast, North – central, North – east, South –

Table 2. Selenium concentrations and glutathione peroxidase activities in whole blood of people reside in Korea

Province	Cities	No. Samples [b]	Se concentration (ug / ml)	Glutathione Peroxidase Activity[a] (EU / mg Hb.)
Kyung Gi Do	Seoul	16	0.10 ± 0.03	10.2 ± 1.0
	In Cheon	10	0.13 ± 0.04	14.4 ± 2.2
	Song Tan	6	0.14 ± 0.03	9.8 ± 3.4
	Eu Jung Bu	10	0.18 ± 0.03	12.2 ± 3.5
Kang Won Do	Chun chun	9	0.25 ± 0.09	12.6 ± 1.9
	In Je	8	0.25 ± 0.02 *	12.3 ± 1.3
	Sok Cho	6	0.31 ± 0.03 *	12.8 ± 1.9
	Weon Ju	10	0.13 ± 0.02	11.0 ± 1.8
Chung Chung Buk Do	Chung Ju	10	0.13 ± 0.04	13.8 ± 2.0
Chung Chung	Dae Jon	10	0.14 ± 0.03	11.8 ± 2.9
Nam Do	Chun An	8	0.14 ± 0.02	11.5 ± 2.4
Kyung Sang	Dae Gu	12	0.16 ± 0.03	13.2 ± 1.1
Buk Do	Ahn Dong	7	0.16 ± 0.03	13.4 ± 2.8
Kyung Sang	Busan	14	0.17 ± 0.05	15.2 ± 3.4
Nam Do	Ul San	9	0.24 ± 0.04	13.7 ± 3.8
	Ma San	5	0.22 ± 0.07	14.1 ± 2.4
Jeon – La	Jean Ju	10	0.11 ± 0.02	14.0 ± 3.5
Buk – Do	Gun San	6	0.24 ± 0.03	15.3 ± 3.4
	Nam Weon	7	0.14 ± 0.04	14.7 ± 0.7
Jeon – La	Kwang Ju	9	0.09 ± 0.03	13.4 ± 1.1
Nam – Do	Mok po	9	0.17 ± 0.06	16.2 ± 1.8
Jae – Ju – Do	Jae Ju	7	0.15 ± 0.04	14.0 ± 1.6
	Su Kuypo	6	0.11 ± 0.03	15.0 ± 1.0
Total	23	204	0.16 ± 0.06	13.0 ± 1.7

a. Samples were obtained from normal person.
b. Enzyme unit (EU) is defined as n moles NADPH oxidized per min and specific activity is expressed as EU per mg hemoglobin.
* Significantly different from over all average value ($P < 0.05$).

east) contain less than 0.1 ppm Se in forages.

In general, selenium deficient areas include coastal regions around the world as is in Korean peninsula. Selenium contents of Japanese forage were reported as 0.018-0.025 ppm in grasses and 0.005 -0.034 ppm in legumes [19].

These values are much lower than that produced in Korea. From these results, it is possible to conclude that feeding of animals dependent only on forages and grains will not supply sufficient amount of selenium in these areas.

Selenium contents and glutathione peroxidase activities in human blood.

Selenium concentrations of human whole blood from 23 cities in Korea are shown in Table 2. Values (mean of each city) ranged from 0.09 to 0.25 μg Se/ml and individual value ranged from 0.05 to 0.35 μg Se/ml. Bloods from In-Je and Sok Cho both located in North-east of Kang-Won Do, contain significantly higher levels of selenium as compared with overall average value of 0.16 μg Se /ml. However, there were no great differences in selenium concentrations in bloods between sites of the country.

The selenium levels in whole human blood from 210 male donors in 19 sites in the United States were reported to range from 0.10 to 0.34 μg $\times$ Se/ml [20] which are slightly higher than the values of Korean. A level of 0.12 ppm Se was reported for the blood of normal Swedish group [21] and Griffiths and Thompson [22] reported that mean whole blood selenium levels of normal New Zealand people wes 0.068 ± 0.013 μg/ml which are much lower than that for Korean people (0.16 ± 0.06 μg Se/ml). Selenium deficiency in human is not documented and no evidence of deficiency is yet observed. Residents in Kang Won Do province has relatively higher blood selenium levels in the present study, indicating a reflection of higher selenium level in soil in the area. Glutathione peroxidase activities in whole blood of normal people in Korea are shown in Table 2.

Because selenium is a constituent of glutathione peroxidase which is related to the prevention of peroxidative damage in animals [23], the relationship between glutathione peroxidase activity and whole blood selenium level was studied. There were no significant differences in glutathione peroxidase activities in blood between cities, and no correlation ($r=0.3$) between selenium contents and the enzyme activities was observed.

Selenium contents in foods.

Selenium contents in major foods consumed by Korean people are shown in Table 3. Cereals and vegetables which are comprised of more than 50% of total diet contain 0.02-0.04 ppm Se.

Animal meats contain 0.11 ppm (beef) and 0.14 ppm (pork). Sea foods contain relatively high amount of selenium (0.2-0.55 ppm). Ocean fishes(Tuna and yellow corvina) contain more selenium than coastal river fishes (grey mullet) and inland lake fish (crucian carp) that contains much less selenium (0.12 ppm).

The dietary composition of normal diet consumed daily by average Korean in 1979 was reported [24] as 477.8g of cereals, 102.6g of animal meats, 215.0g of vegetables, 11.9g of sea foods, 34.8g of soy bean product, 26.9g of potato, 27.8g of fruits, 12.8g of eggs, 10.4g of milk and 4g of oil.

Table 3. Selenium contents in major Korean foods

Item*		No.	Range (ppm)	Average (ppm)
Cereals ; (dried)	Rice	19	0.01-0.07	0.03 ± 0.01
	Barley	15	0.01-0.05	0.03 ± 0.01
	Soybean	16	0.02-0.07	0.04 ± 0.02
Vegetables ; (fresh)	Chinese-cabbage	8	0.02-0.05	0.03 ± 0.01
	Radish	6	0.01-0.02	0.02 ± 0.01
	Garlic	7	0.01-0.03	0.02 ± 0.01
Meat ; (fresh)	Beef	7	0.05-0.16	0.11 ± 0.05
	Pork	8	0.10-0.20	0.14 ± 0.03
Sea food ; (fresh)	Tuna	8	0.48-0.52	0.50 ± 0.02
	Yellow-corvina	6	0.34-0.56	0.42 ± 0.09
	Greymullet	6	0.17-0.22	0.20 ± 0.02
	Dried-anchovy	6	0.49-0.60	0.55 ± 0.04

* All values are mean $\pm$ S.D. Samples were obtained from 6 cities (Seoul, Busan, Daegu, Chunchun, Kwangju, Jaeju) markets.

From the calculation of selenium concentration in foods (table 3 in the present study and table 1 of Schroeder et al[25]) and daily consumption of dietary components listed above gives 42.3 μg Se intake per capita. This valus is slightly lower than 62.3 μg Se of hospital diet reported by Schroeder et al[25] and is much less than 86.488 μg Se intaken by Japanese college students[26].

Although grains and vegetables have relatively low concentrations of selenium, they contribute about 71% of total selenium supply to man in Korea. Therefore, consumption of increased amount of animal products and sea food may improve the selenium status in man.

Because the minimal human requirement for selenium is not known, daily intake of 42.3μg Se (approximately 0.042 ppm Se in diet) can not be judged for human health. However, supplementation of sea foods by-product to animal feed may improve the productivity of animal mainly dependent on local forages and grains, especially in low selenium areas.

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