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SELENIUM IN POTATOES

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Abstract. To investigate soil and potato selenium content, a total of 32 potato and respective soil samples from different locations and from three different soil types (incl. carbonate and noncarbonate soils) in Estonia were collected and analysed. The selenium content of potato was found to be low from the point of view of human and animal nutrition. The mean selenium content for potato tubers was 3.5 μg kg^{-1} (1.6–8.2 μg kg^{-1}), for soil 10.4 μg kg^{-1} (6.3–19.7 μg kg^{-1}). To get potato crops with a satisfactory selenium content further investigations are needed to find out possibilities to use for example selenium containing fertilizers.

Key words: selenium, content in soil and potato.

INTRODUCTION

The role of selenium in the physical life of plants is not known yet. However, this element is indispensable in human and animal organisms. Selenium deficiency in human food or animal feed causes certain diseases, such as liver dystrophy, necrosis, and white muscle disease (Scheffer & Schachtschabel, 1982). It has been established that people with a low blood selenium content are more susceptible to blood vessel diseases and that selenium deficiency causes heart infarction. On the other hand, excess intake of selenium disturbs metabolism and is injurious to the organism. Finck (1991) found that an adult needs 50–200 μg of selenium a day. The selenium content in the animal feed ration must be 100–200 μg kg^{-1} in dry matter (Scheffer & Schachtschabel, 1982; Florinskij & Sedova, 1992). There is often too little selenium in plants and the use of such plants for nutrition does not cover human or animal need for it. In Finland and other Scandinavian countries the selenium content in soil and plants has been thoroughly investigated and it has been found that the food and forage crops grown in this region are poor in selenium. However, in several countries there is much selenium in plants, in particular in arid areas.

Only a few data are available on the selenium content of plants grown in Estonia, potatoes included. Considering the importance of potatoes in the diet in Estonia (more than 20% of the human mineral need is covered by potatoes), the Estonian Institute of Agriculture conducted a study to determine the selenium content of potatoes grown in Estonia and the extent to which our daily selenium need can be covered by potatoes.

MATERIAL AND METHODS

A total of 32 potato and respective soil samples were collected from different locations around Estonia. Every potato sample was taken from two plants and respective topsoil samples were taken from every field. The samples were divided into two groups: field samples and garden samples because garden soils are more fertile and better cultivated. Fields on *Rendzic Leptosols*, *Calcaric Cambisols*, and *Calcaric Luvisols* from northern and central Estonia and on *Eutric* and *Dystric Podzoluvisols* from southern Estonia were studied. Garden soils are represented with six samples. Three of those gardens had been fertilized with a fertilizer containing 0.0006% selenium and the other three with fertilizers containing no selenium.

The soil and potato selenium content was determined at the Agricultural Research Centre in Finland. The content of selenium in soil was determined as that of water soluble one, the plant selenium content was determined as total selenium.

For plant samples wet ashing was used as follows. 1 g of a sample was weighed into a 100 ml digestion tube, then 25 ml of a mixture of concentrated acids (HNO_3 : $HClO_4$: H_3SO_4, 7 : 2 : 1) was added. The mixture was heated very slowly up to 195 °C. After digestion 5 ml of 5 M HCl was added and the mixture was boiled for 15 min to reduce Se^{VI} to Se^{IV} form. The Se content was determined in the cooled solution with an atomic absorption spectrophotometer according to the hydride method (Siemer & Hageman, 1975; Yläranta, 1983). Blank samples and wheat flour reference containing 57 $\mu g\ kg^{-1}$ in dry matter were used in determinations (ARC of Finland/CL wheat flour reference material containing 57 ± 5.45 $\mu g\ kg^{-1}$).

