

Research Article

Investigation of Selected Trace Elements in Ovine Skin Disorders

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Abstract

This study aimed to determine the levels of certain trace elements in 30 sheep presented to Kırıkkale University Animal Hospital with complaints of skin problems and hair loss. Blood, skin, and hair samples were collected from the sheep for microbiological, parasitological, and biochemical analyses. No infectious or parasitic agents were detected in microbiological and parasitological examinations. Serum levels of zinc (Zn), copper (Cu), cobalt (Co), iron (Fe), manganese (Mn), selenium (Se), and molybdenum (Mo) were quantitatively analyzed using an ICP-OES device. The results revealed that Zn, Cu, Mn, and Co levels were below the reference ranges, while Fe was within normal limits and Se was higher than expected. Mo levels were found to be very low. Consistent with existing literature, especially Zn and Cu deficiencies were strongly associated with impaired skin integrity and poor fleece quality in sheep. Additionally, Co deficiency, through its role in vitamin B12 synthesis, indirectly affects skin health. The main cause of these deficiencies was attributed to the flock being fed exclusively with commercial feed and not having access to grazing. These findings highlight the necessity of including trace element analyses in routine examinations for sheep exhibiting dermatological issues. Following appropriate mineral supplementation and dietary adjustments, the flock's skin condition and fleece quality improved significantly. In conclusion, this study emphasizes the critical importance of maintaining trace element balance in sheep nutrition to ensure animal welfare and optimize economic productivity in sheep breeding.

Keywords: Sheep, skin disease, trace element, zinc, copper, mineral deficiency.

Introduction

Skin and wool quality hold significant economic importance in sheep farming. Dermatological disorders in sheep not only compromise animal welfare but also have a substantial impact on wool production and its quality one of the primary outputs of the sheep industry. Both inadequate nutrition and trace mineral deficiencies are recognized as critical factors influencing wool growth.

Trace elements are required in minute quantities to support the normal progression of numerous biochemical activities and metabolic functions within the body. In sheep, essential trace elements include zinc (Zn), molybdenum (Mo), manganese (Mn), copper (Cu), iodide (I), iron (Fe), and cobalt (Co). These elements are vital for maintaining animal health and productivity, as they function as integral components of various enzymes and play regulatory roles in a wide range of biological processes (Al-Zubaidi et al., 2025; Swecker & Van Saun, 2023).

Zinc plays a pivotal role in numerous enzymatic processes and is one of the primary elements influencing the structure and function of the skin. It is also involved in keratinization, calcification, wound healing, as well as somatic and reproductive development. Dietary zinc deficiency, along with factors that interfere with its absorption or utilization, can lead to wool loss, wool-chewing behavior, and the development of parakeratosis in sheep (Zavosthi et al., 2012).

Copper deficiency in sheep can manifest primarily and sometimes exclusively through wool abnormalities. These abnormalities may include loss of crimp, a metallic sheen with increased luster in fur fibers, and a general deterioration of wool structure. Since copper is involved in the activity of enzymes essential for melanin synthesis, its deficiency is also associated with achromotrichia a condition characterized by the loss of fur pigmentation.

Photodermatitis, characterized by skin crusting and ulceration, may be observed in affected animals (Ebrahim et al., 2016). Cobalt is a key component of cobalamin (vitamin B12), which is essential for the formation of red blood cells and the maintenance of nervous tissue integrity. In ruminants, cobalt deficiency may lead to fatigue, reduced milk production, coarse and brittle fur or fleece, anemia followed by muscular weakness, impaired coordination, and an unsteady gait (Helmer et al., 2023).

There is no specific evidence in the literature indicating a direct effect of molybdenum on skin or wool health. However, excessive molybdenum intake can interfere

with copper absorption and bioavailability, potentially leading to secondary copper deficiency. As a result, signs associated with copper deficiency (such as coat depigmentation and wool abnormalities) may emerge indirectly (Helmer et al., 2023).

Iron is a critical structural component of hemoglobin and is essential for erythropoiesis. Iron deficiency anemia has been associated with low birth weight, preterm delivery, and increased oxidative damage in erythrocytes at the placenta–fetus interface. Although there is no clear evidence in the literature directly linking iron deficiency to skin or wool health, trace mineral imbalances can broadly affect animal physiology, potentially leading to general weakening, which may indirectly compromise coat quality. Furthermore, excessive iron intake may contribute to secondary copper deficiency (Moniello et al., 2010). Selenium, in conjunction with vitamin E, contributes to the antioxidant defense of organisms by serving as a component of the enzyme glutathione peroxidase. It also plays a crucial role in the immune system and in the metabolism of thyroid hormones, and is essential for reproduction. Given its importance in immune and metabolic functions, selenium deficiency may lead to general health issues such as weakness in lambs, which could indirectly impair coat quality. As for manganese, there is no specific evidence in the literature suggesting a direct impact on skin or wool health (Moniello et al., 2010).

Materials and Methods

This study was approved by the Kırıkkale University Animal Experiments Local Ethics Committee (Approval No: E.325808).

