THE SELENIUM STATUS OF DAIRY COWS IN ESTONIA

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ABSTRACT. *Based on earlier soil, forage and animal studies, Estonia is considered a Se-deficient country where Se supplementation of dairy cows has been routine practice for more than 10 years. To evaluate the current Se status of Estonian dairy cows, bulk tank milk samples (n=218) from farms (n=110) producing over 60% of the milk purchased in the counties of Estonia, were analysed for the Se concentration. Milk Se content ranged from 5–34 µg/kg. The mean Se content of all the samples was 16 µg/kg, indicating dairy cows' Se status was from high-marginal to adequate depending on the reference level used. The results of the study provide evidence that the Se status of dairy cattle in Estonia has improved. Although Se status was satisfactory on 99 farms (90.8%) there were 10 farms (9.2%) with a milk Se concentration of less than or equal to 10 µg/kg where attention should be given to Se supplementation of the animals.*

Keywords: *bulk milk, trace elements, silage, nutrient deficiency.*

Introduction

Selenium (Se) is one of the most extensively studied microelements, one of the reasons for which is its dual importance in the nutrition of man and animals. Se is an essential micronutrient but too much of it in the diet can be toxic, the difference between these two is measured in minute amounts (Reilly, 2006).

The geographical distribution of selenium, and hence its consumption from local feed/food, varies widely in different parts of the world. For instance there are many Se-rich areas in the USA, Canada, China, and Venezuela (Surai, 2006). The situation is different in Europe where Norway (Mikkelsen, Aas Hansen, 1967), Finland (Oksanen, Sandholm, 1970), Sweden (Lindberg, Bingefors, 1970) and Denmark (Gissel-Nielsen, 1975) were among the first countries to be charted and were all found to be extremely deficient. As a consequence, selenium was permitted as a supplement to animal feed in Finland from 1969, in Denmark from 1975, and in Norway and Sweden from 1980 (Bergström *et al*., 1998).

In Estonia the earliest studies on Se status date from the middle of the previous century when white muscle disease was diagnosed for the first time by Kaarde (1963). In 1993, Suoranta *et al*. found low selenium levels in feedstuffs, milk and tissues on one Estonian dairy farm. Data published by Kevvai (1994) indicate that the Se contents of some Estonian soils are lower than those in the Scandinavian countries. Animal studies confirmed these findings. Malbe *et al*. (1995) reported that the cows on the research farm of the Estonian Agricultural University had an extremely low selenium status. The Se statuses of seven dairy herds with no Se supplementation, from the central regions of Estonia (Pehrson *et al*., 1997), as well as 12 herds from all over the country (Bergström *et al*., 1998), also showed severe deficiency of the element. The first study to give an overall picture of the Se status of cattle in Estonia involved 6–10 young cattle from 46 farms, which had been fed only with local feed for at least three months. The animals were sampled, their whole blood GSH-Px activity determined, and the mean enzyme activities of the farms used to chart Se status in Estonia (Ling, Ploom, 1999). None of the farms achieved the current whole blood deficiency margin of 50 µg/l (Surai, 2006). Based on these data Estonia was considered to be a selenium deficient country and Se supplementation is now common practice.

Several studies have demonstrated that Se concentration in milk is strongly and positively correlated to the Se concentration in the diet, whereas the actual extent of the increase in milk Se due to increased intake depends on the form of Se in the ration (Conrad, Moxon, 1979; Ortman, Pehrson, 1999; Givens *et al*., 2004; Juniper *et al*., 2006; Heard *et al*., 2007; Calamari *et al*., 2010). In addition, significant correlations have been observed between blood and milk Se concentrations (Grace *et al*., 2001; Wichtel *et al*., 2004; Calamari *et al*., 2010). Because of this, in addition to other indicators, milk Se analyses are used to evaluate Se status of dairy cows (Pehrson, 1996; Grace *et al*., 2001; Wichtel *et al*., 2004).

