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Health Risk Connected With the Low Selenium Levels in Foodstuffs of Mongolia

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Abstract

The objective of this study was to evaluate health risks connected with the selenium level in foodstuffs of Mongolia. Meat of domestic animals from 17 provinces of Mongolia (n=142), wheat (n=30), garlic, eggs, blood serum samples from the Dornogovi province of Mongolia (n=40) were obtained to determine the selenium level by fluorimetric method. The Se levels were 105-346 (173±42) µg/kg d.w. in meat of domestic animals, 6-34 (18±10) µg/kg in wheat, 68±2 µg/kg in garlic and 13.14±0.54 µg/100 g in eggs. Contrary to areas of marginal Se deficiency (Moscow region) Mongolia was characterized by elevated Se levels in lung of domestic animals compared to liver concentrations of the element. Calculated Se intake with meat by residents of Mongolia varied from 8.7 to 17 µg/person/day. High concentrations of Cd, Pb and Ni in wheat of Selenge, Tuv and Dornod provinces accordingly, Al in Selenge grain and Ni and Pb in spring garlic of Zavkhan province presented additional health risks for the population. The mean serum Se level of the Dornogovi population was 71±5.7 µg/l, indicating a lower level of glutathione peroxidase activity. The study revealed that the most pronounced Se deficiency in foodstuffs of Mongolia was typical for the Northern and Eastern provinces of the country. Development of effective program of the Se status optimization in Mongolia should become one of the most important health care intervention priority so as to reduce the ecological risk arising from Se deficiency in Mongolia.

Keywords: Mongolia, selenium, meat, wheat, eggs, heavy metals

1. Introduction

Last decades are characterized by an increased interest in environmental distribution of Se because it is directly connected with the wide spectrum of biological activity of the element (Oldfield, 1999). Being strong natural antioxidants, Se-containing proteins demonstrate many properties vitally important to human beings. Se is located in the active site of triiodithyronine deiodinases, participating in thyroid hormone metabolism and affecting the iodine status of the population (Arnaud, Malvy, Richard, Faure, & Chaventre, 2001). Beside triiodithyronine deiodinases, many other Se-proteins determine the biological activity of the element. They are Se-dependant glutathione peroxidases, thioredoxin reductases and other Se-proteins of different location (SelW, SelT, Sel M, Sel P, etc) (Gladishev & Hatfield, 1999). Thus adequate Se consumption is known to decrease the risk of cardiovascular diseases and cancer, optimizes reproductive function and brain activity, prevent the teratogenic effects exerted by heavy metals (Fairweather-Tait et al., 2011). Adequate Se consumption improves immunity affecting both cell-mediated and humoral components of the immune response (Arthur, McKenzie, & Beckett, 2003) and protecting the organism against viral diseases. Se is supposed to improve human longevity (Fairweather-Tait et al., 2011; Gavrilov & Gavrilova, 1991

Geographical situation is known to strongly affect the content of trace elements in animals and human beings (Finley & Penland, 1998; Hoffman, Jenkins, Meranger, & Pigden, 1973). Such an effect is especially significant in regions with intensively developed agriculture and predominant utilization of the foodstuffs of native origin. Specific Se-deficiency diseases (white muscle disease in animals, endemic cardiomyopathy and osteoarthropathy in human beings) are registered in regions with low soil Se content in separate provinces of China, Chita region of

Russia, New Zealand and others (Golubkina & Papazyan, 2006). Geographical distribution of Se levels in the environment are published (Oldfield, 1999). But little is known about ecological risks of Se deficiency in Mongolia. Thus at the beginning of the 70th of the 20th century Se deficiency diseases of domestic animals have been described in the North of Mongolia (Sodnomdargaa, 1967). In 2008 decreased levels of serum Se have been indicated in children of Ulaanbaatar (Lander et al., 2008). And preliminary results devoted to the significance of meat Se levels in Mongolia have been published in 2013 (Golubkina & Monhoo, 2013). Indirect factors of Se-deficiency risks in the country include unfavorable geographical situation, characterized by the neighborhood of endemic Chinese provinces with severe Se deficiency in the East and Se deficient regions of Russia in the North (Amur region, Buryatia, Chita region).

The aim of the present study was evaluation of ecological risks connected with the Se deficiency in Mongolia.

2. Materials and Methods

142 Samples of carcass muscles of beef, sheep, goats and horses from 17 provinces of Mongolia were gathered in autumn 2012. 30 Samples of wheat (harvest of 2013) from the main grain producing provinces (Dornod, Uvs, Tuv и Selenge) were used in the investigation. Places of sampling points are shown in Figure 1.

