ОРИГИНАЛЬНАЯ СТАТЬЯ

RELATIONSHIP BETWEEN MEAT SELENIUM CONTENT AND THE MONGOLIANS SELENIUM STATUS

ВЗАИМОСВЯЗЬ МЕЖДУ СОДЕРЖАНИЕМ СЕЛЕНА В МЯСЕ И СЕЛЕНОВЫМ СТАТУСОМ НАСЕЛЕНИЯ МОНГОЛИИ

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KEYWORDS: selenium, meat of domestic animals, human hair, Mongolia.

КЛЮЧЕВЫЕ СЛОВА: селен, мясо сельскохозяйственных животных, волосы, Монголия.

ABSTRACT. The aim of the work was to evaluate the levels of selenium (Se) accumulation by muscles of domestic animals in Mongolia and reveal the values of Se intake with meat by the population. Fluorimetric method of analysis was used. Se concentrations in muscles of cattle, lambs, horses and goats of 17 Mongolian provinces varied between 99–249 μg Se/kg of dry weight. The lowest values of meat Se were registered in the Northern and Eastern provinces, the highest- in the South-Western part of the country. Mean values of Se daily consumption with meat by the inhabitants of Mongolia reached 8.7–17 μg that corresponds to 15.8–31% of the daily recommended intake. In conditions of Se deprivation lung/muscles Se ratio was larger than in conditions of higher Se consumption level .Water soluble forms of Se composed 51–53% of the total amount of the element in meat irrespective to geographical source of the element.

РЕЗЮМЕ. Цель работы – оценка уровней аккумулирования селена мышечной тканью сельскохозяйственных животных Монголии и расчет уровней потребления населением селена с мясопродуктами. В работе использовался флуорометрический метод определения селена. Концентрация селена в говядине, баранине, конине и козлятине 17 аймаков Монголии составила интервал 99–249 мкг/кг сухой массы. Наиболее низкие значения концентраций были зарегистрированы на севере и востоке страны, наиболее высокие – на юго-западе. Средние показатели суточного потребления селена с мясом жителями Монголии достигали 8,7–17 мкг, что соответствует 15,8–31% рекомендуемого уровня. В условиях недостатка потребления селена сельскохозяйственными животными соотношение селен легких/селен мышечной ткани оказалось выше, чем в регионах с более высоким селеновым статусом. Доля водорастворимых форм селена составила 51–53% от общего содержания микроэлемента в мясе независимо от географического положения места отбора проб.

INTRODUCTION

Evaluation of the human Se status in different regions of the world is of great priority due to essentiality and strong antioxidant properties of the element (Golubkina, Papazyan, 2006; Oldfield, 1996). Se enters human organism from soil via products of plant and cattle breeding so that Se deficiency in soils, especially in agrarian regions, stimulates the development of Se-deficient diseases in domestic animals and human beings. Adequate intake of this element provides high immunity, decreases the risk of cardiovascular diseases and cancer, induces optimum of reproductive function, stimulates excretion of heavy metals from the organism (Golubkina, Papazyan, 2006), and is considered to be one of the factors, affecting life spang (Gavrilov, Gavrilova, 1991).

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The most important sources of Se for human beings are cereals and meat. The main chemical forms of Se in these products are compounds with high bioavailability: selenocystein and selenomethionine in meat and selenomethionine in cereals (Golubkina, Papazyan, 2006). Depending on the dietetic habits of society these products may determine the human Se status that opens the possibility of Se status prognosis via values of Se accumulation in appropriate food products. Thus, a direct correlation between serum Se concentrations for the inhabitants of Russia and Se content in wheat has been demonstrated (Golubkina, Alfthan, 1996). Meat consumption is shown to provide from 37 to 82% of recommended daily intake of the element in European countries (Pilarczyk et al, 2010, 2012). High consumption level of meat in Mongolia (about 110 kg/person/year) supposes the leading role of meat in the formation of the human Se status in the country. Nevertheless data on the Se status of Mongolia are very limited and include a description of Se deficiency diseases in domestic animals in the North of the country (Ermakov, Kovalsky, 1974), and a demonstration of low serum Se levels in children of Ulaanbaatar (Lander et al, 2008). Special attention should be paid to the fact that the country is characterized by low life span of the population and high oxidative stress (Komatsu et al., 2008, 2011). In such a situation evaluation of ecological risks connected with low Se intake by the population using Se accumulation levels in meat seems to be very attractive.

