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# VITAMIN E AND SELENIUM IN THE PREVENTION OF NUTRITIONAL MUSCULAR DYSTROPHY IN LAMBS

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**Abstract:** The study investigates nutritional muscular dystrophy in lambs and the impact of selenium and vitamin E supplementation in their diet on the occurrence and prevention of this disease. Vitamin E and selenium play crucial roles in the animal body in relation to growth and development, reproduction, production performance, health status, and immunity. The physiological importance of selenium and vitamin E for living organisms is based on their strong antioxidant activity.

Nutritional muscular dystrophy, also known as white muscle disease (myopathy, NMD), frequently occurs in lambs and older categories of sheep as a result of selenium and/or vitamin E deficiency in the diet. This deficiency, together with a high intake of unsaturated fatty acids, increases the concentration of peroxides in the body. The consequence is degeneration of skeletal and cardiac muscles. Increased serum concentrations of the enzymes aspartate aminotransferase, lactate dehydrogenase, and creatine kinase, along with low selenium and vitamin E levels and reduced glutathione peroxidase activity, are the most reliable indicators of nutritional muscular dystrophy in lambs.

**Keywords**: nutritional muscular dystrophy, lambs, selenium, vitamin E

## Introduction

Vitamin E and selenium play important roles in efficient and profitable livestock production and in maintaining optimal health during early growth, reproduction, and lactation. Their antioxidant functions overlap, but each also has specific health-related roles. Vitamin E functions primarily within cell membranes,

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whereas selenium functions within the glutathione peroxidase system ofintracellular components. Many factors influence the metabolism of vitamin E and selenium, as well as the symptoms and clinical signs of their deficiency.

The most common causes of this disease are selenium and/or vitamin E deficiency, as well as a high intake of unsaturated fatty acids, which increases the concentration of hydroperoxides in tissues. Other contributing factors to the development of muscular dystrophy include physical exertion and adverse weather conditions that increase energy requirements (McMurray and McEldowney, 1977). The enzymes creatine kinase, aspartate aminotransferase, and lactate dehydrogenase are most relevant for diagnosing muscle damage, with creatine kinase being the most sensitive and specific indicator. Lactate dehydrogenase and aspartate aminotransferase are less specific, as they are also released from other damaged cells, particularly hepatocytes (Duncan and Prasse, 1986).

The physiological importance of selenium for animals is based on its strong antioxidant activity and its role in preventing oxidative stress in cells (Serratos et al., 2024). Selenium digestibility is lower in ruminants than in non-ruminants due to the reduction of selenite to insoluble forms in the rumen by microflora. The presence of sulfur, heavy metals, and metalloids (copper, mercury, arsenic, cadmium, silver) further reduces selenium digestibility. In ruminants, selenium utilization from feed ranges from 30–40%, whereas in non-ruminants it ranges from 65–85%.

Selenium deficiency has a direct or indirect negative impact on the growth, production, and health of ruminants (Mehdi and Dufrasne, 2016), especially in young animals (calves and lambs), in which nutritional muscular dystrophy occurs, i.e., hyaline degeneration of muscle fibers (Żarczyńska et al., 2019). In lambs, the first signs of selenium deficiency manifest as weakness, mild body stiffness, and difficulty in movement and standing. The most common manifestation is degenerative disease of skeletal muscles, characterized by necrotic lesions appearing as white streaks - hence the term white muscle disease.

This paper discusses various aspects of the functional role of selenium and vitamin E in the prevention of nutritional muscular dystrophy in lambs.

## The role of selenium and vitamin E in the occurrence of nutritional muscular dystrophy

Lambs utilize organic sources of selenium more efficiently than inorganic sources, which is associated with better absorption of this element (Ružić-Muslić et al., 2014). Similar results were reported by Qin et al. (2007) in a study

evaluating different selenium sources. Lambs were fed either a control diet (with a selenium deficiency of 0.06 mg/kg) or diets containing 0.10 mg Se/kg derived from sodium selenite, selenized yeast, or selenium-enriched probiotics. The authors reported that organic selenium sources (selenium-enriched yeast and selenium-enriched probiotics) were more effective than inorganic sources (sodium selenite) in increasing selenium concentrations in tissues and blood, as well as glutathione peroxidase activity in lamb blood.