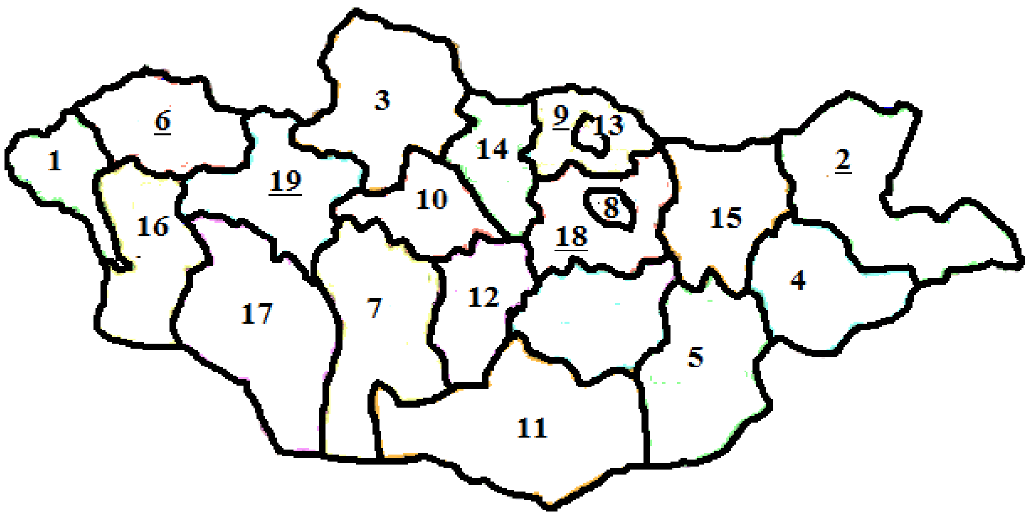

Figure 1. Provinces where samples were gathered: 1) Bayan-Ulgii, 2) Dornod, 3) Khuvsgul, 4) Sukhbaatar, 5) Dornogovi, 6) Uvs, 7) Bayankhongor, 8) Ulaanbaatar, 9) Selenge 10) Arkhangai, 11) Umnu-Govi, 12) Uvurkhangai 13) Darkhan, 14) Bulgan, 15) Khenty, 16) Khovd, 17) Govi-Altai, 18) Tuv, 19) Zavkhan. Underlies numbers indicate provinces of wheat production

To evaluate peculiarities of Se distribution between organs and tissues of domestic animals additional samples of livestock liver, lung and muscles were obtained in the markets of Ulaanbaatar. Samples of meat, liver and lung were preliminary lyophilized; grain was dried at 70 °C to constant weight. The resulting probes of meat and wheat were homogenized and kept at room temperature in polyethylene containers till the beginning of the analysis.

Evaluation of the poultry Se status was achieved by estimation of the Se content in eggs produced by two battery farms situated in the vicinity of Ulaanbaatar (n=20). Eggs imported from Irkutsk region of Russia were taken as control (n=20).

To reveal peculiarities of grain elemental composition, analysis of 24 elements (Al, As, B, Ca, Cd, Co, Cr, Cu, Fe, Hg, I, K, Li, Mg, Mn, Na, Ni, P, Pb, Si, Sn, Sr, V, Zn) in 5 different varieties of Mongolian wheat (Khalhin-gol, Darkhan 34, Selenge, Albidum и Altaiskaya 100) was achieved. Besides this the content of 24 elements was determined in three samples of spring garlic from Zavkhan province (№19 on Figure 1) using ICP-MS and ICP-AES approach.

The human Se status was determined by analyzing the Se content in serum of residents from two settlements of Dornogovi province (n=40, Ulaanbadrakh town and Sainshand settlement). Mean age of persons was 32±6 for the inhabitants of Dornogovi province. Se content in all samples investigated was determined in three replicates fluorimetrically (Alfthan, 1984) using wet digestion of samples with a mixture of nitric and chloric acids, reduction of Se+6 to Se+4 by hydrochloric acid treatment and formation of a fluorescent complex between selenic acid and 2,3-diaminonaphtalene. 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), wheat flour (Agricultural Center of Finland, Se content 57 µg/kg). egg powder (Institute of nutrition, Moscow, Se content 630 µg/kg) and lyophilized serum (Clin. Check, Chemicals and instruments GmbH, Germany, №8880, Se content 83.3 µg/l).

Statistical analysis was achieved using the Student criteria.