Large-scale studies of the Se status of dairy cattle in Estonia date back to the end of the last century. Currently almost every mineral feed of dairy cows in Estonia is supplemented with Se. It was therefore hypothesized that the Se status of the animals has also improved. The objective of this study was to evaluate the Se status of Estonian dairy cows using Se concentration analyses of bulk tank milk. A further aspect of the study was to evaluate possible mean milk-based human Se intake in Estonia.

Material and methods

At the time of the study there were 208 dairy farms in Estonia of more than 100-head. Of these 110 farms from different counties were selected with the calculation, based on the data from Estonian Animal recording Centre, that the farms together produced at

least 60% of the milk purchased in the county (Figure 1). The exception was the island of Hiiumaa, where four farms, with mean herd size of 60, were included in the study.

During farm visits from spring 2008 to spring 2009 (period I, 109 farms) and from autumn 2009 to spring 2010 (period II, 109 farms) one litre of bulk tank milk was sampled. Our co-worker completed a questionnaire on general data (number of cows, milk yield, grazing) and feeding (total mixed ration or not, basic feed, Se supplementation) practice of the farm.

In order to evaluate the Se content of home-grown feed, mean samples (n=6) for different soil type regions were formed from silage samples brought to the feed laboratory (Department of Animal Nutrition and Products Quality of the Institute of Veterinary Medicine and Animal Science, Estonian University of Life Sciences) for routine analyses. The Se content of milk and silage samples were determined at the laboratory of Estonian Agricultural Research Centre where the accredited method EVS-EN 14627:2005 "Foodstuffs – Determination of trace elements – Determination of total arsenic and selenium by hydride generation atomic absorption spectrometry (HGAAS) after pressure digestion" was used.

