

The effect of selenized yeast supplementation on some performance parameters in sheep

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Abstract: The aim of this study was to determine the levels of serum selenium in coarse-haired Pomeranian sheep and to evaluate the effect of the oral supplementation of selenized yeast on selected performance parameters in such sheep. The sheep were divided into 2 groups, with 53 ewes forming the experimental group and 34 ewes forming the control group. The concentration of serum selenium in all 87 sheep from the 2 groups was analyzed. The sheep in the experimental group received selenized yeast for the 3 days before and 3 days after mating (1 g preparation/animal daily, with 1 g of preparation = 1 mg of Se), and in the 7 days before parturition (0.5 g preparation/animal daily). Blood for assays was then collected from the jugular vein (vena jugularis) into tubes, without anticoagulant. The blood samples were taken 14 days after the withdrawal of each supplementation of selenized yeast. Analysis of the concentrations of serum selenium in the sheep showed this element to be deficient in all animals examined. At the start of the experiment, the mean concentration of selenium in the analyzed sheep was 0.013 µg/mL. The use of selenized yeast significantly increased the mean Se concentration, which rose to 0.108 µg/mL. The highest mean serum selenium concentration was recorded after the second administration of selenized yeast. In a group of lambs born from the ewes that had been administered the selenium yeast, a lower mortality rate, a higher birth weight, and a higher number of lambs born alive were all observed compared to the control group. Lambs born from the sheep in the experimental group were characterized by a significantly higher body weight at both 33 days ($P \leq 0.05$) and 90 days of age ($P \leq 0.01$) when compared to the lambs born from the sheep in the control group. In the experimental group, the rates of fertility and prolificacy were 85.71% and 142.67%, respectively, while in the control group, the corresponding rates were 58.82% and 130%. The ewes' reproductive parameters improved as a result of using selenized yeast supplementation.

Key words: Sheep, selenium, reproduction, body weight gains

1. Introduction

The distribution and cycling of selenium in nature is determined by a number of geophysical, biological, and industrial factors. The distribution of selenium is highly variable, with selenium-rich soils being found in large parts of both North and South America and in some parts of China, and selenium-deficient soils found in large parts of Europe (including some regions of Poland), several Chinese provinces, and New Zealand (1–5).

Selenium is currently acknowledged to be the basic trace element determining the normal growth and development of both animals and humans (6,7). It is an essential component of animal bodies and is found in all cells, but is most abundant in the kidneys, liver, and pancreas. Farm-produced feeds are predominantly used in the feeding of

sheep. Any selenium deficiency in the soil is paralleled by low selenium concentrations in plants growing in that soil and, as a result, in the sheep. Ramisz et al. (8) reported that sheep fecundity was highly dependent on the concentration of Se in their feed. However, the selenium status of animals is dependent not only on the selenium content of their feed, but also on its availability. In pigs, up to 77% of Se in the form of selenite (an inorganic form of selenium) is resorbed from the gastrointestinal system, compared to just 29% in sheep (9). According to Cristaldi et al. (10) and Mynhardt et al. (11), this relationship results from bacterial reduction processes in the rumen, which lead to combinations of mineral selenium being converted to unavailable forms, which in turn results in their low bioavailability.

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Selenium deficiency in farm animals can cause large economic losses due to white muscle disease, mulberry heart disease, diarrhea in young cattle and sheep, nutritional muscular dystrophy, and stiff lamb disease, which are all associated with it. In pregnant ewes, it can lead to the death of fetuses due to arrested development, retained placentas after delivery, and a decrease in the breeding abilities of males (1,9,12,13). In addition, Magolski et al. (14) reported that the maternal Se status had an influence on the quality of their lambs' wool.

