

INFLUENCE AND EVALUATION OF THE SEASON ON THE CONCENTRATION OF TRACE ELEMENT ZINC IN THE FOOD CHAIN OF SHEEP KEPT IN THE ENDEMIC MOUNTAIN REGIONS OF MIDDLE RHODOPE

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Abstract

The provision of livestock during the pasture period with minerals in the various mountain areas is closely linked to the detailed study of the role of all ecological factors affecting the transfer of essential components to the meadows vegetation. The reasons for certain deviations in the flow of zinc from the soil in the plant (pasture grass) and in the animal body are mainly due to the geological origin of the soil, its acidity, the effect of anthropogenic pollutants and microelement interactions. Each case of traceability of the zinc in the "soil-plant-animal" food chain is unique and should be investigated in the specific environment. The established heterogeneity of the pastures with regard to the transfer of trace elements Zn is a prerequisite for studying the changes in the mineral composition of the milk depending on the availability of the pasture vegetation. Important is the achievement of an optimal level of Zn, which is an integral part of the mineral premixes and influenced the micro nutrient composition of sheep's milk. The concentration of zinc in the milk decreased slightly with advance of lactation period. The high content of element correlate with the average levels of zinc in the plants during the grazing period. There are also data on the zinc intake and correlation with different dairy product. The Zn-consumption via milk and the different dairy product in the endemic region and the local produced dairy products varied between 3.52 – 3.57 mg/day. the women consumed on the average 11.7% more raw milk and 44% more yogurt in comparison to the men, but 21.4% less white brined cheese and 32.5% less yellow cheese than men.

Key words: zinc, food chain, ewe's milk, Middle Rhodope Mountain

Introduction

The extensive system in husbandry of small ruminants is associated with some nutrient imbalances that can occur due to irregular mineral supply from natural pastures. Great variations exist in trace element contents of meadow vegetation in depends on different factors: plant species, stage of maturity, season, chemical properties of soil (Kashamov et al., 2005). The low availability of Zn is typical for mountainous areas and corresponds to geological origin of pastures. The data published in the literature for the zinc content in the soil of Bulgaria show a large variations - from 2.5 mg/kg for soils of marble base to 120-160

mg/kg for delluvial gneiss and schist (Faytondzhev, 2000). The transfer of zinc from soil into plants is geologically determined. Independent on the relatively high concentrations in the soil, due to its poor mobility may lead to clear-driven deficits. The transport and balance of Zn in surface soils of different ecosystems shows that the atmospheric input of this metal exceeds its output due to both leaching and the production of biomass. Only in unpolluted forest region (Sweden) is the discharge of Zn by water flux reported to be higher than its atmospheric input. The total Zn contents in surface soils in different countries and U. S. range from 17 to 125 mg/kg. The data on Table 1 show that weathering soils of new red sandstone, clay, musselkalk and keuper weathering soils produce poor in Zn vegetation. Zinc deficiency lead to different form of diseases in plants animals and man (King and Cousins, 2014). Syenite and phyllite weathering soils provide the highest Zn transfer.

Table 1. Effect of geological origin of the site on the zinc content of the flora

geological origin	relative number
syenite weathering soils	100
phyllite weathering soils	92
granite weathering soils	85
weathering soils of the lower strata of new red sandstone	84
slate weathering soils (Silurian, Devonian, Culm)	82
moor, peat	82
diluvial sands	79
gneiss weathering soils	75
alluvial riverside soils	70
loess	62
boulder clay	61
weathering soils of new red sandstone	61
musselkalk weathering soils	59
keuper weathering soils	52

Plant uptake of trace elements is generally the first step of their entry into the agricultural food chain. Better understanding the processes of the soil/plant transfer is not only of great scientific significance but has a practical implication (Reimann et al., 2013). The plant species in the meadow grass are presented mainly with fescue and ryegrass, and the presence of typical areas only with *Nardus stricta*. The trace element zinc, despite the relatively low ratio transfer due to acidic pH, adequate concentrations are reached and thus ensuring the minimum needs of animal organism (30.0 mg Zn / kg).