Nutritional muscular dystrophy in lambs, resulting from vitamin E deficiency, most often occurs during winter and early spring and is associated with poor feed quality (Fancote et al., 2013).

The enzyme creatine kinase is considered the most sensitive biomarker of muscle degeneration due to its high specificity for muscle tissue (Kohli et al., 2005). Delesalle et al. (2017) reported that creatine kinase activity can increase markedly during nutritional muscular dystrophy, depending on disease progression, while Żarczyńska et al. (2017) emphasized that increased lactate dehydrogenase activity is also a valuable indicator in the diagnosis of this disease.

Lambs affected by nutritional muscular dystrophy exhibit stiffness, tremors, painful musculature, tachycardia, and irregular heart rhythms (arrhythmias) (Ghanem et al., 2016), and may also present with anemia. Clinical and biochemical blood serum parameters of diseased and healthy lambs are shown in Table 1.

Table 1. Clinical and biochemical parameters of nutritional muscular dystrophy in lambs (Ghanem et al., 2016)

| Parameters | Control (healthy lamb) | Diseased lamb |
|---|---|---|
| Body temperature | 39.2±0.17 | 39.3±0.08 |
| Respiratory rate (breaths per minute) | 23.66±1.2 | 37.33±0.88* |
| Pulse rate (per minute) | 81.0±1.52 | 121.6±2.60* |
| Hemoglobin (gm/dl) | 9.87±0,12 | 6.13±0,15* |
| Red blood cells (million cells/mcL) | 10.68±0.15 | 6.38±0.16* |
| Procalcitonin (%) | 33.1±0.12 | 22.6±0.4* |
| Blood cell size (fl) | 18.3±0.26 | 26.45±0.25* |
| Average hemoglobin mass in each red blood cell (pg) | 23.3±0.26 | 31.9±3.5* |
| Selenium (ppb) | 57.35±1.04 | 18.8±0.52* |
| Vitamin E (mg/dl) | 400.8±4.59 | 141.4±3.38* |
| Alanine transaminase (U/L) | 9.92±0.19 | 44.01±0.84* |
| Aspartate aminotransferase (U/L) | 59.95±0.1 | 966.46±9.8* |
| Creatine kinase (U/L) | 46.35±1.12 | 1143.39±16.56* |
| Glutathione peroxidase activity (u/g protein) | 7.96±0.17 | 4.56±0.21* |
| Malonyldialdehyde (mmol/L) | 0.46±0.01 | 1.64±0.01* |
| Superoxide dismutase (mmol/L) | 1.60±0.035 | 0.55±0.016* |
| Lactate dehydrogenase (U/L) | 571.75±4.9 | 1321.05±22.8* |

* - significant differences

Yildirim et al. (2016) reported that in lambs showing symptoms of nutritional muscular dystrophy, the concentration of vitamin E in blood serum was very low ($p \leq 0.01$), whereas the activities of aspartate aminotransferase, lactate dehydrogenase, and creatine kinase were significantly increased ($p \leq 0.001$) compared with the control group.

The concentration of sialic acid in blood serum can also be used in the diagnosis of white muscle disease (Değer et al., 2008). In lambs affected by nutritional muscular dystrophy, a significant increase in serum sialic acid concentration was observed, accompanied by a simultaneous decrease in selenium and vitamin E concentrations ($p<0.001$) compared with healthy lambs. One month after treatment with a commercial preparation containing selenite and vitamin E, serum sialic acid levels decreased in diseased lambs; however, they remained higher than those recorded in healthy animals.