The administration of selenium can minimize the adverse effects of Se deficiency. Selenium can be administered to sheep by giving an injection of sodium selenite to lambs or an injection of barium selenate to ewes, or as a dietary supplement (15). Muñoz et al. (16) observed that ewes that received an injection of a long-acting supplement containing 50 mg/mL selenium as barium selenate had lower abortion rates and reared 9% more lambs than the control ewes. In Holstein cows, the administration of Se at 60 and 21 days prior to parturition and 30 and 90 days after parturition reduced the incidence of uterine pathologies and improved the pregnancy rate at 150 days postpartum (17). Furthermore, prepartum supplementation of vitamin E and selenium decreases the incidence of retained fetal membranes and increases pregnancy rates, and thereby reduces the interval from calving to conception in lactating dairy cows (18). Sánchez et al. (19) found that in Se-supplemented ewes that ovulated naturally, the reproductive parameters of conception rate, lambing rate, and prolificacy were higher than in animals that had not received Se supplements; they reported that the conception rate, lambing rate, and prolificacy increased from 0.56 to 0.68, 0.60 to 0.76, and 1.07 to 1.12 per ewe, respectively. According to Koyuncu and Yerlikaya (20), the administration of Se by intramuscular injection had significant positive effects on the incidence of estrus, on fertility, and on prolificacy in ewes, as well as on the live weight gains of lambs up to 60 days of age. They observed that such injections increased fecundity by 131% when compared to their control group. Gabryszuk and Klewicz (21) reported positive effects of Se on fertility, prolificacy, and lamb body weight in 3-year-old ewes after 2 injections (before mating and lambing, respectively). However, in younger ewes, the prolificacy and lamb live weight at birth after the administration of selenium was lower than in their control group.

The aim of this study was to determine the serum selenium levels in a flock of coarse-haired Pomeranian sheep with a history of low fertility and to evaluate the effect of the oral supplementation of selenized yeast on selected performance parameters in the sheep.

2. Materials and methods

2.1. Animals and sampling

A total of 87 coarse-haired Pomeranian sheep, imported into Poland in 2004 from the island of Rügen (Germany), were studied. After Poland joined the European Union, Rügen and Pomerania were both included in the Natura 2000 network as conservation areas for threatened and rare species of plants and animals. Native breeds of sheep are very well adapted to the local environment because they are undemanding in feeding requirements and highly resistant to disease and adverse living conditions.

The flock was kept on an organic farm. Their summer feeding was based on pasture with a 24-h pasture turnout, supplemented by hay and straw. Winter feeding was based on ground grain (rye, triticale, and barley), meadow hay, and triticale straw. In both summer and winter, the sheep had free access to water and salt licks. Harem mating was performed from 10 September to the end of October.

The experiment was conducted in a flock with a history of low reproductive parameters, including low fertility (50%–60%). Before the experiment started, infertility was observed to be developing among the sheep. There also occurred difficult births, miscarriages that required assistance, and several births per year of either dead or very weak lambs.

The selenium level of the sheep, as a factor potentially affecting the fertility of the ewes, was measured in their serum ($n = 87$) before the start of the experiment. The 87 ewes, aged between 3 and 5 years and weighing between 45 and 60 kg, were divided into 2 groups, with 53 ewes in the experimental group and 34 ewes in the control group. In the experimental group, the sheep were administered selenized yeast (1 g of preparation = 1 mg of Se) for 3 days before mating (1 g preparation/animal daily), 3 days after mating (1 g preparation/animal daily), and 7 days before parturition (0.5 g preparation/animal daily). The blood was sampled 14 days after the withdrawal of each supplementation of selenized yeast. The blood for assays was collected in 5-mL samples from the jugular vein (vena jugularis) into tubes without anticoagulant and was kept at room temperature until centrifugation at 4000 rpm for 10 min. The serum was then removed and frozen at $-20\text{ }^{\circ}\text{C}$ until it was subjected to chemical analysis.

The reproductive performance of the ewes was analyzed based on their mating and lambing data for 2008 and 2009. The rearing performance was analyzed based on the lambs' growth data. The lambs' body weights were measured at 1, 33, and 90 days of age.