Additional factors such as altitude and rainfall block the transfer or exhaustion. Various types of vegetation can also lead to significant changes in the intensity of growth (Broadley et al., 2007). To assess more accurately the distribution of zinc in different periods of development of the vegetation, an investigation of the dynamics of the Zn during the pasture period (May-July) is presented.

Taking into account that in Bulgaria sheep livestock contribute a considerable share of the milk and dairy product production the preliminary data indicating a real danger to agriculture production, as well as the above mentioned consideration defined the objectives of this study.

Material and methods

The subject of investigation was a region near Smilyan village in the Middle Rhodope Mountain. Average samples of pasture grass from 10 (5 + 5) standard plots (2x2 m) situated at two levels of altitude were collected in 2 replications. For assessment the effect of vegetation stage this procedure was performed once monthly during the grazing period (from May to July). In the experiment research on the dynamics of zinc in the raw milk and cheese was involved the most popular breeds in the investigated area - Karakachan sheep, Rhodope Zygay and Aborigen (Middle Rhodope breed). Data was compared with the typical Zn-content in cow's milk received in the area. Studied are derived from white brine cheese and yellow cheese produced in the region with a homemade recipe. The zinc content was determined using Varian FAAS and AGILENT ICP-MS analysis. All results were expressed as mean $\pm$ standard deviation and compared through standard t-test procedure.

Results and discussion

The soil samples from standard plots showed very low acidity - pH (4.27 ± 0.25), which adversely affect the biological assimilation of nitrogen (N), phosphorus (P) and potassium (K) in the food chain "soil-plant system". All pastures were extremely poor in nitrogen. The amount of absorbable forms of nitrogen - ammoniacal and nitrate in the soil was < 25 mg / kg. Considering that with levels of pH 4.0 – 4.5 development of nitrogen-fixing bacteria is greatly reduced, it was expected that in the acidic soil nitrogen content is substantially below the required good soil that the availability. Typical of the region botanical species and lack of basic and secondary macro and micro nutrients determined botanical diversity.

