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ORIGINAL PAPERS

EFFECT OF SUPPLEMENTING SELENIZED YEAST TO EWES FROM AN ORGANIC FARM ON SERUM Se CONCENTRATION IN LAMBS

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Abstract

Our objective has been to determine the effect of supplementing selenized yeast to ewes kept on a poor diet, composed of fodder from periodically flooded meadows, on the reproductive results of ewes and the serum Se concentration in lambs, their body weight and daily weight gain. The study involved 25 ewes and 25 lambs, which were divided into two groups: experimental (12 ewes) and control (13 ewes). Their lambs were also assigned to different groups. Prior to supplementation, all the sheep from the two groups were analysed for selenium concentrations in the serum. The serum selenium concentrations were determined fluorometrically using a DAN and Shimadzu RF-5001 PC spectrofluorometer. The excitation wavelength was 376 nm, while the fluorescence emission wavelength was 518 nm. All sheep in the analysed flock were found to be selenium deficient. The supplementation of selenized yeast to the experimental group caused an almost 2.5-fold increase in the serum selenium concentration in the ewes. Lambs from the experimental group were characterized by a significantly higher concentration of selenium at 7 and 14 days of age ($P \leq 0.05$) compared to control lambs. Very high ($P < 0.001$) positive correlations were found between the serum selenium concentration in Se-supplemented ewes and the serum selenium concentration in their lambs at 7 days ($r_{x,y} = 0.779$) and 14 days of age ($r_{x,y} = 0.774$). The enrichment of ewes' diet with selenized yeast contributed to an increase in the serum selenium concentration in their lambs. However, only 14.29% of lambs achieved optimum levels of

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Se on day 7 after birth. At day 14 after birth, none of the lambs reached the optimum Se concentration. The serum selenium concentration in sheep can be a good indicator of the body's supply with this element in adult sheep and of a possible selenium status in their offspring. On organic farms, the selenium content in sheep should be monitored constantly.

Keywords: Pomeranian Coarsewool sheep, selenium, selenized yeast, serum, organic farm.

INTRODUCTION

Pomeranian Coarsewool sheep (Rauhwolliges Pommersches Landschaf) are a primitive sheep breed adapted to extensive grazing. They make efficient use of meadow salt marshes because they can tolerate high concentrations of chlorides and carbonates in feed. Pomeranian Coarsewool sheep are used for the management of local landscapes, such as reserves, dunes, polders, floodbanks, set-aside fields, fallow land and orchards (Gardzielewska et al. 2010). One of the factors compromising the health of sheep is the inability to supply them with adequate amounts of trace elements, of which selenium is of particular importance.

Selenium is unevenly distributed in the environment. Some areas have soils with a high selenium content (large stretches of land in North and South America as well as some areas in China) whereas others have soils deficient in this element – much of Europe, including some regions of Poland and Bulgaria, several provinces of China, New Zealand (Gabbedy et al. 1977, Lozanov et al. 2008, Pilarczyk et al. 2008, 2009, 2013, Nowakowska et al. 2014, Jankowiak et al. 2015).

Sheep are fed on locally produced feeds, which may contain insufficient amounts of selenium when it is deficient in the soil and consequently in plants. Selenium absorption varies depending on animal species. In pigs, as much as 77% of Se in the form of selenite is resorbed from the digestive tract, compared to just 29% absorbed in sheep (Grela, Sembratowicz 1977). The absorption of inorganic selenium in ruminants is poor due to the specific rumen environment. Cristaldi et al. (2005) and Mynhardt et al. (2006) report that microorganisms present in the ruminal microflora reduce inorganic selenium to a form that cannot be absorbed by ruminants. Microorganisms in the rumen metabolize more organic forms of selenium.

Selenium deficiency in sheep may cause severe economic losses associated with white muscle disease, and diarrhoea in lambs. In pregnant sheep, fetuses may die around 35 days after fertilization due to their impaired development. Selenium deficiency in the body leads to worse bone mineralization, abnormal tooth development, decline in milk production, placental retention and impaired reproductive capacity in males (Grela, Sembratowicz 1997, Petrova et al. 1999, van Metre, Callan 2001, Mynhardt et al. 2006, Magolski et al. 2011). In ewes, dietary selenium deficiency has a negative effect on its transfer to milk, and indirectly on the body's content of this element in lambs (Petrova et al. 1999). Lambs born to such ewes are particularly prone to selenium deficiency during the first period after birth. There is insufficient information about the selenium content in Pomeranian Coarsewool sheep kept on a poor diet, based on feeds from periodically flooded meadows. Petrova et al. (1999) believe that the results of trace element supplementation in animals of one genotype cannot be extrapolated to those of another genotype without experimental studies.

The objective of the study was to determine the effect of supplementing selenized yeast to ewes kept on a poor diet, based on fodder from periodically flooded meadows, on the reproductive results of ewes and the serum Se concentration in lambs, their body weight and daily weight gain.

MATERIAL AND METHODS

Material

The study involved 25 ewes and 25 lambs of the Pomeranian Coarsewool breed kept on an organic farm in West Pomerania, Poland. The flock was divided into two groups: experimental (12 ewes) and control (13 ewes). Their lambs were also assigned to different groups.