3. Results

Taking into account that Se levels are similar for beef, sheep, goat and horse flash in Mongolia (Golubkina & Monhoo, 2013), the results presented in Table 1 demonstrate mean values of meat Se concentrations for each province investigated, the concentration range being 105-346 µg/kg.

Table 1. Se content in meat of domestic animals (µg/kg d. w.)

№	Province	N	M±SD	Concentration range
1	Bayan-Ulgii	3	105±10	94-116
2	Dornod	3	123±6	118-129
3	Khuvsgul	12	131±16	109-155
4	Sukhbaatar	27	141±13	124-180
5	Dornogovi	3	150±30	120-180
6	Uvs	3	154±7	145-166
7	Bayankhongor	9	156±31	115-213
8	Ulaanbaatar	12	161±22	115-211
9	Selenge	3	163±23	140-189
10	Arkhangai	18	174±40	94-296
11	Umnu-Govi	6	183±21	158-210
12	Uvurkhangai	6	183±38	140-242
13	Darkhan	21	184±23	150-225
14	Bulgan	3	194±10	183-204
15	Khenti	3	229±18	211-247
16	Khovd	9	259±14	193-296
17	Govi-Altai	6	346±110	227-470
	Mean		178±57	

*Number on the map (Figure 1).

The lowest Se values are revealed for meat of Dornod and Bayan-Ulgii provinces (94-129 µg/kg d.w; № 1,2, Figure 1), the highest- for meat of Arkhangai, Khovd, Govi-Altai and Khenti provinces (193-470 µg/kg d.w ; №15-17, Figure 1).

The Se content in 5 varieties of native wheat (Altaiskaya 100, Khalhin-gol, Darkhan 34, Albidum and Selenge) and mixed probes of retail grain composes concentration range of 6 - 34 µg/kg (Table 2). Se levels close to 7-8 µg/kg are registered in wheat grown in Selenge, Dornod and Uvs provinces (№2, 6, 9; Figure 1).

Table 2. Se content in wheat of Mongolia (μg/kg d. w.)

Province (a)	Location	Wheat variety	M±SD	Concentration range
Selenge (9)	Khongor	Selenge	8±1	7-9
Tuv (18)	Gargalant	Altaiskaya 100	12±3	9-15
	Sant (Erdene-sant)	Retail	16±2	12-18
	Bornuur	Altaiskaya 100	12±1	10-14
Dornod (2)	Choibalsan	Khalhin-gol	7±1	6-8
	Khalkingol	Retail	28±1	27-29
Uvs (6)	Zuunturuun	Darkhan 34	26±2	24-28
		Albidum	7±1	6-8
	Baruunturuun	Retail	32±2	28-34
	Ulaankhotgor 36	Retail	29±1	28-31
	Mean		18±10	

(a) number on the map (Figure 1).

Elemental analysis of 5 wheat varieties (Table 3) indicates significant variations in the content of Al (18.6-79.2 mg/kg), Ca (465-833 mg/kg), Cd (0.03-1.61 mg/kg), Fe (44.8-71.3 mg/kg), Mn (38.59-54.19 mg/kg), Ni (0.36-7.32 mg/kg), Pb (0.98-0.20 mg/kg), Sn (0.008-0.02 mg/kg), Sr (4.01-6.60 mg/kg), and Zn (23.4-43.1 mg/kg). Extremely high Cd concentration are registered in Selenge wheat (1.61 mg/kg), Ni - in grain of Dornod province (7.32 mg/kg) and Pb in wheat grown in Tuv province (0.2 mg/kg; Table 3). Among two wheat varieties Darkhan 34 and Albidum, grown in Uvs province, the first one is characterized by significantly higher levels of Se, Ca, Cu, Fe, Mn, Si and Zn.

Table 3. Elemental composition of Mongolian wheat varieties (mg/kg)