The study material consisted of 30 sheep of varying ages presented to the Animal Hospital of Kırıkkale University with complaints of skin disorders and fur loss. Anamnesis revealed that similar symptoms were observed across the entire flock. On-site examination indicated that the sheep were not allowed to graze, were raised in an open housing system, and were fed exclusively with commercial feed. From a total population of 250 animals on the farm, 30 sheep were selected for inclusion in the study.

From the 30 sheep included in the study, fur samples were collected for microbiological analysis and skin scrapings were obtained for parasitological examination. All animals underwent clinical examination for ectoparasites. Blood samples were collected from the clinically examined sheep into vacuum serum tubes. The samples were centrifuged

at $1500 \times g$ for 10 minutes, and the resulting sera were stored at -20°C for the analysis of trace elements zinc, selenium, copper, manganese, cobalt, and molybdenum using inductively coupled plasma optical emission spectrometry (ICP-OES; SpectroBlue, Germany).

Inductive Plasma Optical Emission Spectrometry Review

The analysis of trace elements was carried out using inductively coupled plasma optical emission spectrometry (ICP-OES; SpectroBlue, Germany). Quantitative measurements of the analyzed elements were performed using the external calibration method based on calibration curves constructed from analytical standards at concentrations of 0, 0.001, 0.002, 0.005, 0.01, 0.02, 0.05, 0.1, 0.2, 0.5, 1, 2, 5, 10, and 20 ppm (Merck, Germany). The measurements of these analytical standards are summarized in Table 1.

Tissue sample digestion was performed using a microwave digestion system (CEM MARS 6), following the Blood Human and Animal Tissue methods. For sample pre-treatment (microwave digestion), 1 mL of serum was combined with 1 mL of 35% H_2O_2 and 5 mL of HNO_3 . The mixture was subjected to digestion in the CEM MARS 6 microwave system under the following conditions: Power: 290–1800 W, Ramp time: 20:00 minutes, Hold time: 15:00 minutes, Temperature: 200°C . The final volume was adjusted to 15 mL before proceeding with the analysis.

The instrumental conditions used during ICP-OES measurements are summarized in Table 2.

Table 1. Wavelength and optical emission values of elements analyzed in the ICP-OES device.

Display Name:	BEC:	DL:	Std.Error:	Corr.Coeff	Range
Cu 224.700	47,5 ppb	1,300 ppb	1,26 ppb	0.99989	1,300 - 240 ppb
Co 228.616	22,2 ppb	0,063 ppb	0,156 ppb	0.99999	0,063 - 240 ppb
Se 196.090	140 ppb	4,060 ppb	3,81 ppb	0.99994	4,060 - 1200 ppb
Mn 257.611	4,79 ppb	3,750 ppb	2,58 ppb	0.99997	0,375 - 1200 ppb
Zn 226.5029	95 ppb	0,199 ppb	0.94 ppb	0.999760	199-120 ppb
Fe 238.204	19,5 ppb	0,493 ppb	3,38 ppb	0.99996	0.493 - 1200 ppb
Se 196.090	140 ppb	4,060 ppb	3,81 ppb	0.99994	4,060 - 1200 ppb
Mo 202.095	24,9 ppb	1,070 ppb	3,56 ppb	0.99995	1,070 - 1200 ppb

Table 2. ICP-OES instrument conditions.

Parameters	Value
Plasma Power	1435 W
Pump Speed	30 rpm
Coolant Flow	13 L/min
Auxiliary Flow	0,80 L/min
Nebulizer Flow	0,75 L/min
Number of replicates	3
Integration time (s) :	3 s
Sample uptake rate ($\mu\text{L}/\text{min}$)(speed)	0.3 rps

Table 3. Limit detection value for heavy metals

	Cu	Co	Zn	Fe	Mn	Se	Mo
Tespit Sınırı	1,300	0,063	0,071	0,493	0,375	4,060	1,070

Results

Field observations of the sheep included in the study revealed widespread fur loss across the entire flock. In some animals, wool loss was concentrated particularly around the neck and shoulder regions (Figures 1 and 2), with fibers shed at varying lengths. In several sheep, complete alopecia was noted in the dorsal and cranial regions, with a total absence of fur in these areas (Figures 3 and 4). Aside from dermatological findings, the general condition, feeding behavior, and mobility of the animals remained normal, and no pruritus (itching) accompanied the skin problems.



Figure 1. Fur loss localized in the neck and chest regions.



Figure 2. Fur loss of varying lengths observed in the neck and shoulder regions.



Figure 3. Severe alopecia observed in the cranial (head) region.



Figure 4. Alopecia involving the entire dorsal and cranial regions.