The aim of the present study was the determination of geographical peculiarities of Se accumulation by muscles of domestic animals in Mongolia and revelation of the values of Se intake with meat by the population.

MATERIALS AND METHODS

141 Samples of carcass muscles of cattle, sheep, goats and horses were collected from 17 provinces of Mongolia in 2009 (Fig. 1). To evaluate Se distribution between organs and tissues samples of muscles, liver and lung were collected from three animal species (horses, lambs, cattle; n = 3). Samples of beef imported from China were obtained in shops of Ulaanbaatar. All samples were homogenized, freeze dried and kept at room temperature before the analysis. To estimate the human Se status 40 samples of human hair were gathered in Ulaanbaatar (mean age of the participants was 32 ± 6 years). Hair samples were washed with 1% solution of sodium dodecyl sulphate to remove fat, distilled water and dried to constant weight at 70 °C.

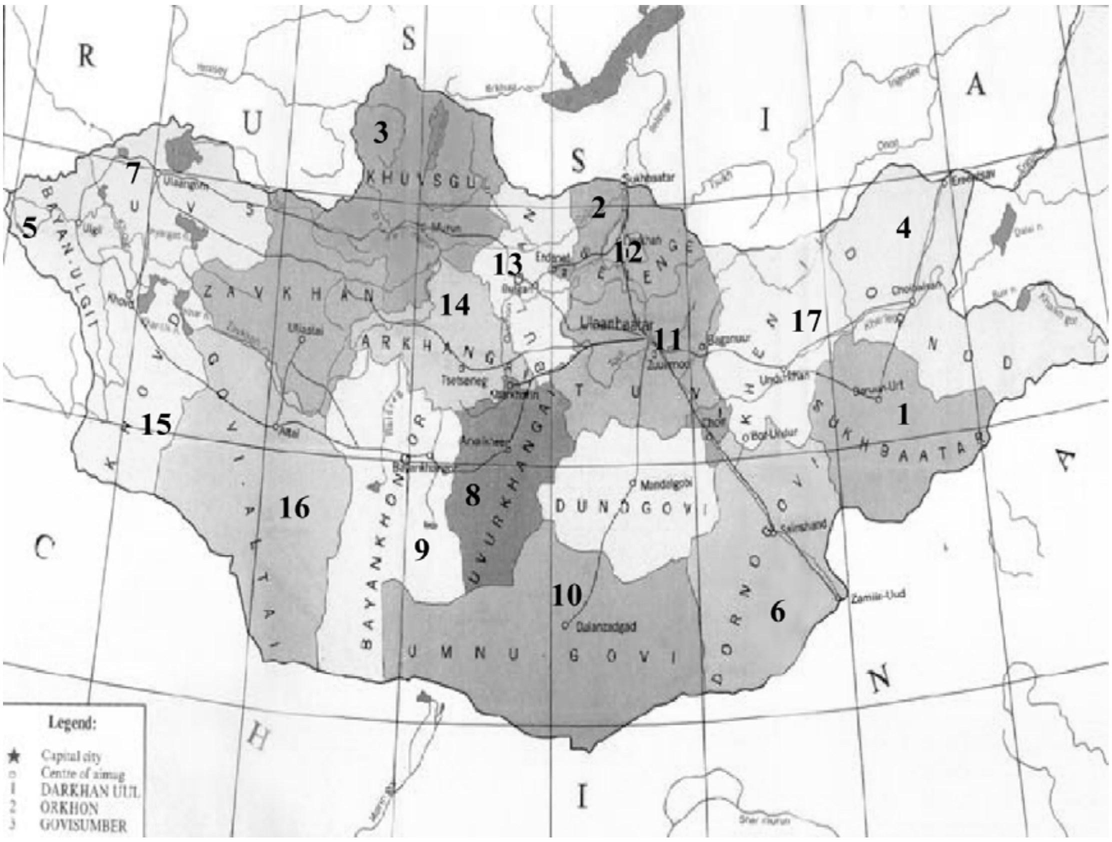

Fig. 1. *Provinces of Mongolia where meat samples were collected (see Table 1)*

Table 1. ***Se content in meat of domestic animals of Mongolia (μg Se /kg of dry weight)***