RESULTS AND DISCUSSION

Soil selenium content

The content of water soluble selenium varied between 6.3 and 19.7 $\mu g\ kg^{-1}$, being 10.4 $\mu g\ kg^{-1}$ as the average (Table). The selenium content in garden samples was higher (13.6 $\mu g\ kg^{-1}$) than in the topsoil samples from fields (9.7 $\mu g\ kg^{-1}$). As calcareous deposits are richer in selenium than noncalcareous

ones (Kabata-Pendias & Pendias, 1984), the top of the field soils formed on calcareous parent material is also enriched with selenium. Moreover, soils on calcareous till contain more humus than those on noncalcareous till. After Sillanpää & Jansson (1992) the content of soluble selenium compounds increases parallel to an increase in the humus content in soil.

Because of the calcareousness of parent material in Estonia soils are here a little richer in water soluble selenium than in Finland where the average is only 5 $\mu g\ kg^{-1}$ (Kurki, 1982). It was established that there is no difference between the content of water and AAAc-EDTA extractable selenium in soil in Finland (Sillanpää & Jansson, 1992). The average content of AAAc-EDTA extractable selenium in soils of 30 countries of the world is 14 $\mu g\ kg^{-1}$ according to Sillanpää & Jansson (1992).

In Estonia no gradation of soil selenium content has been worked out. According to the gradation used in Finland (Aura, 1986), 13% of the soil samples we collected in Estonian potato fields were poor, 67% medium, and 20% rich in selenium.

Potato selenium content

The relationship between the selenium content in potatoes and soil was weak. For Finland a correlation coefficient of 0.195 between soil and crop selenium content was reported by Sillanpää & Jansson (1992).

Selenium content of potato and the soil of its growth place

Origin of samples	*n*	Content, $\mu g\ kg^{-1}$	
		in potatoes	in soil
Field	26		
variation range		1.6–6.5	6.0–15.0
average		3.3	9.7
of these			
on calcareous till	16		
variation range		1.6–6.5	7.4–15.0
average		3.2	10.6
on noncalcareous till	10		
variation range		1.6–4.9	6.3–10.9
average		3.3	8.3
Garden	6		
variation range		1.6–8.2	11.2–19.7
average		6.2	13.6
Total	32		
variation range		1.6–8.2	6.3–19.7
average		3.5	10.4

According to Sillanpää & Jansson (1992), with an increase in the pH value of soil the plant selenium content also increases. Soil humus content has an opposite effect on plant selenium content: with an increase in the soil humus content the plant selenium content decreases considerably.

Low temperature and high precipitation decrease the assimilation of soil selenium by plants (Kabata-Pendias & Pendias, 1984). This explains why the plants growing in the northern countries are poorer in selenium than those of warmer regions. The plants that have been growing in arid climate are the richest in selenium (Mengel, 1972).

In Estonia the potato selenium content varied from 1.6–8.2 $\mu g\ kg^{-1}$, being as an average 3.5 $\mu g\ kg^{-1}$ in the analysed samples. Against the background of different selenium contents in soils on calcareous and noncalcareous till, there was no statistical difference in the selenium content of potatoes, because of positive correlation between soil humus and selenium content. Potato samples from gardens contained more selenium (6.2 $\mu g\ kg^{-1}$) than field samples. Evidently the reason is application of complex selenium containing fertilizes.

For explanation it can be said that until the selenium containing fertilizers were taken into use in Finland the selenium content of the raw potato mass grown in Finland was 1–2 $\mu g\ kg^{-1}$, that is 5–10 $\mu g\ kg^{-1}$ in dry matter (Koivistoinen, 1980).

In spite of a higher content of water soluble selenium in Estonian soils, the potatoes grown in Estonia are poorer in selenium than those grown in Finland.

Sillanpää & Jansson (1992) declare that the selenium content in food and forage crops should be 2000–5000 $\mu g\ kg^{-1}$. The corresponding figure given by Florinskij & Sedova (1992) is 3000 $\mu g\ kg^{-1}$ and by Scheffer & Schachtschabel (1982) 4000 $\mu g\ kg^{-1}$. In Estonia the selenium content in potatoes is about 500 times lower than the optimal value.