Element	Tuv (Bornuur)	Dornod (Choibalsan)	Uvs (Zuunturuum)		Selenge (Khongor)
	Altayskaya 100	Khalhin-gol	Darkhan 34	Albidum	Selenge
Al	31.6±3.2	26.3±2.6	27.1±2.7	18.6±1.9	79.2±7.9
As	0.030±0.005	0.030±0.005	0.020±0.002	0.010±0.002	0.020±0.003
B	1.03±0.1	1.23±0.12	1.38±0.14	1.02±0.1	0.86±0.103
Ca	465±47	536±54	833±83	643±64	493±49
Cd	0.03±0.005	0.03±0.004	0.02±0.003	0.02±0.004	1.61±0.16
Co	0.050±0.007	0.020±0.003	0.030±0.004	0.020±0.003	0.030±0.004
Cr	0.150±0.018	0.120±0.015	0.110±0.013	0.190±0.023	0.150±0.019
Cu	5.6±0.6	6.7±0.7	6.8±0.7	4.8±0.5	5.0±0.5
Fe	64.5±6.5	44.8±4.5	71.3±7.1	48.7±4.9	58.7±5.9
Hg	0.004±0.0008	0.003±0.0006	0.004±0.0007	0.003±0.0006	0.004±0.0008
I	0.050±0.008	0.040±0.006	0.030±0.005	0.020±0.002	0.020±0.002
K	4206±421	4637±464	4767±477	4037±404	3768±377
Li	0.050±0.007	0.040±0.006	0.050±0.007	0.040±0.006	0.040±0.007
Mg	1291±129	1257±126	1376±138	1371±137	1314±131
Mn	41.93±4.19	33.74±3.37	54.19±5.42	38.59±3.86	40.96±4.1
Na	18.4±1.9	16.0±1.6	24.4±2.4	14.8±1.5	25.3±2.5
Ni	0.750±-0.090	7.320±0.730	0.450±0.054	0.390±0.047	0.360±0.043
P	3613±361	3454±345	3888±389	3231±323	3646±365
Pb	0.2±0.024	0.12±0.014	0.1±0.015	0.09±0.014	0.08±0.012
Si	20.56±2.06	21.71±2.17	25.14±2.51	18.12±1.81	16.42±1.64
Sn	0.02±0.002	0.008±0.0016	0.02±0.003	0.02±0.003	0.01±0.002
Sr	4.01±0.4	4.22±0.42	5.54±0.55	5.29±0.53	6.6±0.66
V	0.11±00.014	0.060±0.010	0.080±0.012	0.050±0.007	0.090±0.014
Zn	23.4±2.3	31.4±3.1	43.1±4.3	31.6±3.2	27.7±2.8

Samples of spring garlic grown in Zavkhan province accumulate about 68±2 μg Se/kg w.w. The samples are characterized by high concentrations of Pb (0.63±0.08 μg/kg) and Ni (1.390±0.140 μg/kg).

Mean Se level in eggs of Mongolia is equal to 13.14±0.54 μg/100 g and is close to the values typical for eggs imported from Irkutsk region of Russia (Figure 2).

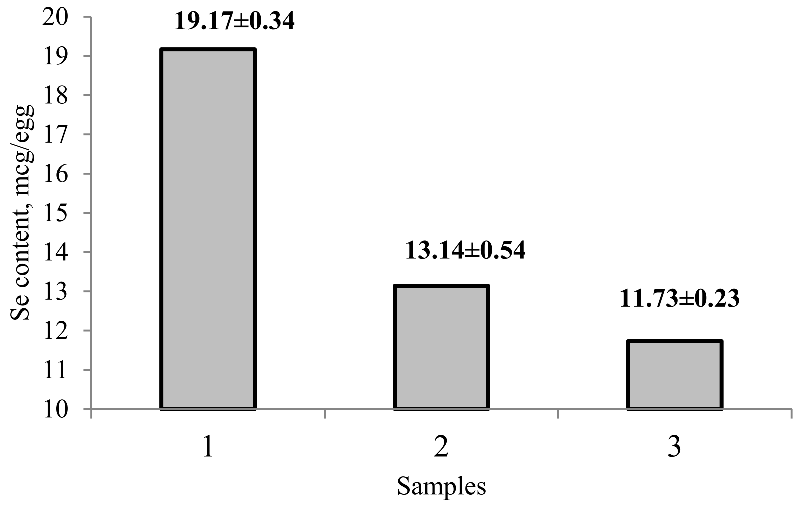

Figure 2. Se content in eggs produced in: 1) Moscow region (Russia), 2) battery farms of Ulaanbaatar suburb, 3) Irkutsk region (Russia). P<0,001 for (1) - (2) and (1)-(3) pairs and for (2)-(3) pair P<0.02

Serum Se levels of Dornogovi province residents vary from 50 to 81 μg/l with mean value equal to 71 μg/l (Table 4 and Figure 3).