N*		Province	Beef	Lamb	Horse-flash	Goat-flash
1	I Provinces with significant Se deficiency	Sukhbaatar	166±13 (9) 150–180	128±6 (6) 124–132	134±3 (3) 133–138	135±7 (3) 124–143
2		Selenge	163±23 (3) 140–189	–	–	–
3		Khuvsgul	131±16 (12) 109–155	–	–	–
4		Dornod	123±6 (3) 118–129	–	–	–
5		Bayan–Ulgii	–	105±10 (3) 94–116	–	–
6		Dornogovi	–	–	150±30 (3) 120–180	–
7		Uvs	–	154±7 (3) 145–166	–	–
Mean**			139 ±19			
8	II Provinces with moderate Se deficiency	Uvurkhangai	196±22 (3) 149–242	170±30 (3) 140–200	–	–
9		Bayankhongor	187±27 (6) 160–213	125±9 (3) 115–134	–	–
10		Umnu Govi	184±16 (3) 158–210	–	–	181±15 (3) 165–197
11		Ulaanbaatar	129±12 (3) 115–142	175±14 (3) 160–190	191±15 (3) 175–211	149±12 (3) 136–164
12		Darkhan–Uul	–	168±13 (9) 150–186	216±9 (6) 207–225	168±8 (6) 156–176
13		Bulgan	–	–	–	194±10 (3) 183–204
Mean**			174±24			
14	III Provinces with light Se deficiency	Arkhangai	249±46 (6) 181–296	99±5 (6) 94–104	178±12 (3) 167–190	170±16 (3) 150–190
15		Khovd	245±52 (6) 193–296	–	273±23 (3) 250–296	–
16		Govi–Altai	236±10 (3) 227–246	–	446±27 (3) 418–470	–
17		Khenti	229±18 (3) 211–247	–	–	–
Mean**			234±85			
Concentration range			123–249	99–168	134–446	135–194

*N – number on the map (Fig. 1); ** – Statistical significance between groups: (II – III) – $p < 0.01$; (I – III) and (II – I) – $p < 0.001$.

Se concentration was determined fluorimetrically (Alfthan, 1984). The accuracy of the method was assessed using certified reference materials: lyophilized muscles (Agricultural Centre of Finland, Se content 394 µg/kg,), lyophilized chicken liver (no 32/EKT; National Public Health Institute, Helsinki, Se concentration 2766 µg/kg) and hair (GBW09101b; China, reference value 590 µg/kg).

Statistical analysis was achieved using the Student criteria.

RESULTS AND DISCUSSION

Se content in meat of domestic animals is known to vary in a very broad range from tens to hundreds of µg Se /kg depending on feed characteristics and geographical origin (Pilarczyk et al, 2012). Data presented in Table 1 and Fig. 2 indicate Se concentration range 99–249 µg/kg of dry weight for 17 Mongolian provinces. About 46% of all meat samples investigated are characterized by Se levels of 140–180 µg/kg d.w. (Fig. 2), while more than 25% of registered parameters happen to be lower than 140 µg/kg. Significantly higher values are registered in other countries. Thus beef of Australia contains 257–432 µg Se /kg d.w. (McNaughton, Marks, 2002), Poland – 107-310 µg/kg d.w. (Pilarczyk et al, 2010), Ireland – 218-375 µg/kg d.w. (Murphy, Cashman, 2001), the Urals regions of Russia – 270-511 µg/kg d.w. (Golubkina, Papazyan, 2006), Island – 50–343 µg/kg d.w. (Reykdal et al, 2011). And only in New Zealand and Chinese provinces with deep Se deficiency the values are lower and often do not exceed 35-70 µg/kg (the data of (Combs, Combs, 1986) is calculated per dry weight). The demonstrated parameters for meat of Mongolia bear evidence of serious problems connected with Se deficiency in the objects of the environment of the country. The results seem to be the first concrete characteristics of environmental Se status in Mongolia.

Geographical situation is known to greatly affect Se concentrations in plants and animals (Finley, Penlandl, 1996; Hoffman et al, 1972). Values of Se accumulation in muscle tissues of domestic animals in Mongolia allow define three regions of significant (I), moderate (II) and light (III) deficiency. The first group of significant Se deficiency combines the Northern provinces (Uvs, Bayan-Ulgii, Khuvsgu, Selenge) and the Eastern part of the country (Sukhbaatar, Dornod, Dornogovi), where mean Se concentration in meat is equal to 139 µg/kg.