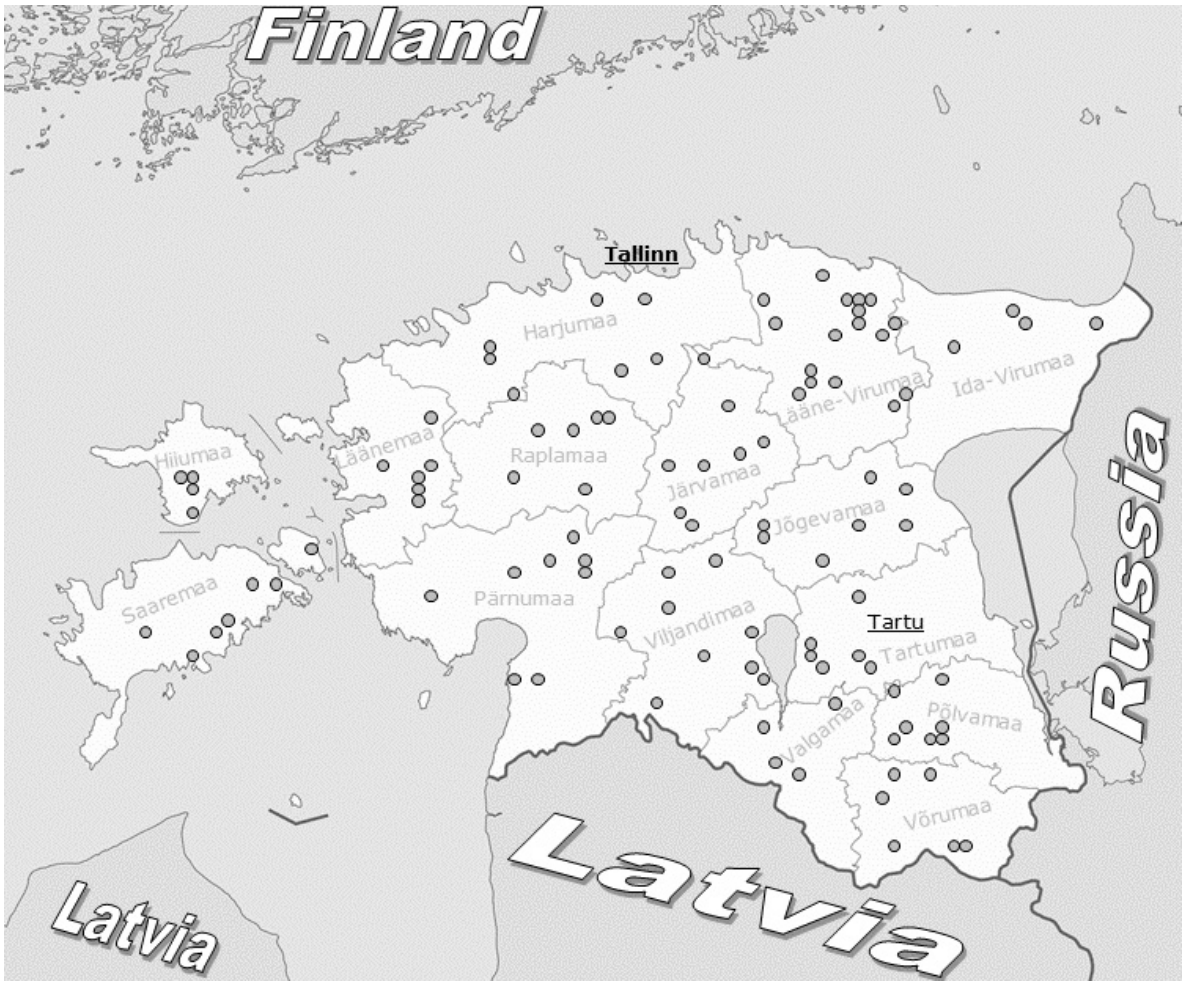

Figure 1. Distribution of the sampled farms
Joonis 1. *Uuringusse kaasatud farmide paiknemine*

Results and discussion

The mean herd size of the farms visited was 349 (48–1260) and daily milk yield was 23.7 kg (10.0–33.1). Grazing of dairy cows was practiced on 41 of the farms. All the farms visited used silage during the indoor overwintering period. A total mixed ration (TMR) was used on 80% of the farms; four farms switched over to TMR and two gave it up during the study period.

The results of the analyses of the mean silage samples from different soil-types confirmed Estonia to be a Se-deficient country as the Se content of these samples (Table 1) was 4.7 to 6.3 times less than the 0.3 mg/kg dry matter requirement of Se for dairy cattle (NRC, 2001). These results are in accord with earlier fragmentary studies on the Se content of Estonian crops (Seleen, 2004). Therefore, in Estonia, Se-supplementation of dairy cattle is necessary.

During the first period of visits six farms used no mineral feed, during the second period the number of farms had decreased to three; the mean Se content of the milk samples was 12 µg/kg. The Se compound used in the mineral feeds was sodium selenate. One of the mineral feeds used did not contain any Se. Based on the data from 87 questionnaires mean daily Se supplementation was 6.4 mg during the first period and 7.1 mg (p=0.1; t-test) during the second period. In the first study period 11 farms supplemented dairy cows with less than half (<3 mg) the average daily requirement (6 mg; NRC, 2001), in the second study period the number was five. In addition to mineral feeds, some purchased concentrates were supplemented with Se; their mean contribution to total Se supplementation was 8%.

Table 1. The Se content of mean silage samples formed on the bases of the soil-types of the counties of origin of the individual samples
Tabel 1. *Muldade põhitüübi alusel jaotatud maakondade keskmise siloproovi seleenisisaldus*