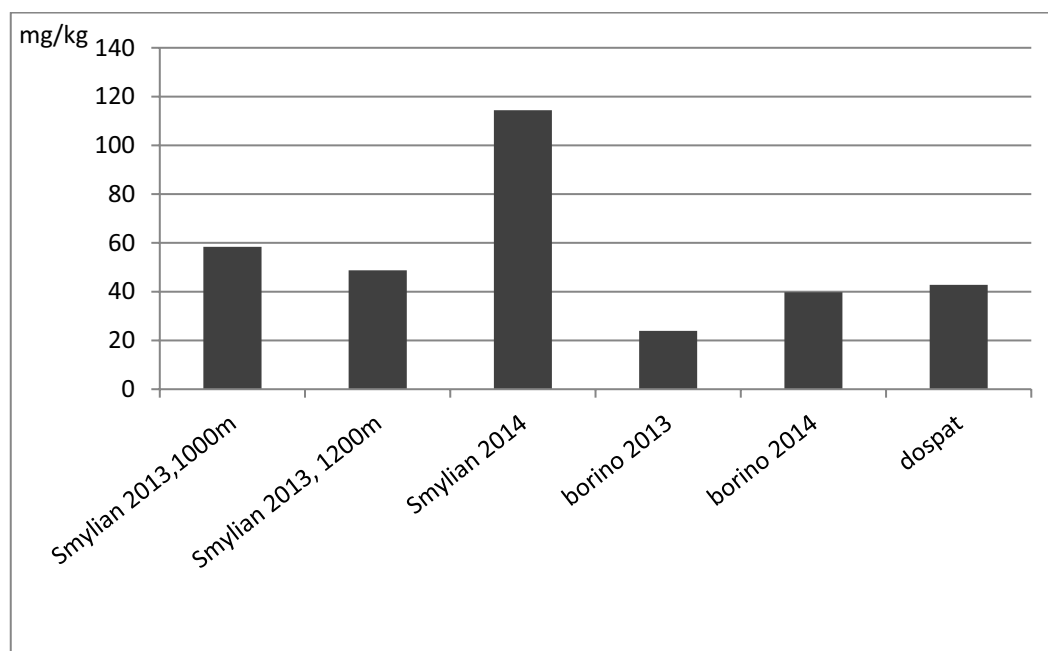


Figure 1. Zinc variation in concentrations from different regions in Rhodope Mountain

We observed medium to good zinc in the soil in sienite and gnies geological formations (average concentration of 74 mg/kg) and twice lower concentrations in regions with Andesite and Rhiolithic geological structures (average concentration 36 mg/kg).

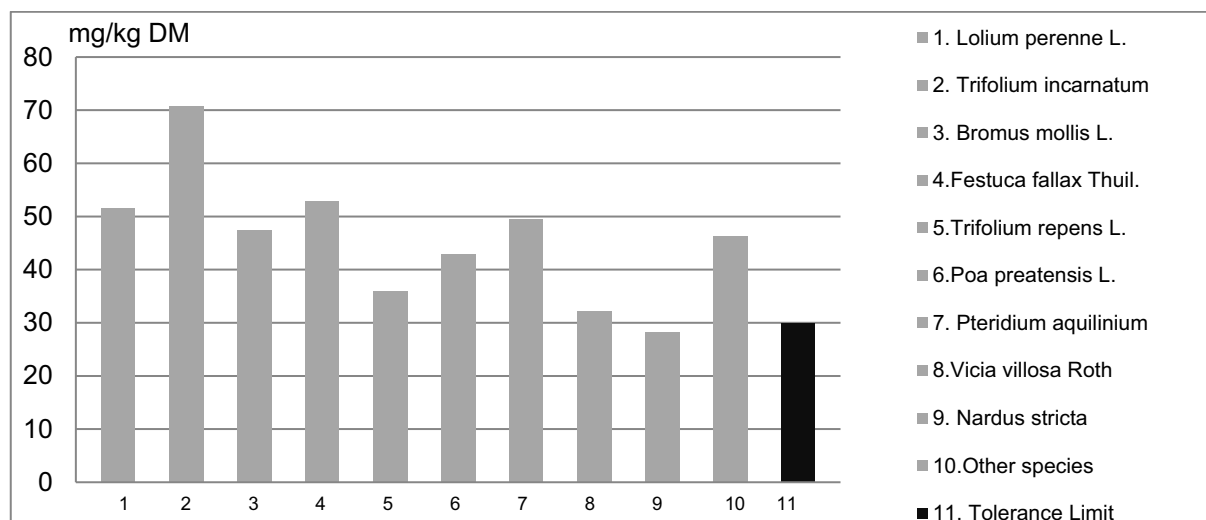


Figure 2. Zinc content in different plant species (mg/kg DM)

The samples of pasture grass were collected at two levels of altitude (800 and 1100 m) in 2 replications (Figure 2). The natural composition in this area consists mainly of cereals - 75%; legumes - 8% and different grass species 17% from witch *Nardus stricta* L reaches 13% , while in the cultivated pastures it's content is minimal / 1.4% /.

There is a pronounced deficit in all species close and below the critical 30 mg/kg DM (Figure 3). The study of meadow grass containing all typical of the region indicator plants shows that there is no species, which can compensate the low supply of zinc with except at an altitude of 1200 m, so that the average level of element is about 10-15% of the necessary needs of the animal organism.