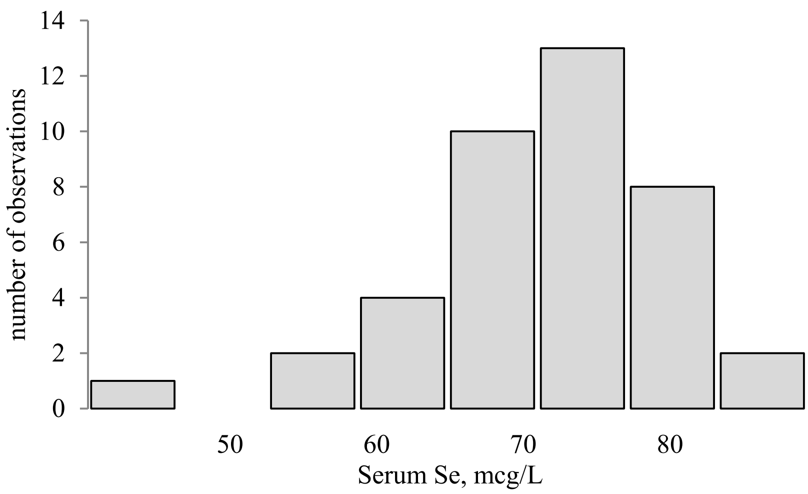

Figure 3. Histogram of serum Se content in residents of Dornogovi province

Table 4. Se content in human serum (μg/l)

Region	Location	N	M±SD	Concentration range
Dornogovi province, Mongolia	Ulaanbadrakh town	20	72.3±4.6*	57-81
	Sainshand cettlement	20	69.9±5.8*	50-81
Neighboring to Mongolia regions of Russia**	Amur region	23	72,1±21.0	39-119
	Buryatia	41	85,0±7,1	79-92

*the difference is not significant, P>0.1 ** Golubkina&Papazyan, 2006.

4. Discussion

4.1 Meat

Cereals and meat are considered to be the main Se sources for the population of most countries of the world (Navaro-Alarcon & Cabrera-Vique, 2008). These foodstuffs are known to contain highly bioavailable Se compounds: selenomethionine and selenocystein in meat (Pilarczyk et al., 2012) and selenomethionine in cereals (Golubkina & Papazyan, 2006). Lack of meat and cereals import in Mongolia determines the predominant influence of the biogeochemical peculiarities of the environment on the Se accumulation levels. Meat products are of special importance as among different countries of the world Mongolia ranks one of the leading places in meat consumption value per person due to centuries-old tradition of pasture livestock.

Despite rather small sampling and a certain variability of the data for Arkhangai province, the results presented in Table 1 indicate the predominance of low meat Se concentrations reaching 94-116 µg/kg in Bayan-Ulgii and 118-129 µg/kg in Dornod province (№1,2; Figure 1). Registered values of Se concentration in meat of these provinces do not differ from that of neighbouring Se deficient regions: Amur, Irkutsk, Chita regions of Russia and Buryatia (Table 5) and are only slightly higher than that of the North-East of China (Li et al., 2014).

Table 5. Se content in meat of domestic animals from neighboring to Mongolia regions (µg/kg d.w.)

Region	M±SD	Concentration range	References
Mountainous Altay	224±48	172-272	Golubkina a& Maimanova, 2006
Irkutsk region	132±33	98-165	Golubkina et al., 1998
Chita region	123±95	32-218	Aro, Alftha&Varo,1994
Buryatia	98 ±36	49-144	Golubkina & Papazyan, 2006
Amur region	97±10	84-108	Golubkina & Papazyan, 2006
China	-	78-111	Li, Banuelos, Wu & Shi, 2014

Among 17 provinces investigated only three (Khenti, Khovd and Govi-Altai; № 15-17, Figure 1) may be considered as territories with marginal Se deficiency where meat Se levels exceeds 200 µg Se/kg. The values registered here are close to that found for Mountainous Altai of Russia (Table 5). Thus according to these data only 6% of the territory of Mongolia are within the marginal Se deficiency while the other 94% corresponds to severe Se deficiency areas.

It should be especially emphasized that exactly in the Northern provinces of Mongolia white muscle disease in livestock have been registered in the 70th of the 20th century (Sodnomdagaa, 1967).

Among European countries the closest to Mongolian data meat Se content is typical to Poland - 107-310 µg/kg d.w. (Pilarczyk et al., 2010). Livestock products of other countries contain more Se: 257-432 µg/kg d.w. in Australia (McNaughton & Marks, 2002), 218-375 µg/kg d.w. in Ireland (Murphy & Cashman, 2000), 270-511 µg/kg d.w. in the Urals regions of Russia (Golubkina & Papazyan, 2006) and 50-343 µg/kg d.w. in Island (Reykdal, Rabich, Steingrimsdottir, & Gunnlaugsdottir, 2011).