Before Se supplementation, blood from ewes in both groups was sampled and the serum Se concentration was determined as the control level. Ewes from the experimental group received selenized yeast (1 g of selenized yeast contains 1 mg Se) in the following doses: 1 g of selenized yeast/day/animal at 3 days before mating, 1 g of selenized yeast/day/animal at 3 days after mating and 0.5 g of selenized yeast/day/animal at 7 days before lambing.

Blood for assays (5 ml samples) was drawn from the jugular vein (Pilarczyk et al. 2013). Blood samples from lambs were collected for analysis at 7 and 21 days after birth. Blood from ewes was collected prior to the experiment and 14 days after the selenized yeast supplementation was terminated. Lambs consumed only mother's milk for the first 14 days of life and afterwards received good quality hay and ground cereals (ground oat, wheat and rye grain).

Chemical analysis

Serum concentrations of selenium were determined using the Watkinson's spectrofluorometric method, modified by Grzebuła and Witkowski (1977). The tissues were digested in HNO_3 at 230°C for 180 min and in $HClO_4$ at 310°C for 20 min. Then the samples were hydrolyzed with 9% HCl. Selenium was derivatized with 2,3-diaminonaphthalene (Sigma-Aldrich) and the complex was extracted into cyclohexane. The Se concentration was determined fluorometrically using a Shimadzu RF-5001 PC spectrofluorometer. The excitation wavelength was 376 nm and the fluorescence emission wavelength was 518 nm.

The accuracy of the analyses was verified using certified reference material BCR 185R (bovine liver). The Se concentration ranged between 87% and 96% of the reference values.

Statistical analysis

The results were subjected to statistical analysis. Means, standard deviations (SD), coefficient of variation (V) and significant differences between the groups were calculated by Student's *t*-test using Statistica PL software. The relationship between serum selenium concentrations in ewes and those in lambs was determined by calculating the Pearson's coefficient of correlation ($r_{x,y}$).

RESULTS

Our study showed selenium to be deficient in all the analysed sheep in the flock. As a result of using selenized yeast in the experimental group, the serum selenium concentration in the ewes increased more than 2.5-fold (Table 1). Prolificacy in the experimental group was 116.7% compared to only 84.6% in the control group (Table 2).

Table 1

Serum Se concentration in ewes and their lambs

Specification	*N*	Se concentration (μg ml^{-1})				
		mean	SD	range	GM	median
Ewes						
14 days after Se supplementation						
C	13	0.022*	0.005	0.013-0.033	0.021	0.021
E	12	0.057*	0.016	0.031-0.078	0.054	0.056
Lambs						
7 days after birth						
C	11	0.015*	0.003	0.010-0.019	0.014	0.015
E	14	0.044*	0.026	0.021-0.090	0.038	0.029
14 days after birth						
C	11	0.012*	0.003	0.007-0.015	0.011	0.013
E	14	0.039*	0.023	0.018-0.076	0.033	0.026

C – control group, *E* – experimental group, GM – geometric mean, * significant differences at $P \leq 0.05$

Table 2

Effect of selenized yeast on the reproductive results of ewes

Parameters	Group	
	C	*E*
Number of ewes mated	13	12
Number of ewes lambed	13	12
Total number of lambs born	13	14
Number of lambs born alive	11	14
Number of stillborn lambs	2	-
Prolificacy (%)	84.6	116.7

C – control group, *E* – experimental group

The results obtained for the serum selenium content in lambs are shown in Tables 1 and 3. Lambs from the experimental group were characterized by a significantly higher concentration of selenium at 7 and 14 days of age ($P \leq 0.05$) compared to control lambs (Table 3).

Table 3

Serum selenium levels in lambs at 7 and 14 days of age

Group	*N*	Selenium level		
		deficient	marginal	optimal
		(<0.041 μg ml^{-1})	(0.041-0.079 μg ml^{-1})	(>0.079 μg ml^{-1})
7 days after birth				
	11	11	-	-
C	(%)	100	-	-
	14	8	4	2
E	(%)	57.14	28.57	14.29
14 days after birth				
	11	11	-	-
C	(%)	100	-	-
	14	9	5	-
E	(%)	64.29	35.71	-

C – control group, *E* – experimental group

Very high ($p < 0.001$) positive correlations were found between the serum selenium concentration in Se-supplemented ewes and serum selenium content in their lambs on days 7 ($r_{x,y} = 0.779$) and 14 ($r_{x,y} = 0.774$) – Table 4.

Table 4

Coefficients of correlation between serum Se concentration in ewes and lambs

	Ewes (- Se)	Ewes (+Se)
Lambs		
7d	-0.056, $p = 0.869$	0.779 $p = 0.001$
14d	-0.062, $p = 0.856$	0.774 $p = 0.001$

(- Se) – without Se supplementation
(+ Se) – with Se supplementation

The analyses concerning serum selenium concentrations in lambs born to ewes receiving selenized yeast showed that 7 days after birth, 57.14% of the analysed lambs were deficient in Se. Marginal levels of Se were found in 28.54%, and optimum levels appeared in 14.29% of the lambs. On day 14 after birth, selenium deficiency was observed in 64.29% and marginal levels in 35.71% of the lambs in the experimental group. None of the analysed lambs reached the optimum level of Se. All the lambs born to ewes from the control group (without supplemental Se) were found to be deficient in selenium (Table 3).