Counties *Maakonnad*	Dominant soil characteristics and types *Muldade iseloomustus ja -tüüp*	Number of individual samples *Individuaalproovide arv*	Se-content in the mean sample µg/kg *Keskmise proovi Se sisaldus*
Põlvamaa, Valgamaa, and Võrumaa	Acid, light textured soils (Podzols, Albeluvisols) *Happelise reaktsiooni ja kerge lõimisega leetunud mullad*	20	48
Lääne-Virumaa, Ida-Virumaa, and Jõgevamaa	Soils developed on calcareous parent material (Luvisols, Cambisols) *Karbonaatsel lähtekivimil välja kujunenud leostunud ja leetjad mullad*	20	60
Tartumaa and Viljandimaa	Soils with stagnic properties, slightly acid reaction (Albeluvisols, Luvisols) *Kahkjad mullad; muldade lähtekivimid osaliselt nõrgalt karbonaatsed*	20	64
Pärnumaa and Läänemaa	Gleyic soils and Gleysols *Gleistunud ja gleimullad*	10	58
Saaremaa and Hiiumaa	Young, poorly developed soils / Kõige nooremad mullad	10	58
Harjumaa, Raplamaa and Järvamaa	Rendzinas with neutral to alkaline reaction (Leptosols, Regosols, Cambisols) *Neutraalse kuni leelisese reaktsiooniga, karbonaatsel lähtekivimil välja kujunenud rähkmullad*	20	59

Milk Se content on the studied farms (Table 2) ranged from 5 to 34 µg/kg, both the extremes falling outside the average 10 to 25 µg/kg according to Nutrient Requirements of Dairy Cattle (NRC, 2001).

Table 2. Mean Se content and its variation for bulk milk of farms (is the number of the farms during the period 2009/2010 in brackets) from different counties of Estonia
Tabel 2. *Farmide segupiima keskmine seleenisisaldus ja selle varieeruvus erinevates maakondades (sulgudes farmide arv perioodil 2009/2010)*

County *Maakond*	Number of farms *Farmide arv*	Mean Se content and its variation in bulk milk (µg/kg) *Segupiima keskmine Se-sisaldus ja varieeruvus (µg/kg)*	
		2008/2009	2009/2010
Raplamaa	6	21 (18–24)	14 (11–16)
Valgamaa	4	21 (20–22)	17 (15–19)
Võrumaa	6	20 (15–24)	18 (11–21)
Põlvamaa	7	18 (13–29)	16 (11–20)
Saaremaa	7	18 (13–25)	15 (11–18)
Ida-Virumaa	4 (3)	17 (14–20)	16 (15–16)
Järvamaa	8	17 (12–20)	14 (11–17)
Lääne-Virumaa	20 (21)	17 (8–25)	15 (8–22)
Pärnumaa	8	17 (13–21)	17 (13–24)
Tartumaa	6	17 (12–24)	15 (13–22)
Jõgevamaa	7	16 (14–19)	19 (15–26)
Viljandimaa	9	16 (5–23)	15 (10–20)
Läänemaa	6	14 (10–17)	15 (11–18)
Harjumaa	7	13 (9–17)	17 (13–34)
Hiiumaa	4	9 (7–11)	9 (6–10)
All-Estonia	109	17 (5–29)*	15 (6–34)*

* Significant (p=0.01) difference between the study periods

During the whole study period there were 16 samples (7.3%) with a milk Se concentration of less than or equal to 10 µg/kg, the postulated threshold for adequacy (Surai, 2006), and 25 samples (11.5%) with a Se concentration over 20 µg/kg, the target level achieved by fertilization of soil in Finland (Aspila, 1991; Ekholm, 2005). Overall, the Se status of dairy cattle was insufficient on ten (9.2%) farms as one of the samples was less than or equal to 10 µg/kg. The mean Se content of all milk samples was 16 µg/kg indicating dairy cows' Se status was from high-marginal (Wichtel *et al*., 2004) to adequate (Surai, 2006) depending on the reference level used for the comparison. During the first study period the mean Se content was 17 µg/kg and during the second period 15 µg/kg (p=0.01; t-test) in spite of the increase in reported Se supplementation. The discrepancy between the increase in Se supplementation and decrease in milk Se content in the second period could be explained by the origin of the concentrates used – due to economic recession the number of farms that used only Se deficient home-grown cereals increased from 50 to 72 in the second period. Se injections before or after calving, or regularly once a year, to all the cows were used on 21 (19%) farms during at least one of the visiting periods. Milk Se content on these farms over the whole period of the study was 17.4 µg/kg compared to 15.7 µg/kg (p=0.03) on the farms without injections, although there was no difference in the amounts of Se in the ration (p=0.09).