Taking into account that mean value of meat consumption by residents of Mongolia reaches about 300 g/person/day, the daily Se intake with meat products will be equal to 8.7 - 14 µg in regions of high Se deficiency risk (№1-2; Figure 1), that corresponds to 15.8-25.5% from the recommended daily Se intake. Se intake by the population of other provinces is a little bit higher, but does not exceed 17 µg/day (or about 31 % from the recommended daily intake value). Despite the fact that the population of Europe consumes significantly less amount of meat the latter provides higher intake levels of the element: 20-45 µg/person/day, or 36-82% from the recommended level (Table 6).

Table 6. The daily Se intake with meat by residents of Mongolia and several European countries (Pilarczyk et al., 2012)

Country	Daily Se intake with meat products, µg/person/day	% from the recommended intake	Total daily intake, µg Se
Mongolia (№1-2 provinces)	8,7-14	15.8-25.5	
Mongolia (№3-17 provinces)	14-17	25.5-31.0	
The Slovak republic	20	36	38
Poland	21	37	30-40
Belgum	27	49	28-61
Grece	28	51	39.3-110
Germany	30	55	35
Great Britain	32	58	63
Ireland	36	65	50
France	38	69	29-43
Finland	45	82	100-110

Se Deficiency is dangerous both for human beings and animals. Muscle distrophy, low immunity, liver degradation and disturbances in reproducrion are typical problems of Se deficiency in livestock (Combs & Combs, 1986). In conditions of Se deficiency the element is known to accumulate predomunanty in vitally important organs: brain, endocrine glands and reproductive organs, that is accompanied by appropriate decrease of Se concentration in muscle tissue and liver (Behne et al., 1995). Analogous changes in Se metabolism have been registered by us in domestic animals of Mongolia. At the same time we have found out that Se deficiency in animals of Mongolia is characterized by a significant increase of Se lung/musles ratio – the phenomenon absent in regions with marginal Se deficiency of Moscow region (Figure 4).

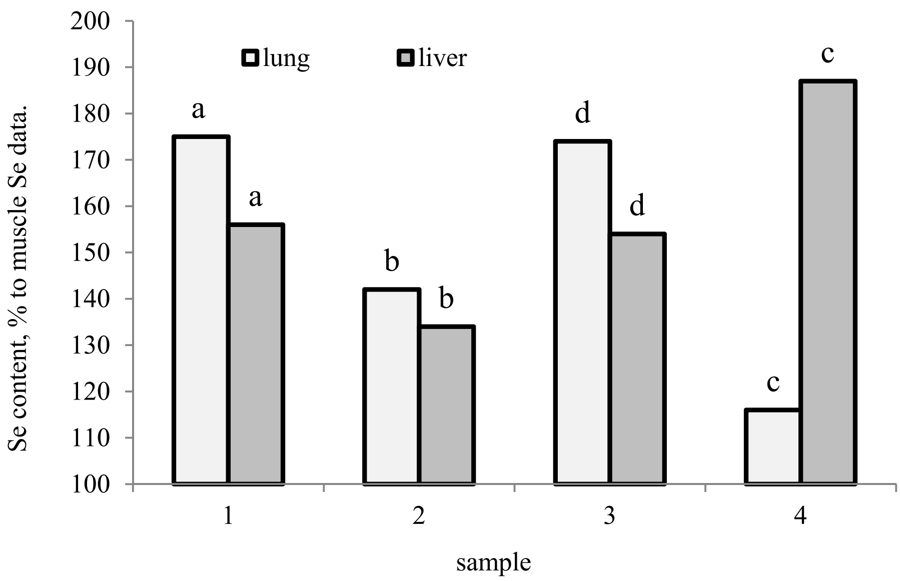

Figure 4. Se content in lung and liver of 1) horse, 2) sheep, and 3) cattle in Mongolia compared to 4) cattle of Moscow region, Russia (Golubkina&Papazyan, 2006). For (a) and (d) P<0.002; for (c) p<0.001;for (b) P<0.01

The necessity of strong antioxidant protection in lung of Se deficient animals seems to be the reason of detected elevated lung Se levels.

At the same time it should be noted that the content of the most biologically active water soluble Se compounds in muscle tissue seem to be constant for beef, mutton, horse and goat flash of Mongolia 50,5-52,8%. The same values have been registered for appropriate meat of Moscow region with marginal Se deficiency (51.8±1.0%) and for meat of Moldova republic (50.9±0.9%) (Kapitalchuk, Kapitalchuk, & Golubkina, 2011) (Differences are not statistically significant, P>0.5).