Table 4. Trace element levels in sheep

Element	mean	std	min	max	Normal serum level	Referans
Cu µg/ml	0,696667	0,180485	0,32	1,12	0.70–1.27 µg/ml	Laboklin.com, Underwood & Suttle (1999)
Co µg/ml	0,000714	0,00378	0	0,02	0.05 – 0.15 µg/ml	Radostits et al. (2007), Underwood & Suttle (1999)
Zn µg/ml	0,594667	0,13164	0,36	0,9	0.78–1.18 µg/ml	Laboklin.com, Underwood & Suttle (1999)
Fe µg/ml	2,175	0,833413	0,99	4,94	1.0 – 2.5 µg/ml	Laboklin.com, Underwood & Suttle (1999)
Mn µg/ml	0,038667	0,118489	0,01	0,66	0.08–0.14 µg/ml	McDowell (2003)
Se µg/ml	0,512	10,31382	0,38	0,57	0.04–0.08 µg/ml	Radostits et al. (2007), Underwood & Suttle (1999)
Mo µg/ml	0,001333	0,007303	0	0,04	0.05 – 0.15 µg/ml	Radostits et al. (2007), Underwood & Suttle (1999)

Discussion

The mean concentrations of the analyzed trace elements were as follows: copper (Cu) – 0.696667 µg/mL, zinc (Zn) – 0.594667 µg/mL, iron (Fe) – 2.175 µg/mL, manganese (Mn) – 0.038667 µg/mL, selenium (Se) – 0.512 µg/mL, and molybdenum (Mo) – 0.001333 µg/mL. Cobalt levels were found to be below the detectable limit. The average iron level of 2.175 µg/mL was within physiological reference ranges. Findings from the sampled animals revealed a strong correlation between reduced zinc and copper levels and the observed dermatological symptoms.

The findings of this study are consistent with the effects of zinc (Zn) deficiency on skin integrity, wound healing, and wool quality as described by Gade et al. (2023). Zn plays a critical role in keratin synthesis and maintaining epithelial integrity, while copper (Cu) is essential for melanin synthesis, enzymatic oxidation, and connective tissue stability (Underwood & Suttle, 1999; Stapay et al., 2023). Helmer et al. (2021) reported a direct association between reduced serum Cu and Zn levels and skin disorders in sheep. The immunological, epithelial, and keratinization-related functions of Zn and Cu have been well documented in the literature, and the current findings are in agreement with these reports (Radostits et al., 2007; Gade et al., 2023). Autukaitė (2023) reported that mineral deficiencies are more frequently observed in sheep flocks in Estonia during the winter season. Similarly, Silva et al. (2018) observed dermatological and wool abnormalities in animals with serum concentrations below Cu: 10.97 ± 3.61 µmol/L and Zn: 8.63 ± 2.22 µmol/L. Zavoshti et al. (2012) also associated zinc deficiency with dermatological symptoms in Makuui breed sheep.

Cobalt (Co) deficiency, particularly in ruminants, disrupts energy metabolism by impairing vitamin B12 synthesis and may indirectly affect skin health. Therefore, undetectable Co levels may serve as an important indicator for identifying subclinical cases. On the other hand, the inability to detect Co concentrations suggests a profound deficiency of this trace element. Cobalt is an essential precursor for vitamin B12 synthesized by rumen microorganisms, and its deficiency is associated with weight loss, reduced appetite, anemia, and decreased performance (Radostits et al., 2007).

In our study, the mean iron (Fe) level was determined to be 2.175 µg/mL, falling within the established reference range, while the mean selenium (Se) concentration of 0.512 µg/mL was found to be

higher than standard reference values. Selenium (Se) and molybdenum (Mo) are considered critical trace elements for maintaining skin health in sheep. In a case of molybdenosis reported by Helmer et al. (2021), excessive Mo intake was shown to disrupt copper metabolism, indirectly contributing to deficiencies in both selenium and cobalt. This imbalance was associated with reduced wool quality and the presence of dermatological lesions. Majak (2006) emphasized the safety limits of Mo as a feed additive, warning about the risk of copper deficiency with excessive Mo intake. He examined in detail the influence of pasture and feed composition on Se and Mo levels, highlighting that high Mo content can negatively impact skin health due to its antagonism with copper (Silva et al., 2018). In the present study, Mo levels were low, and therefore, the observed copper deficiency was not attributed to molybdenum imbalance.

In the examined flock, the fact that the animals were exclusively fed with commercial feed, had no access to grazing, and showed negative results in both microbiological and parasitological analyses—along with decreased serum levels of Cu, Zn, Mn, and Mo—combined with widespread skin disorders and fur loss in nearly all animals, suggested that the problem might have originated from the feed.

Following changes in the feeding regimen and the supplementation of the deficient trace elements, the dermatological symptoms in the flock were resolved.

Conclusion

In this study, significantly reduced levels of zinc (Zn), copper (Cu), and manganese (Mn) were detected in sheep presenting with skin disease. The inability to detect cobalt (Co) concentrations indicates a severe deficiency. These findings highlight the importance of incorporating trace element analysis into routine clinical evaluations. Mineral supplementation strategies should be individualized according to the animal's age, physiological status, and environmental conditions.

Treatment protocols should be based not only on clinical symptoms but also on trace element analyses. The findings of our study are supported by existing literature and emphasize the need for regular monitoring of trace element levels. Routine serum trace element analysis is crucial for developing feeding strategies tailored to specific rations and the individual mineral requirements of animals.

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