2.2. Chemical analysis

The concentration of serum selenium was determined using the spectrofluorimetric method (22). The tissues were digested in HNO_3 at $230\text{ }^{\circ}\text{C}$ for 180 min and in HClO_4 at $310\text{ }^{\circ}\text{C}$ for 20 min. After this, the samples were

hydrolyzed with 9% HCl. The selenium was derivatized with 2,3-diaminonaphthalene (Sigma-Aldrich) under controlled pH conditions (pH 1–2) with the formation of a selenodiazole complex. This complex was then extracted into cyclohexane. Ethylenediaminetetraacetic acid (EDTA) and hydroxylamine hydrochloride were used as masking agents. The Se concentration was determined fluorometrically using a Shimadzu RF-5001 PC spectrofluorophotometer. The excitation wavelength was 376 nm and the fluorescence emission wavelength was 518 nm.

The accuracy of this method was verified using certified reference material BCR 185R (bovine liver) (European Commission Joint Research Centre Institute for Reference Materials and Measurements). The Se concentrations obtained ($n = 6$) were in the range of the reference values ($96.4 \pm 3.1\%$). In this study, the precision and reproducibility of the analyses were 2.5% and 3.9%, respectively.

The results were analyzed statistically by calculating their mean values, standard deviations (SD), coefficients of variation (V), and the significance of the differences between the groups using Student's t-test with STATISTICA PL software.

3. Results

Before the start of the experiment, the serum selenium content of the sheep was in the range of 0.003–0.033 $\mu\text{g}/\text{mL}$ and the mean Se concentration was 0.013 $\mu\text{g}/\text{mL}$ (Table 1). The use of selenized yeast significantly increased the serum selenium concentrations in the sheep. The mean Se concentration in the serum of the experimental group was $0.108 \pm 0.064 \mu\text{g}/\text{mL}$. Significant differences ($P \leq 0.01$) were observed between the concentrations of selenium in the control and experimental groups.

The highest concentration of Se in the serum of the sheep was observed after the second administration of selenized yeast, averaging $0.161 \mu\text{g}/\text{mL} \pm 0.059$. After the third administration, the mean concentration of selenium was $0.105 \pm 0.071 \mu\text{g}/\text{mL}$.

The reproductive parameters of the ewes improved as a result of using selenized yeast (Table 2). Fertility and prolificacy in the experimental group were 85.71% and 142.67%, respectively. Additionally, lamb mortality in the lambs born to the experimental group was lower than in those born to the control group, and lambs born to the experimental group had a significantly higher body weight than those born to the control group at both 33 ($P \leq 0.05$) and 90 ($P \leq 0.01$) days of age (Table 3).

The administration of selenized yeast to the ewes led to improved daily gains in the lambs. Lambs from the experimental group had significantly ($P \leq 0.05$) higher daily weight gains between 1 and 33 days of age compared to the control lambs. These lambs also showed significantly ($P \leq 0.01$) higher daily weight gains between 33 and 90 days of age compared to the control lambs. Similar results were obtained for lambs between 1 and 90 days of age (Table 4). A lower percentage of lambs showing signs of diarrhea was found in the experimental group receiving Se (Table 5).

4. Discussion

According to Grace (23), the biochemical criteria used in the diagnosis of serum selenium deficiency are as follows: below 0.041 $\mu\text{g}/\text{mL}$, deficiency; 0.041–0.079 $\mu\text{g}/\text{mL}$, marginal level; and above 0.079 $\mu\text{g}/\text{mL}$, optimal level for sheep. Our preliminary research showed that all of the sheep in the flock were deficient in selenium, with this low Se level probably being due to the low levels of selenium in the feed given to these animals. In general, West Pomerania is a region that is deficient in selenium; this was documented by Zabłocki (24), who found very

Table 1. Mean selenium concentration ($\mu\text{g}/\text{mL}$) in the control and experimental groups after each administration of selenized yeast.

	n	Selenium concentration ($\mu\text{g}/\text{mL}$)			
		Mean	SD	Range	V (%)
Before Se administration	87	0.013	0.006	0.003–0.033	46.15
Control group	34	0.035 ^A	0.015	0.013–0.065	42.86
Experimental group	53	0.108 ^{A*}	0.064	0.026–0.339	52.30
14 days after the 1st Se administration		0.070	0.025	0.026–0.114	35.71
14 days after the 2nd Se administration		0.161	0.059	0.069–0.339	36.65
14 days after the 3rd Se administration		0.105	0.071	0.041–0.280	67.62

^A: Significant at $P \leq 0.01$.