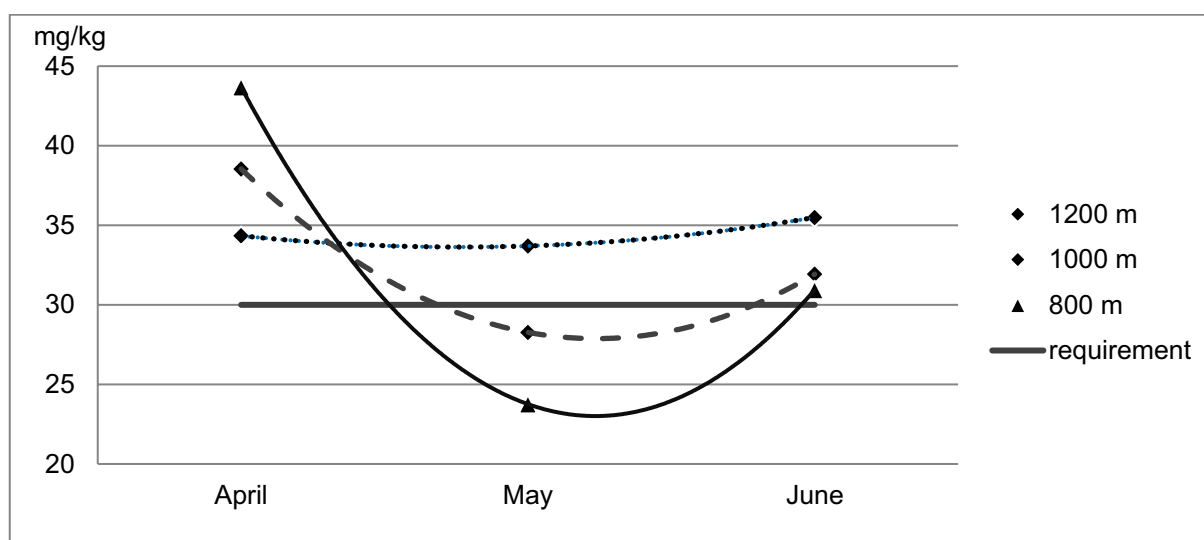


Figure 3. Seasonal dynamics of zinc in meadow grass depending on the altitude

Differences in zinc concentration in the course of vegetation are mainly due to changes in botanical composition and to the influence of geological origin of site at different altitudes. Changes in soil acidity depending on rainfall in different periods, as well as inter-element interactions, also affect the differences between May and July.

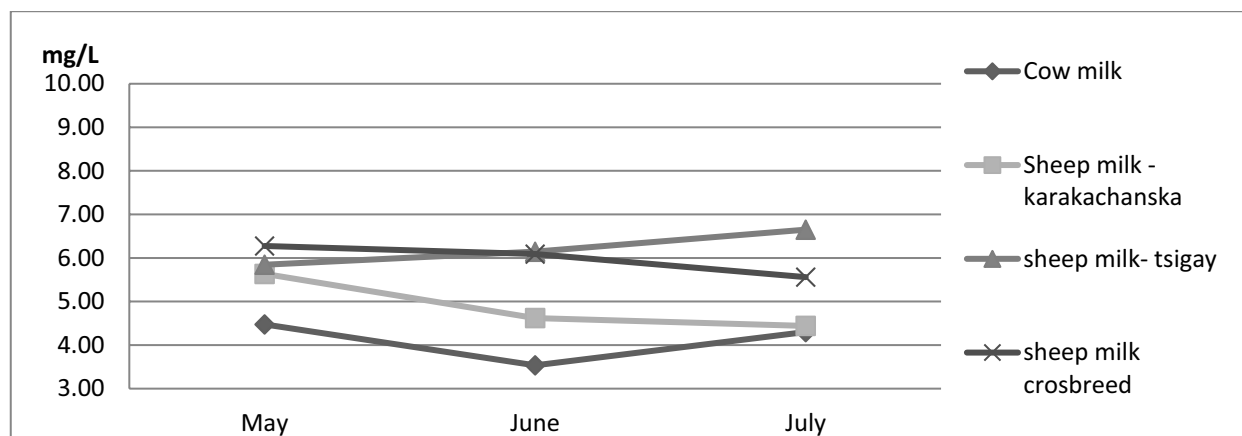


Figure 4. Zinc concentrations variation in raw milk from different sheep breeds during the investigated period (May-July)