However, selenium is necessary for human and animal organisms and its dietary intake should meet the need. It has been found (Finck, 1991) that a human has to get with food 50–200 µg of selenium a day.

Considering that in Estonia an adult eats about 90 kg of potatoes a year (18 kg of dry matter) and there is on an average 3.5 $\mu g\ kg^{-1}$ selenium in potatoes, a person gets daily only 0.2 µg of selenium from potatoes. This is only a fraction of the daily need. In order to meet the selenium need of an adult there should be at least 100 µg of selenium in 1 kg of food dry matter (Scheffer & Schachtschabel, 1982).

The selenium content of crops can be increased by the use of complex selenium containing fertilizers because plants assimilate selenium from fertilizers more easily than from soil. For example, in Finland fertilizers containing 0.0006% Se are in wide use. It was mentioned above that the potatoes grown in soils fertilized with selenium containing fertilizers contained more selenium than the potatoes from soils to which no selenium containing fertilizers had been appiled. The respective calculations on the importance of selenium containing

fertilizers in the enrichment of food ration with selenium made by Sillanpää & Jansson (1982) prove the same. They indicate that before selenium containing fertilizers became extensively used, an adult got 30–40 μg of selenium a day in Finland, but since the application of complex selenium containing fertilizers the selenium content of field crops has increased and the daily uptake of selenium is 100–200 μg.

The potatoes grown in Estonia are poor in selenium also for animal feed. According to the data given by several authors (Scheffer & Schachtschabel, 1982; Florinskij & Sedova, 1992) feed dry matter should contain at least 100–200 μg kg^{-1} of selenium. In the potatoes grown in Estonia the selenium content is much lower than the forage crop selenium content required. As there is little selenium in potatoes and other feeds, Upits & Gubar' (1988) found that the selenium content of feed ration covers 10–15% of cattle and 11–14% of sheep selenium need.

CONCLUSIONS

Estonian soils are poor in selenium, containing 10.4 μg kg^{-1} water soluble selenium as an average. The content of selenium in potato dry matter is 1.6–8.2 (on an average 3.5) μg kg^{-1}. In case of potatoes grown in Estonia there is no question of selenium contamination; on the contrary, potatoes contain considerably less selenium than required for human and animal nutrition. In order to get more valuable potatoes regarding selenium content, further investigations are needed to find out possibilities for raising crop selenium content. For example, application of complex selenium containing fertilizers is worth studying.

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KARTULI SELEENISISALDUS

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Eesti erinevate alade kartulipõldudelt ja aedadest on paariti kogutud 32 mulla- ja kartuliproovi ning määratud mulla ja kartulimugulate seleenisisaldus. Saadud analüüsitulemuste põhjal on selgitatud kartuli seleenisisalduse sõltuvust selle sisaldusest kartuli kasvukoha mullas. Lähtuvalt kartuli seleenisisaldusest on Eestis kasvatatud toidukartulile antud hinnang hügieeni aspektist ja söödakartulile zootehnika aspektist. Selgus, et Eesti põllu- ja aiamuldades sisaldub vähe (6,3–19,7 $\mu g\ kg^{-1}$) vees lahustuvat seleeni ja kartuli seleenisisaldus korreleerub nõrgalt kasvukoha mulla seleenisisaldusega. Eestis kasvanud kartul on seleenivaene, sisaldades seda kartulimugulate kuivaines 1,6–8,2, keskmiselt 3,5 $\mu g\ kg^{-1}$. Väikese seleenisisaldusega kartul jääb nii hügieenilisest kui ka zootehnilisest seisukohast ebakvaliteetseks. Seleenisisalduselt väärtuslikuma toidu- ja söödakartuli saamiseks oleks soovitav kartuli väetamisel kasutada seleeni sisaldavaid väetisi.