*: Average Se concentration from 3 samplings (after the 1st, 2nd, and 3rd Se administrations).

Table 2. Effect of selenized yeast on the reproductive performance of ewes and the rearing performance of their offspring.

Parameters	Group	
	Control	Experimental
Number of ewes mated	34	56
Number of ewes lambed	20	48
Total number of lambs born	31	69
Number of lambs born alive	26	68
Number of stillborn lambs	5	1
Lamb survival to 7 days of age (%)	92.31	98.53
Fertility (%)	58.82	85.71
Barrenness (%)	41.18	14.29
Prolificacy (%)	130.00	142.67
Rearing performance (%)	76.92	97.06
Lamb mortality (%):		
From 7 to 33 days of age	16.67	1.47
From 33 to 90 days of age	5.00	0.00
From birth to 90 days of age	26.92	2.89

Table 3. Body weight (kg) of lambs at 1 (birth weight), 33, and 90 days after birth.

Group	Birth weight			Body weight at 33 days of age			Body weight at 90 days of age		
	Mean	SD	V (%)	Mean	SD	V (%)	Mean	SD	V (%)
Control	2.89	0.29	10.03	7.21 ^a	0.89	12.34	19.43 ^A	1.41	7.26
Experimental	3.15	0.27	8.57	7.83 ^a	0.97	12.39	21.12 ^A	1.28	6.06

^a: Significant difference, $P \leq 0.05$; ^A: significant difference, $P \leq 0.01$.

Table 4. Daily weight gains in lambs from the control and experimental groups.

Group	Daily gains (g/day)								
	Between 1 and 33 days			Between 33 and 90 days			Between 1 and 90 days		
	Mean	SD	V (%)	Mean	SD	V (%)	Mean	SD	V (%)
Control	135.00 ^a	20.31	15.04	214.38 ^A	24.17	11.27	185.84 ^B	86.01	46.28
Experimental	146.25 ^a	18.70	12.79	233.16 ^A	23.98	10.28	201.91 ^B	27.13	13.44

^a: Significant difference, $P \leq 0.05$; ^{A,B}: significant difference, $P \leq 0.01$.

Table 5. Proportion of lambs with signs of diarrhea (%).

Group	From birth to 7 days of age	From 7 to 33 days of age	From 33 to 90 days of age	From birth to 90 days of age
Control	15.38	40.00	15.79	57.69
Experimental	7.35	4.54	6.06	17.64

low concentrations of Se (i.e. below 0.3 mg/kg dry matter) in the soil profiles that he analyzed.

In a Se-deficient area, supplementation is the only method of protecting animals against the health consequences of too low a supply of this element. Gabryszuk and Klewicz (21) and Hemingway (25) observed a clear improvement in serum Se status (from 0.036 µg/mL to 0.095 µg/mL) after sodium selenite application. Palmieri and Szarek (26) reported that Se supplementation in cattle and ewes is associated with increased embryo production, higher fetal mass, and a reduced incidence of retained placentas. In this study, we found that the use of selenized yeast significantly increased the serum selenium concentration in the sheep studied (Table 1). A comparison of the concentrations that we observed with those reported by Grace (23) leads us to conclude that the optimum Se level for sheep was obtained. The highest mean concentration of selenium in the examined sheep was found after the second administration of Se. Similar results were reported by Matthes et al. (27), who observed a significant increase in the serum selenium concentrations of cattle given selenized yeast.

In Morocco, enzootic muscle degeneration was previously responsible for high lamb mortality (28). After the prophylactic use of Se in heavily pregnant sheep, this disease process stopped and their newborn lambs were healthy. Sánchez et al. (19) reported that health problems in lambs related to selenium deficiency were common in southwestern Spain and mainly manifested as nutritional myodystrophy. The administration of sodium selenite to Se-deficient lambs resulted in a favorable resolution of these problems.