Selenium injections administered to lambs suffering from nutritional muscular dystrophy at different doses (0.25 or 0.5 mg Se/kg body weight) increased blood selenium concentrations, and both doses were effective in preventing white muscle disease lesions and improving lamb survival to weaning. In a study involving 45 lambs aged 3–7 days, born to selenium-deficient ewes, Ramírez-Bribiesca et al. (2004) divided the animals into three groups to evaluate the effectiveness of selenium injections: control, Trial I (0.25 mg Se/kg), and Trial II (0.5 mg Se/kg). They reported that blood selenium concentrations increased rapidly—by 44% in Trial I and by 163% in Trial II—20 days after the initiation of treatment ($p \leq 0.01$).

The level of selenium supplementation, rather than its chemical form, appears to be more important for the utilization of this trace element in lambs. Słupczyńska et al. (2009), examining the effects of different selenium sources in lambs, found that both inorganic (sodium selenate) and organic (selenium-enriched yeast) selenium sources, added to complete lamb diets, had a positive effect on tissue selenium concentrations and significantly increased blood glutathione peroxidase activity, particularly in animals receiving selenium-enriched yeast.

In animals with better body condition and faster growth rates, the amounts of vitamin E and selenium administered should be higher than in animals with slower growth and development, in order to enhance antioxidant system activity and reduce oxidative stress (Bayomi et al., 2017).

If ewes are fed selenium-deficient diets during pregnancy, they may give birth to stillborn or weak lambs that die shortly after birth or suffer permanent damage to individual organs. Supplementation of ewes with selenium during gestation increases selenium concentrations in lambs at birth and enhances

selenium transfer via colostrum and milk, thereby minimizing the risk of nutritional muscular dystrophy (Suttle, 2010).

Abood et al. (2012) reported that clinical signs of selenium and vitamin E deficiency in sheep appeared after three months of feeding a deficient diet. Serum concentrations of selenium and vitamin E were 0.02 ppm and 0.61 mg/L, respectively. In newborn lambs from these ewes, deficiency symptoms appeared within the first three days of life, with serum selenium concentrations of 0.01 ppm and vitamin E concentrations of 0.34 mg/L, accompanied by increased activities of creatine kinase and aspartate aminotransferase in both the ewes and their newborn lambs.

An effective method for preventing nutritional muscular dystrophy (NMD) in lambs is the administration of vitamin E and selenium preparations to ewes during the last third of pregnancy. Lambs born to supplemented ewes had significantly higher serum creatine phosphokinase concentrations compared with lambs from control ewes (El-Neweehy et al., 2001).

Similarly, Błażejak-Grabowska et al. (2022) reported that barium selenate injections administered to sheep in the third month of pregnancy represent an effective long-term form of selenium supplementation. This was confirmed by increased selenium concentrations in sheep serum during the first 100 days of lactation, enhanced humoral and cellular immune status of the ewes, and faster growth and improved muscle development of their lambs, without significant changes in carcass fat content.

Vitamin C, in combination with vitamin E and selenium, can aid in the treatment of nutritional muscular dystrophy in affected lambs, as this combination has been shown to be more effective than administration of vitamin E and selenium alone (El-Deeb, 2010).

Caution is required when dosing selenium and vitamin E, as high concentrations may cause toxicity in ruminants (Yanuartono et al., 2024). When selenium concentrations in the body increase excessively, selenium becomes toxic. The maximum non-toxic selenium level is 2 mg Se/kg dry matter of feed, whereas toxicity occurs at concentrations of 3–5 mg Se/kg dry matter. The margin between tolerable and toxic selenium concentrations is therefore narrow.

Selenium toxicosis may occur in acute or chronic forms. Acute toxicity is characterized by blindness, teeth grinding, salivation, and eventual death. Chronic selenium toxicity manifests as anemia, liver cirrhosis, loss of appetite, hair or wool loss, hoof deformities, and death. Excess selenium is excreted via urine, feces, and respiration.