Exactly in the Northern regions Se deficient diseases in domestic animals have been registered in the 70th of the 20th century (Ermakov, Kovalsky, 1974). This area neighbours Se deficient territories of Russia: Mountainous Altay (Golubkina, Maimanova, 2006), Buryatia, Amur, Irkutsk (Golubkina, Papazyan, 2006) and Chita regions (Aro et al, 1994). Data of Table 2 show that meat Se levels of these Mongolian provinces are close to the appropriate parameters demonstrated for Chita region (Table 2).

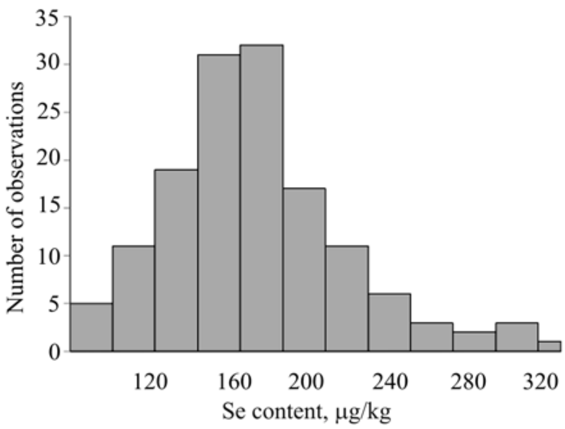

Fig. 2. *Histogram of Se content in meat from Mongolia*

Table 2. ***Se content in livestock meat from neighboring to Mongolia regions (µg/kg dry weight)***

Meat	Region	M±SD	Concentration range	References
Lumb	Mountainous Altay	172±59	87–339	Golubkina, Maimanova, 2006
Goat-flesh		272±3	269–275	
Horse-flesh		241±50	183–317	
Beef	Mountainous Altay	210±52	96-319	
	China* (n = 8)	330±128	183–511	The present investigation
	China **		10–30	Combs, Combs, 1986
	China ***		50–250	
	Buryatia****	98 ±36	49–144	Golubkina, Papazyan, 2006
	Irkutsk region****	132±33	98–165	Golubkina et al, 1998
	Chita region	123±95	32–218	Aro et al,1994

*– imported to Mongolia; ** – endemic regions of Se deficiency (Keshan disease); *** – moderate Se deficiency; **), ***) and ****) – the values are given per kg of fresh weight.

Locations of provinces with light Se deficiency (mean Se concetrations 234 µg/kg d.w.) are more mosaic, though an area in the South-West of the country (Khovd, Govi-Altay) seems to be a continuation of Chinese provinces of light Se deficiency (Oldfield, 1999). In fact Se concentrations in beef imported from China are close to the above mentioned values (183–511 µg/kg d.w). Relatively high Se level has been detected in horse-flash of Govi-Altay province (446 µg/kg d.w). Nevertheless, one should take into account that among other domestic animals horses occupy only 8% (Reading et al, 2004) that restricts a positive effect of favorably elevated Se content in horse-flash on the human Se status in Mongolia.

Calculated Se daily intake with meat by Mongolian residents is close to 8.7–14 µg/day in the first group of provinces, that corresponds to 15.8–25.5% of the recommended daily intake. Se consumption levels in other provinces are lightly better but do not exceed 17 µg/day (or about 31% of the recommended value) even in the third group of provinces. In European countries Se consumption with meat is significantly higher: 20–45 µg/day, providing from 36 to 82% of the recommended Se intake level (Pilarczyk et al, 2012). Nevertheless, in Europe a significant part of Se intake by the population composes Se of cereals, whereas in Mongolia this food source of the element is practically excluded due to high meat consumption. The results are in good agreement with low serum Se levels of Mongolian children (Lander et al, 2008) and high oxidative stress (Komatsu et al, 2008, 2011) registered earlier. Low Se concentrations in hair of Ulaanbaatar residents demonstrated in this work (Fig. 4) compose an additional prove of Se deficiency. Indeed mean hair Se level is equal to 193±19 µg/kg that is even lower than the appropriate parameter found in the Amur region of Russia (231±74 µg/kg) (Golubkina, Papazyan, 2006). Narrow concentration range demonstrated in Mongolia compared to the Amur region of Russia (170–299 µg/kg and 83-481 µg/kg respectively) indicates more limited sources of Se to the population of Mongolia.