The concentration of zinc in the milk (Figure 4) varied during the lactation period. High contents in plant species reflect on the transfer of zinc from plants to milk during the pasture period. The normal zinc content in the milk varies between 4.0 - 8.0 mg/l. The Zn-content in the milk samples correlated very well with the results obtained from other authors (Ivanova 2011; Ivanova et al., 2015 a, b).

The results of the study indicate the significant differences in the daily intake of milk and cheese from different participants. On average, the women consumed on the average 11.7% more raw milk and 44% more yogurt in comparison to the men, but 21.4% less white brined cheese and 32.5% less yellow cheese than men (Table 2).

Table 2. Average daily intake of milk and milk products by women and men

Products / woman	x g/day	sd	Minimum g/day	Maximum g/day
raw milk	273.81	94.51	85.71	342.86
white brine cheese	39.29	25.46	14.29	85.71
yellow cheese	33.57	4.65	26.43	38.57
yogurt	185.71	61.94	114.29	257.14
Total	532.38			

Products / woman	x g/day	sd	Minimum g/day	Maximum g/day
raw milk	245.24	56.72	171.43	342.86
white brine cheese	50.00	35.57	14.29	114.29
yellow cheese	49.76	19.64	21.43	75.71
yogurt	128.57	78.25	85.71	285.71
Total	473.57			

The average daily Zn-consumption (Table 3) via milk and the different dairy product showed that hadn't any significant differences between woman and man. On the average, the body supplies of zinc was 3.57 mg (women) and 2.52 mg (men), which represents about 24-36% of the required normal daily average zinc intake for the human body (Scientific Committee on Food, 2002).

Table 3. Zinc consumption via milk and dairy products from the population living in the endemic regions of Middle Rhodope Mountain (♂n=7; ♀n=7)

Kind of products	women		men		average	
	Average daily Zn consumption	% from total Zn consumption via milk products	Average daily Zn consumption	% from total Zn consumption via milk products	Average daily Zn consumption	% from total Zn consumption via milk products
	µg/day	%	µg/day	%	µg/day	%
raw milk	1113.0	31.2%	996.9	28.3%	1054.96	29.7%
white brined cheese	609.7	17.1%	776.0	22.0%	692.86	19.5%
yellow cheese	595.9	16.7%	883.3	25.1%	739.58	20.9%
yougurt	1 253.6	35.1%	867.9	24.6%	1060.77	29.9%
Total	3572,2	100.0%	3524.1	100.0%		100.0%

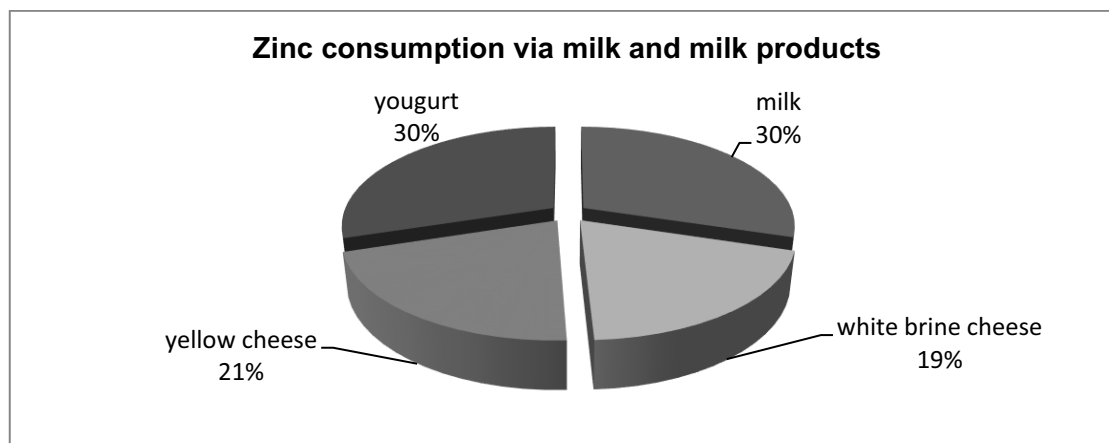


Figure 5. Distribution of the average zinc intake by Rhodope population via milk and different milk products