Comparing acute toxicosis caused by organic selenium (selenomethionine) with that caused by inorganic selenium (sodium selenite), Tiwary et al. (2006)

orally administered selenium to lambs as sodium selenite (0, 1, 2, 3, or 4 mg Se/kg body weight) or selenomethionine (0, 1, 2, 3, 4, 6, or 8 mg Se/kg body weight), followed by euthanasia and necropsy seven days later. Sodium selenite at doses of 2, 3, and 4 mg/kg, as well as selenomethionine at doses of 4, 6, and 8 mg/kg, caused tachypnea and/or respiratory distress after minimal movement. Severity and recovery time varied depending on the administered dose.

The main histopathological findings in high-dose groups included multifocal myocardial necrosis and pulmonary alveolar vasculitis with edema and hemorrhage. Analysis of liver, renal cortex, heart, blood, and serum samples showed a linear dose-dependent increase in selenium concentrations. Administration of sodium selenite, but not selenomethionine, also resulted in decreased hepatic vitamin E concentrations.

## Conclusion

Vitamin E and selenium play important roles in maintaining optimal health during the early growth and development of lambs, as well as in the production, reproduction, and lactation performance of adult sheep. Nutritional muscular dystrophy (NMD), also known as white muscle disease (myopathy), frequently occurs in lambs and older sheep as a result of selenium and/or vitamin E deficiency in the diet and is characterized by degeneration of skeletal and cardiac muscles.

Selenium deficiency in lambs occurs when the diet contains less than 0.06 mg Se/kg dry matter. The most reliable indicators of nutritional muscular dystrophy in lambs are increased concentrations and activities of the enzymes aspartate aminotransferase, lactate dehydrogenase, and creatine kinase, together with low serum selenium and vitamin E levels and reduced glutathione peroxidase activity.

The administration of selenium - either in inorganic forms (sodium selenite or sodium selenate) or organic forms (selenomethionine, selenium-enriched yeast, selenium-enriched probiotics) - along with vitamin E, should be an integral component of prevention strategies for nutritional muscular dystrophy in all categories of sheep. The recommended selenium concentration in lamb diets is 0.2–0.3 mg Se/kg dry matter, while vitamin E requirements are approximately 0.3 mg/kg body weight per day. The maximum non-toxic selenium concentration for lambs is 2 mg Se/kg dry matter.

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**References**

Abood H.K., Judi A.M.H., Al-Ani A.A. (2012). The effect of experimentally induced vitamin E and selenium deficiency on Creatine Kinase (CK) and Aspartate Aminotransferase (AST) activities in Awassi ewes and their newborn lambs. Kufa Journal For Veterinary Medical Sciences, 3 (1), 132-137.

Bayomi Y.H., Mohamed W.A.M., Morsi A.K.M. (2017). Oxidative stress biomarkers in dystrophic lambs and kids in relation to body condition scores. Zagazig Veterinary Journal, 45 (S1), 189-200.

Błażejak-Grabowska J., Milewski S., Ząbek K., Sobiech P.H., Wójcik R.M., Żarczyńska K., Miciński J. (2022). Effect of longacting selenium preparation on health and productivity of sheep. Animals, Multidisciplinary Digital Publishing Institute, 12 (2), 140.

Değer Y., Mert H., Mert N., Yur F., Kozat S., Yörük I.H., Sel T. (2008). Serum selenium, vitamin E and sialic acids concentrations in lambs with white muscle disease. Biological Trace Element Research 121, 39-43.

Delesalle C., De Bruijn M., Wilmink S., Vandendriessche H., Mol G., Boshuizen B., Plancke L., Grinwis G. (2017). White muscle disease in foals: focus on selenium soil content. A case series. BMC Veterinary Research, 13, 121.

Duncan J.R., Prasse K.W. (1986). Veterinary laboratory medicine, clinical pathology. Second edition, Iowa, State University Press, Ames, 285.

El-Deeb W.M. (2010). Ascorbate-glutathion affiliation and the treatment of nutritional muscular dystrophy in lambs with special reference to the oxidative stress. Cercetrri Agronomice ĭn Moldova XLIII, (2), 77-86.