Six farms used Se fertilization of their pastures, grasslands or crop fields. The mean Se content of bulk milk on these farms was higher than the overall mean – 19 μg/kg on the first (p=0.35) and 20 μg/kg (p=0.05) on the second visit. One of the visited farms used organic selenium, its bulk milk Se content was higher than the mean – 24 μg/kg – due to higher bioavailability of organic Se (Ortman, Pehrson, 1999).

According to meta-analyses of the effect of oral selenium supplementation on milk Se in cattle (Ceballos *et al*., 2009), there is no effect on milk Se when less than 3 mg per day is given. An earlier study on milk Se concentration in Estonia (Bergström *et al*., 1998) also showed little effect of Se supplementation when small amounts were used – the selenium concentration in milk was very low, irrespective of whether there had been a selenium supplementation or not (5.1 and 4.5 μg/l, respectively). Although in the present study there were several farms where the cows received less than 3 mg Se per day, analyses of the data still showed moderate correlation (r=0.4, p<0.001) between Se supplementation and milk Se content, confirming that supplementation with Se is essential to achieve adequate Se status of dairy cows in Estonia.

Conclusions

The results of the study confirmed expectations that Se status of dairy cattle in Estonia has improved recently. Although Se status was satisfactory on 99 farms (90.8%) there were still 10 farms (9.2%) where more attention has to be paid to Se supplementation of the animals. Another aspect of the study was to estimate how much Se Estonian citizens obtain from home-produced milk and dairy products. Considering the mean milk Se concentration of 16 μg/kg, and consumption of ca 750 g milk and dairy products in raw milk equivalents per day in Estonia (Eesti piimaturg 2010. aastal, 2011) daily Se consumption would be 12 μg, or 22% of the daily population reference intake in EU (Nutrient and energy intakes for the European Community, 1993).

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Piimalehmade seleeniga varustatusest Eestis

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Kokkuvõte

Seleen on üks enim uuritud mikroelemente eelkõige selle tõttu, et ta on väikestes kogustes nii veistele kui inimesele (veistel 3…40 mg, inimestel 20…200 µg, päevas) oluline biogeenne element ja samas suuremates kogustes (inimestele >800 µg, veistele >100 mg päevas) mutageense, geno- ja tsütotoksilise toimega (Surai, 2006). Sööda seleenisisaldus alla 0,05…0,1 mg ühes kuivaine kilogrammis loetakse defitsiidiks, kui aga regulaarselt sööta üle 1 mg seleeni söödakilogrammi kohta, siis on see juba toksiline kogus (Hartikainen 2005). Varasemad uurimised on näidanud (Kaarde, 1963; Suoranta jt, 1993; Kevvai, 1994; Pehrson jt, 1997; Bergrström jt, 1998; Ling, Ploom, 1999), et Eesti kuulub seleenidefitsiitsete piirkondade hulka ning veiste seleeniga varustatus on puudulik.

Kuna viimasel kümnendil rakendatakse Eestis ulatuslikult seleeni lisasöötmist, siis oletasime, et lüpsilehmade seleeniga varustatus on paranenud. Uurimuse eesmärgiks oligi hinnata lüpsilehmade seleeniga varustatust määrates varutava piima seleenisisaldus.

Uuringusse kaasatavate farmide valikul kasutati Jõudluskontrolli Keskuse maakondade zootehnikpeaspetsialistide abi ning lähtuti farmi suurusest (lüpsilehmi üle 100, v.a Hiiumaal) ja põhimõttest, et uuritavates farmides toodetakse üle poole maakonnas varutavast piimast. Farme külastati kaks korda: I periood – sügis 2008 kuni suvi 2009, II periood – sügis 2009 kuni suvi 2010. Külastatud farmides võeti üks liiter segupiimaproovi, piima Se-sisaldus analüüsiti Põllumajandusuuringute Keskuse jääkide ja saasteainete uurimise laboris. Selleks, et saada ühtne ülevaade farmide suuruse, kasutatava sööda, võimalike seleeniallikate jmt kohta paluti farmitöötajatel täita vastav küsitlusleht. Kokku külastati kummalgi perioodil 109 farmi, nende paiknemisest annab ülevaate joonis 1.