We found that supplementation with selenized yeast resulted in improved reproductive parameters, such as fertility and prolificacy. Barrenness decreased from 41.18% to 14.29%. The positive effects of selenium on fertility have also been observed by other authors (21,29–31). Balicka-Ramisz et al. (32) and Hemingway (25) reported that the prolificacy of ewes is determined to a large extent by the level of dietary selenium. Pilarczyk et al. (33) found in a previous study that the use of sodium selenite in ewes improved their reproductive performance (fertility, 96% and prolificacy, 137.5%). Gabryszuk and Klewicz (21) also reported that Se treatment had a positive influence

on fertility in 3-year-old ewes, with fertility increasing from 68% to 100% and prolificacy from 100% to 112%, respectively. Pilarczyk et al. (33) observed that lamb mortality in the experimental group receiving sodium selenite was lower than in the control group (9.2% vs. 12.1%). In our study, the mortality rate during the period from birth to 90 days of age in lambs born to those ewes that had received selenized yeast was almost 9 times lower than in lambs born to the ewes in the control group (Table 2); the birth weight of the lambs was also higher (Table 3) and a greater number of lambs were born alive than in the case of lambs born to the control group. The data obtained in this study are similar to those reported by Gabryszuk and Klewicz (21), Ramisz and Buzek (34), and Segerson et al. (35), who found that the number of lambs per ewe born alive in the control group was lower compared to the Se- and vitamin E-treated group. Higher body weights in lambs born to ewes that had received selenium in their diet were also observed by El-Shahat and Abdel Monem (36) (2.9 kg in the control group vs. 3.3 kg) and Sánchez et al. (19) (4.63 kg vs. 4.82 kg). Mauka et al. (37) demonstrated that the Se level in sheep that had been given a diet enriched with Se and vitamins was 25% higher in the blood serum and 35% higher in the liver. This increase in Se levels was subsequently translated into lamb body weight gains; at 5 months of the experiment, the body weight of the lambs born to the treated ewes was 28.6% higher than that of the lambs born to the control group. We observed that the mean body weight gain of lambs born to Se-treated ewes was significantly higher than that of lambs born to the control animals (Table 4). This finding is similar to the results obtained by Koyuncu and Yerlikaya (20).

Gabryszuk and Klewicz (21) reported that 2 injections of Se given to 2- and 3-year-old ewes before mating and before lambing increased the body weight of the lambs by about 0.7 kg and 1.5 kg, respectively, on day 28 in the experimental groups compared to the control group. These authors also established that Se given to ewes increased the average daily weight gain of their lambs from birth to 28 days of age. Similar results were obtained by Langlands et al. (38), who observed larger weight gains in lambs born to ewes that had been given Se-enriched feed than in lambs born to untreated ewes.

Kołać et al. (39) reported that administering selenized yeast to sows at 0.9 mg Se/animal daily for 3 days before parturition and 21 days of lactation significantly increased the level of Se in the milk, improved the conception rate, and increased both the number of piglets per litter and the birth weight of the piglets after the next gestation. These authors also found an increase in the blood selenium concentration, larger weight gains during rearing, and lower mortality in piglets born to sows that received dietary selenized yeast during lactation.

Selenium deficiency in ruminants has been reported to be associated with neonatal diarrhea (40,41). In our study, a lower percentage of lambs with signs of diarrhea was found among those born to the experimental group (Table 5). Guyot et al. (42) reported that during the first 15 days of life, diarrhea occurred in 6%, 21%, and 35% of the calves from the groups that had received 0.5 ppm Se

(selenized yeast), 0.5 ppm Se (Na-selenite), and 0.1 ppm (Na-selenite), respectively. Over the first 75 days of life, the incidence of diarrhea in this study was 19%, 29%, and 65%, respectively.

In conclusion, the use of selenium supplementation significantly increased the serum selenium concentration and also improved the reproductive value of the sheep. This shows that it is appropriate to use selenized yeast in sheep, especially in flocks from Se-deficient areas. The use of proper prophylactic programs should enable optimum Se levels in animals to be maintained, thus helping to limit economic losses due to poor reproductive performance.

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