El-Neweehy T.K., Abdel-Rahman H.A.R., Al-Qarawi A.A. (2001). Some studies on nutritional muscular dystrophy in Qassim region in Saudi Arabia. Effect of administration of vitamin E-selenium preparation to pregnant ewes on serum muscle-specific enzymes in their lambs. Small Ruminant Research, 41 (1), 87-89.

Fancote C.R., Vercoe P.E., Pearce K.L., Williams I.H., Norman H.C. (2013). Backgrounding lambs on saltbush provides an effective source of Vitamin E that can prevent Vitamin E deficiency and reduce the incidence of subclinical nutritional myopathy during summer and autumn. Animal Production Science, 53 (3), 247-255.

Ghanem M.M., Anwar M.R., Abd El-Raof Y.M., El-Attar H.M. (2016). Clinical, hematological and biochemical changes in lambs suffered from nutritional muscular dystrophy. Behna Veterinary Medical Journal, 30 (2), 61-66.

Kohli R., Harris D.C., Whitington P.F. (2005). Relative elevation of serum alanine and aspartate aminotransferasee in muscular dystrophy. Journal of Pediatric Gastroenterology and Nutrition, 41 (1), 121-124.

Mc Murray C.H., Mc Eldowlney P.K. (1977). A possible prophylaxis and model for nutritional degenerative myopathy in young cattle. British Veterinary Journal, 133, 535-542.

Mehdi Y., Dufrasne I. (2016). Selenium in Cattle. A Review Molecules, 21, 545.

Qin S., Gao J., Huang K. (2007). Effects of different selenium sources on tissue selenium concentrations, blood GSH-Px activities and plasma interleukin levels in finishing lambs. Biological Trace Element Research, 116, 91-102.

Ramírez-Bribiesca E., Hernández-Camacho E., Hernandez-Calva L.M., Tórtora-Pérez J.L. (2004). Effect of parenteral supplement with sodium selenite on lamb mortality and hematic values of selenium. Agrociencia 38 (1), 43-51.

Ružić-Muslić D., Petrović M.P., Caro-Petrović V., Petrović M.M., Bjelić Z., Ilić Z., Stojković J. (2014). Effects of adding different forms of selenium in diets for fattening lambs. Biotechnology in Animal Husbandry 30 (4), 589-600.

Serratos M.J.H., Ramirez M.J., Farina I.G., Perez J.L.T., Trujillo E.H., Sanchez V.M.D. (2024). Description of lesions in lambs intoxicated with sodium selenite included in intraruminal boluses, lambs intoxicated with selenium. Veterinary Medicine and Science, 10 (5), 1584.

Slupczyńska M., Kinal S., Król B. (2009). Utilization of selenium compounds in nutrition of lambs. Journal o Elementology, 14 (1), 159-161.

Suttle N.F. (2010). Mineral Nutrition of Livestock (4th edition). CAB International.

Tiwary A.K., Stegelmeier B.L., Panter K.E., James L.F., Hall J.O. (2006). Comparative toxicosis of sodium selenite and selenomethionine in lambs. Journal of Veterinary Diagnostic Investigation, 18 (1), 61-70.

Yanuartono Y., Indarjulianto S., Paryuni A. D. (2024). The role of selenium and vitamin E in ruminants. Jurnal Ilmiah Ilmu-Ilmu Peternakan, 27 (1), 9-37.

Yildirim S., Irak K., Mert H., Dogan I., Mert N. (2016). Serum biochemical and histopathological examinations of some tissues of lambs with muscular dystrophy in van. Veterinary Medicine, 2, 52-55.

Żarczyńska K., Babińska I., Snarska A., Sobiech P. (2019). Levels of selenium and vitamin E in the blood and morphological changes in the biceps femoris muscle during nutritional muscular dystrophy of calves. Journal of Elementology, 24 (4), 1363-1370.

Żarczyńska K., Baumgartner W., Sobiech P. (2017). Coagulology, biochemical profile and muscle pathology in calves diagnosed with nutritional muscular dystrophy. Polish Journal of Veterinary Sciences, 20 (2), 387-394.