Selgitamaks Eestis kasvatatud põhisööda seleenisisaldust, koostati 2010. aastal söötmisosakonna laborisse toodud siloproovidest maakondliku jaotuse alusel keskmised siloproovid. Maakondliku jaotuse koostasid Eesti Maaülikooli mullateadlased Enn Leedu ja Avo Toomsoo, kes lähtusid oma jaotussoovituse andmisel Eesti mullastikutüüpidest.

Tulemuste statistiline analüüs tehti programmiga Excel, statistilist trendi iseloomustavate või statistiliselt oluliste tulemuste korral on sulgudes esitatud olulisuse tõenäosus.

Külastatud farmides oli keskmiselt 349 lüpsilehma (48…1260) ja nende keskmine piimatoodang oli 23,7 kg (10,0…33,1).

Söötade analüüsitulemustest (tabel 1) selgus, et Eesti silo sisaldab seleeni kuivaine kilogrammi kohta

4,7 kuni 6,3 korda vähem soovituslikust 0,3 mg/kg (NRC, 2001).

Piimaanalüüside tulemused kinnitasid oletust, et lüpsilehmade seleeniga varustatus on paranenud. Farmide segupiima keskmine seleenisisaldus erinevates maakondades oli I perioodil 9…21 µg/kg, kõige väiksem oli see Hiiumaal ja suurim Valgamaal. II perioodil kõikus maakondade farmide piima keskmine seleenisisaldus vahemikus 9…19 µg/kg, väikseim oli see endiselt Hiiumaal, suurim aga Jõgevamaal (tabel 2).

Perioodil 2008–2009 kogutud 109 piimaproovi keskmine seleenisisaldus oli 17 µg/kg, II perioodil oli see langenud tasemele 15 µg/kg (P=0,01). Kirjanduse andmeil iseloomustab selline piima seleenisisaldus peaaegu (Wichtel *et al*., 2004) või täiesti piisavat (Surai, 2006) seleeniga varustatust. Uuringusse kaasatud farmide piima seleenisisaldus kõikus vahemikus 5…34 µg/kg. Kogu uurimisperioodi vältel oli 16 piimaproovi (7,3%) seleenisisaldus alla kirjanduses esitatud piisavat varustatust iseloomustavat 10 µg/kg (Surai, 2006) ja 25 proovi (11,5%) Se sisaldus oli suurem kui Soomes muldade väetamisega eesmärgiks võetud 20 µg/kg (Aspila, 1991; Ekholm, 2005). Kokkuvõttes oli enamus farmide lüpsilehmade Se varustatus piisav, puudulik oli see 10 farmis (9,2%), kus vähemalt ühe piimaproovi Se sisaldus oli võrdne või väiksem kui 10.

Korrelatsioonanalüüsi tulemusena selgus, et piima seleenisisalduse ja söödaga, eelkõige mineraalsöödaga lehmale söödetava seleenikoguse vahel on keskmise tihedusega oluline positiivne seos (r=0,4; P<0,001). Küsitluste andmeil pärines ligikaudu 95% ostusöödaga saadavast seleenikogusest mineraalsöötadest. Seega selleks, et kindlustada lehmade seleeniga varustatus Eesti tingimustes, tuleb kindlasti regulaarselt kasutada seleeni lisasöötmist või manustamist.

Arvestades Eestis toodetava piima keskmiseks seleenisisalduseks 16 µg/kg ning keskmiseks päevaseks piima ja piimatoodete tarbitavaks koguseks toorpiima alusel 750 g (Eesti piimaturg 2010. aastal, 2011), oleks sellest saadavaks seleenikoguseks ligikaudu 12 µg ehk 22% inimese päevasest normist (Nutrient and energy intakes for the European Community, 1993).