The main source of zinc of the investigated four dairy products is the fresh milk (29.7%) and yogurt (29.9%). The consumption of dairy products also contributes to additional zinc offer – white brined cheese (19.5%) and yellow cheese (20.9%).

The summarized results of the study (Figure 5) showed that, via milk and yoghurt the people living in the endemic regions of Middle Rhodope Mountain received 60% of the available Zn. Zinc consumed through the yellow cheese and white brined cheese was 21 and 19%.

Conclusion

The provision of livestock during the pasture period with minerals in the various mountain areas is closely linked to the detailed study of the role of all ecological factors affecting the transfer of essential components to the meadows vegetation. The reasons for certain deviations in the flow of zinc from the soil in the plant (pasture grass) and in the animal body are mainly due to the geological origin of the soil, its acidity, the effect of anthropogenic pollutants and microelement interactions. Each case of traceability of the zinc in the "soil-plant-animal" food chain is unique and should be investigated in the specific environment. With extensive sheep breeding, the quality of milk directly depends on the composition of the grass. The established heterogeneity of the pastures with regard to the transfer of microelement zinc is a prerequisite for studying the changes in the mineral composition of the milk depending on the availability of the pasture vegetation. Especially important is the achievement of an optimal level of Zn, which is an integral part of the mineral premixes and influenced the micro nutrient composition of sheep's milk.

References

- Broadley, M. R., P. J. White, J. P. Hammond, I. Zelko, A. Lux (2007): Zinc in plants, *New Phytologist*, 173 (4): 677-684
- Ivanova, S. (2011): Dynamical changes in the trace element composition of fresh and lyophilized ewe's milk, *Bulgarian Journal of Agricultural Science*, 17(1): 25-30
- Ivanova, S., D. Gadjev, L. Angelov, T. Odjakova, B. Blajev (2015): Trace element composition of cheese from ewe's milk Karakachan breed, Rhodope Tsigay and Moddle

Rhodope breed, Proceeding of the 10th Workshop on Biological activity of metals, synthetic components and natural products, Bulgarian Academy of Sciences, 17-19 November 2015: 56-60

Ivanova, S., D. Gadjev, L. Angelov, T. Odjakova (2015): Trace element composition of cheese from Bulgarian Rhodope breed, Journal of Mountain Stockbreeding and Agriculture, 18 (3): 403-411

Kashamov, B., I. Petrova, H. Wagner, L. Angelow (2005): Transfer of zinc along the chain “soil-plant-animal” in Foothill area of Western Bulgaria, Ecology and Future 4(2-3): 138-141

King, J.C., R. Cousins (2014): Zinc. In: Modern Nutrition in Health and Disease. (eds.), Ross A.C., Caballero B., Cousins RJ, Tucker KL and Ziegler TR. Lippincott Williams & Wilkins, Philadelphia, USA: 189-205

Reimann, C., M. Birke, A. Demetriades, P. Filzmoser, , P. O'Connor (2013): Chemistry of Europe's agricultural soils. Geologisches Jahrbuch (Reihe B), Schweizerbarth. available: Dec. 5, 2013

SCF (Scientific Committee on Food), 2002. Opinion of the Scientific Committee on Food on the Tolerable Upper Intake Level of zinc (expressed on 5 March 2002). SCF/CS/NUT/UPPLEV/ 62 Final, 18 pp.