4.2 Wheat and Garlic

Low consumption level of wheat by the population of Mongolia compared to meat products makes Se levels in grain less significant for the human Se intake. Nevertheless lack of wheat import to Mongolia may lead to significant health risks connected with Se deficiency. About 85% of wheat in Mongolia is grown in the Central provinces of Tuv and Selenge (№18 and 9; Figure 1), other 15% are produced in Uvs and Dornod provinces, situated in the North-West and North-East of the country accordingly (№6 and 2; Figure 1). As can be seen from Tables 1 and 2 both meat and wheat Se concentrations data allow attribute these provinces to the territory of severe Se deficiency. Indeed, a typical Se concentration range for wheat of Mongolia is only 6-34 µg/kg (Table 2). Comparable values have been registered earlier for wheat of Se-deficient Chita region of Russia (Aro et al., 1994) and for rice of Se-deficient China (Li et al., 2014).

Revealed differences in Se accumulation by two wheat varieties of Uvs province (Darkhan 34 and Albidum, Table 2) are rather small to be able to improve Se consumption level of the population. Besides this studies in Australia have shown that registered differences in Se accumulation by wheat varieties are connected not so much with genotypic differences but with variations in the content of bioavailable soil Se (Lyons, Ortiz-Monasterio, Stangoulis, & Hraham, 2005). Up to the present time no data of Se distribution and Se availability in soil of Mongolia have been received.

Determination of the elemental composition of Mongolian wheat (Table 3) allows indicate other ecological risks associated with the pollution of the territory by heavy metals and Al. Thus Ni concentration in wheat of Dornod province exceeds 14 times the maximally permissible level, and 16 times excess of Cd is demonstrated for wheat of Selenge province. Zn concentration in wheat of Uvs province is found to be close to the maximum permissible level (43 mg/kg compared to 50 mg/kg). High concentrations of Al in wheat of Selenge province suppose enhanced risks of neurological diseases among the population (Komatsu et al., 2011).

Zavkhan province situated in the North of Mongolia neighbors Uvs and Khuvshel Se-deficient provinces. Ni and Pb content in springs garlic grown in Zavkhan province exceeds the maximum permissible levels 2.8 and 1.2 times accordingly. Being a natural accumulator of Se, garlic of Zavkhan province accumulates only 68 µg Se/kg f.w. – the value that is more than two times lower than the appropriate values typical for garlic of Moscow region in Russia (Golubkina & Papazyan, 2006).

High concentrations of heavy metals reflect negative effect of the booming mining industry development in Mongolia. The situation is redoubled by the fact that heavy metals are well known Se antagonists (Gajewska et al., 2014; Golubkina & Papazyan, 2006) and, as a result, they decrease the accumulation intensity of Se by plants and assimilation of Se by animals and human beings. Cd, Pb and Ni excess in food is known to stimulate lung cancer development (Aquino, Sevigny, Sabangan, & Louie, 2012). In this connection one should indicate high levels of mortality from lung cancer among the population of Tuv, Dornod, Selenge and Zavkhan provinces, characterized by the excess of Cd and Ni and low Se levels in plants. Apparently regions of mining operations in Mongolia need intensive monitoring of foodstuffs pollution by heavy metals and Se.

4.3 Eggs

In most of the countries of the world Se in poultry products are the least affected by biogeochemical characteristics of the territory. The reason lies in wide practice of Se-premixes utilization. Such a policy provides defense against exudative diathesis and pancreas cirrhosis (Golubkina & Papazyan, 2006). Sodium selenite is a traditional Se additive to poultry premixes. Mongolia imports poultry fodder from China. Se content in such feed is rather high and composes a concentration range: 221-305 µg/kg. That is why it is not surprising that extremely low Se levels in eggs of Mongolia have not been registered (Figure 3). Data, presented on Figure 3 indicate close relationship of eggs Se concentrations for Ulaanbaatar and Irkutsk region battery farms, which supposes similar Se concentrations in feed.

4.4 The Human Se Status

Large-scale epidemiological investigations in Mongolia are still waiting for their realization. Nevertheless calculations of Se consumption levels with meat and Se content in wheat and eggs indicate the existence of pronounced Se deficiency in the population of Mongolia. Rural and urban population investigation in Dornogov province, situated in the South-East of the country (№5; Figure 1) and characterized by lack of Se-deficient diseases in domestic animals reveals relatively low human Se status. Thus mean levels of Se in blood serum happen to be about 71 µg/l (Table 5, Figure 4) that corresponds to decreased activity of glutathione peroxidase in blood of residents (Rayman, 2009). Similar serum Se levels in Buryatia, Amur, Chita regions and Khabarovsk land (Aro et al., 1994; Golubkina & Alfthan, 1999; Golubkina@Papazyan, 2006) testify the indivisible genesis of Se deficient territory, embracing regions of the South-Eastern Russia, North-Eastern China and Mongolia. Epidemiological investigations held in different countries estimate significant correlation of the above serum Se levels with high human mortality, indicating 120-160 µg Se/l serum to be optimal concentration range necessary for protection of human organism against cancer (Bleys, Navas-Acien,&Guallar, 2008; Thomson, 2004; Hurst et al., 2010).