Se deprivation is dangerous both for human beings and domestic animals. Muscular dystrophy, low immunity, degeneration of liver and reproductive disorders are typical concequences of Se deficiency in livestock (Combs, Combs, 1986). It is known that in conditions of Se deficiency the element accumulates predominantly in vitally important organs: brain, endocryne glands and reproductive organs – with the appropriate decrease of Se concentration in muscles and liver (Behne et al, 1995). We have shown that Se deficiency in domestic animals of Mongolia is acompanied also by a significant increase in lung/muscles Se ratio – the phenomenon clearly seen from a comparison with Moscow region data (Fig. 3). The intensity of oxidation processes in lung seems to be a reason of elevated levels of natural antioxiant Se – the phenomenon most pronounced in conditions of low Se content in the environment.

Another aspect of deficiency effect on the Se status parameters may include changes in watersoluble Se forms concentration of animal muscles due to the fact that such compounds are known to exibit the highest biological activity in living beings (Golubkina, Papazyan, 2006). We have shown that the share of watersoluble forms of the element in muscles does not differ between cattle, lambs, horses and goats of Mongolia and is equal to 50,5–52,8% (the differences being statistically insignificant, $p > 0.5$). Furthermore the demonstrated values do not differ with those for meat of domestic animals for other regions: 51.8±1.0% in Moscow region with light Se deficiency (Garanina, 2003) and 50.9±0.9% in Moldova republic with high Se status of the environment (Kapitalchuck et al, 2011). Thus, different biogeochemical conditions seem not to affect the percentage of water soluble forms of Se in muscles of domestic animals.

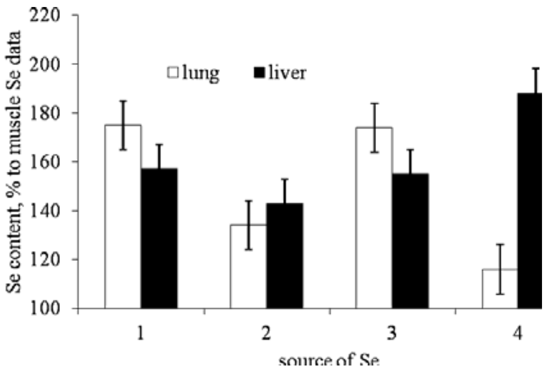

Fig. 3. *Se content in lung and liver of 1) horse, 2) lumb, and 3) cattle in Mongolia compared to 4) cattle of Moscow region, Russia (Golubkina, Papazyan, 2006)*

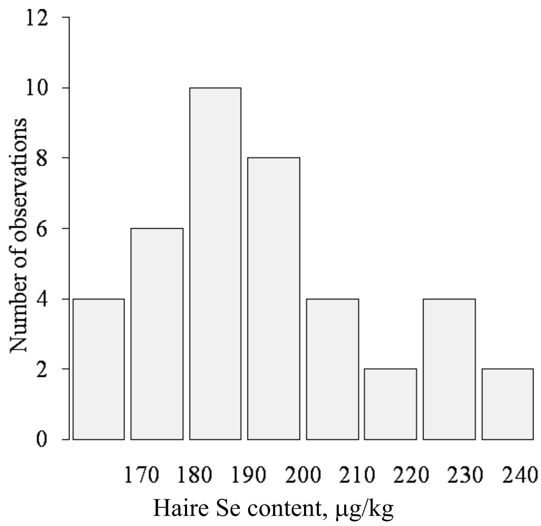

Fig. 4. *Histogram of hair Se content of Ulaanbaatar residents*

CONCLUSIONS

Results of this small monitoring reveal serious problems of Se deficiency in Mongolia. More detailed monitoring of Se accumulation in meat of domestic animals in Mongolia is necessary to obtain a full picture of Se geographical distribution. Combined with epidemiological investigations, such data will allow not only to establish territories of ecological risk connected with Se deficiency, but also to achieve scientifically based correction of the Se status both for livestock and residents of the country. Such investigations may become the basis in improving livestock productivity and human health.

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