Our study also showed that the birth weight of the lambs which were the offspring of the ewes receiving selenized yeast (E) was only slightly higher than that in group C (without supplemental Se). Lambs from the experimental group were characterized by a significantly higher body weight at 90 days of age ($P \leq 0.05$) compared to control lambs (Table 5).

Table 5

Body weight of lambs (kg) and daily weight gains (kg day^{-1}) in experimental groups

Group	Mean	SD	V (%)	Mean	SD	V (%)	Mean	SD	V (%)
Body weight (kg)									
	birth weight			33 days of age			90 days of age		
C	3.30	0.15	1.94	7.7	0.50	2.61	19.0*	0.90	4.75
E	3.20	0.24	7.46	7.92	0.48	6.11	21.1*	0.68	3.24
Daily gains (kg day^{-1})									
	between 1 and 33 days			between 33 and 90 days			between 1 and 90 days		
C	0.173	0.01	9.85	0.200*	0.02	7.93	0.177*	0.01	5.7
E	0.148	0.01	9.22	0.231*	0.01	3.43	0.201*	0.01	3.35

C – control group, E – experimental group, * significant differences at $P \leq 0.05$

Supplementation of the ewes with selenized yeast improved daily weight gains in the lambs. Lambs from the experimental group had significantly ($P \leq 0.05$) higher daily weight gains between 33 and 90 days of age compared to control lambs. Also, lambs from the experimental group had significantly ($P \leq 0.05$) higher daily weight gains between 1 and 90 days of age compared to control lambs. No such differences were observed in the lambs between 1 and 33 days of age (Table 5).

DISCUSSION

The present study showed that the mean serum selenium concentration in control lambs was lower than the optimum concentration. The biochemical criteria used to diagnose selenium deficiency in ovine serum are as follows: less than 0.041 μg ml^{-1} – deficient level; 0.041 to 0.079 μg ml^{-1} – marginal level; more than 0.079 μg ml^{-1} – appropriate (optimal) level for a flock of sheep (Gabryszuk and Klewiec 2002). Our results indicate that selenium levels in the ewes from the control group were insufficient to meet the selenium requirement of lambs early in life. The insufficient supply of the ewes with selenium is also confirmed by the analysis of serum selenium concentrations in the studied ewes. Selenium deficiency in ewes is one of the risk factors for placental retention. Presumably, lambs born to ewes with the retained placenta will be deficient in selenium absorbed through the placenta in fetal life, and after lambing their mothers' colostrum will not be an adequately rich source of this element for the lambs. This will result in poor growth of the lambs, proneness to diarrhoea and, in extreme cases, development of white muscle disease (Davis et al. 2006).

The supplementation of selenized yeast to the ewes contributed to a significant increase in their serum selenium concentrations and increased prolificacy compared to the control group (without Se supplementation). Balicka-Ramisz et al. (2006) and Hemingway (2003) reported that ewe prolificacy is largely determined by the level of selenium in feeds. Our results indicate that it is recommendable to use selenized yeast in ewes. Selenium concentrations in the ewes fell within the range of marginal and optimum values. Our results are corroborated by the findings of other authors (Knowles et al. 1999, Orthman, Pehrson 1999, Faixova et al. 2007, Pilarczyk et al. 2013).

The use of selenized yeast in the ewes contributed to an increase in serum selenium concentrations in the lambs. However, only 14.29% of the lambs had reached the optimum level on day 7 after birth. At 14 days after birth, no lamb had the optimum level. Selenium passes through the blood-placenta barrier and can reach the fetus, in amounts sufficient for a newborn lamb during the first period of its life. However, the transfer of selenium through the placenta to the fetus in the final stage of pregnancy is not completely effective in preventing hyposelenosis in lambs.

No statistically significant effect of supplementing selenium-containing preparations on the body weight of lambs at birth and 33 days after birth was found in our study. Statistically significant differences were only verified in lambs aged 90 days. Thus, the current results differ from our earlier findings, when lambs from the experimental group had significantly higher body weight at 33 and 90 days of age compared to control lambs (Pilarczyk et al. 2013). Gabryszuk and Klewiec (2002) reported that two injections of Se given to ewes before mating and lambing increased the body weight of lambs by about 0.7 kg on day 28 in the experimental group compared to the control group. Mauka et al. (1998) showed a 28.6% higher body weight in the lambs (5th month of the experiment) after selenium supplementation.

CONCLUSIONS

Serum selenium concentration in sheep can be a good indicator of the body's supply with this element in adult sheep and a possible selenium status in their offspring. On organic farms, selenium content in sheep should be monitored constantly. Implementation of adequate prophylaxis programmes will help to maintain optimum Se levels in organic sheep.

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