Hair Se content is considered to be a good indicator of the human Se status, possessing high correlations with Se concentration in serum and whole blood (Li et al., 2014). Investigation of hair Se content of Ulaanbaatar residents reflects low Se levels (Golubkina & Monhoo, 2013). Detected mean hair Se concentration (about 190 µg/kg) happens to be much lower than reported for residents of Amur region of Russia (231±74 µg/kg) (Golubkina & Papazyan, 2006). According to Chinese investigations such levels reflect severe Se deficiency among the population (Li et al., 2014). Narrow hair Se concentration range was observed in Mongolia compared to the Amur region of Russia (170-299 µg/kg and 83-481 µg/kg respectively) suggesting the availability of limited sources of Se to the population of Mongolia. One should pay attention to the fact that in Se-deficient Poland, possessing similar Se levels in livestock products with that of Mongolia (Pilarczyk et al., 2010), hair Se content of the residents is significantly higher than of Ulaanbaatar residents and is close to 300 µg/kg (Hać, Krechniak, & Szyszko, 2002). Such differences seem to be connected with larger assortment of the main food sources of Se in Poland compared to Mongolia.

Low levels of the human Se status may be associated with a significant oxidant stress and low longevity as shown in previous reports for residents of Mongolia (Komatsu et al., 2008, 2011). The low iodine status of Mongolia (Enhtuya, 2003) may be considered as an additional risk factor, capable to enhance Se deficiency, as Se and I metabolisms are known to be inseparably linked (Banuelos, Lin Zhu-Qing, & Yin Xuebin, 2014).

The most well known methods of Se deficiency liquidation in different countries of the world is utilization of Se-containing fertilizers (Aro et al., 1995), foliar application of Se salts, and/or utilization of Se-containing premixes in feed of domestic animals and poultry (Golubkina & Papazyan, 2006; Surai, 2006).

Though meat of Mongolia is the main Se source to its population, utilization of Se containing premixes are restricted owing to the existence of exclusively pasture livestock. Efficiency of sodium selenite utilization as an additive to salt used for grazing animals also seems to be of low efficiency due to low availability of inorganic Se salts to ruminants (Grela & Sembratowicz, 1997).

More effective may become production of functional food enriched with Se. In this respect the utilization of organic Se forms in poultry premixes are of great value. Many investigations in this field indicate high prospects of Se enriched yeast utilization, containing bioavailable selenomethionine (Surai, 2006). Practice of such premixes application may result in Se concentration increase up to one half of the recommended daily consumption level per egg.

Other functional food products may include Se-enriched garlic possessing large quantities of Se-methylselenocysteine, showing anticarcinogenic properties. A study from China reports that consumption of garlic rich in Se effectively protects the organism against breast cancer (Ip, Lisk, & Stoewsand, 1992).

Commercially cultivated Champignon and Shiitake mushrooms fortified with Se are known to contain protein-bound selenomethionine (Falandysz, 2008) that makes the products highly valuable among Se-rich functional food.

A significant improvement of the human Se status optimization in Mongolia may be achieved via utilization of Se containing fertilizers in wheat and other plant vegetation (Aro et al., 1995). Such a practice in condition of Se deficiency is known to improve harvest (Lyons, Stangoulis, & Graham, 2003). At the same time antagonism of Se with heavy metals can decrease accumulation of the latter by plants. In case of environmental pollution with Ni it will also improve Fe and Mg accumulation by plants (Gajewska et al., 2014).

5. Conclusions

The results of the present investigation indicate that the development of effective program of the Se status optimization in Mongolia should become one of the most important elements of development of economics and health care of the country. Such a policy will undoubtedly result in health improvement of the population, decrease of the oxidant stress and cancer levels, directly connected with low Se intake and high concentrations of heavy metals and Al in food products, and also will become the basis for improvement of livestock productivity and cereals production and a decrease of Cd, Ni and Pb content in plants. Taking into account strict relationship of Se and I metabolism, realization of such a program will also promote to a certain extent the decision of I deficiency problem in the country.

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