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ELEMENTAL COMPOSITION OF DISTAL PHALANX IN CROSSBRED CATTLE OF KERALA AND ITS ASSOCIATION WITH CLAW HORN DISRUPTION LESIONS

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ABSTRACT

The present study was aimed at evaluating the mineral composition of the distal phalanx in crossbred cattle of Kerala and exploring its possible association with Claw Horn Disruption Lesions (CHDL). A total of 24 crossbred female cattle were categorised into four groups based on parity and presence of CHDL. The distal phalanges were collected post-mortem and analysed for 19 elements using ICP-OES following AOAC protocols. Significant differences in the levels of calcium, copper, magnesium, molybdenum, manganese, phosphorus, and zinc were noted across groups. Notably, cattle affected with CHDL showed elevated concentrations of Ca, Cu, Mg, Sr, and Zn. The findings suggested that mineral composition of the distal phalanx may influence claw health and potentially contribute to the development of CHDL, though further research is warranted to establish a definitive link.

Keywords: Distal phalanx, Crossbred cattle, Claw horn disruption lesions, Mineral composition, Lameness

INTRODUCTION

Lameness is a pressing welfare and economic issue in the dairy industry, often attributed to Claw Horn Disruption

Lesions (CHDL) such as sole ulcers, white line disease and haemorrhages. These conditions are linked to biomechanical and metabolic factors influencing claw health (Enting *et al.*, 1997; Chapinal *et al.*, 2010; Machado *et al.*, 2010; Newsome *et al.*, 2017; Thomas *et al.*, 2023). Among the internal anatomical structures of the bovine hoof, the distal phalanx plays a pivotal role in supporting the animal's weight and shaping the claw capsule.

The integrity and mineral density of the distal phalanx are believed to influence the biomechanical resilience of the claw, affecting how forces are distributed during locomotion (Lischer *et al.,* 2002). Studies have suggested that alterations in the mineral content of bone may predispose cattle to hoof-related pathologies, especially in metabolically active tissues like those in the claw region (Newsome *et al.,* 2016). Minerals such as calcium, phosphorus and magnesium contribute to bone rigidity, while trace elements like zinc and copper influence keratin synthesis and tissue repair (Zaho *et al.,* 2015).

Despite the anatomical and physiological importance of the distal phalanx, limited data is available regarding its elemental composition in Indian cattle, especially in relation to CHDL. This study was undertaken to determine the mineral profile of the distal phalanx in crossbred cattle and assess possible associations with the occurrence of CHDL.

MATERIALS AND METHODS

The study was conducted on hoof capsule of 24 crossbred female cattle that were slaughtered at the Meat Technology Unit (MTU), Mannuthy, Kerala Veterinary and Animal Sciences University (KVASU). The cattle bought for slaughter at the MTU, Mannuthy were subjected to a thorough clinical examination of feet prior to slaughter and the body condition score (BCS) of the cattle were recorded. Those with medium to good BCS and sound claws were selected and divided into three groups based on parity. The fourth group of cattle included cows, which were culled with a history of CHDL (Table 1).

Table 1. Experimental groups under study

Groups	Animal category	Criteria	Number of animals
Group- I	Heifers	Medium to good BCS and sound claws	6
Group- II	First to third parity		6
Group- III	More than three parities		6
Group- IV	All age groups	With CHDL	6

Once the slaughter procedure was completed, the hooves were separated from the carcass by cutting at the level of carpal joint in forelimb and at the level of tarsal joint in hindlimb. After collection, the hooves were thoroughly cleaned to remove the dirt and dung particles and were stored at -20ºC. By putting a sagittal incision at the sole region, the distal phalanx was exposed and a small piece of distal phalanx was separated.

Elemental/ mineral composition of distal phalanx was as estimated as per AOAC(2016), using ICP- OES. The composition of 19 minerals was analysed in the distal phalanx of the left lateral claw of the hindlimb in all groups of cattle under study. Statistical significance of the difference between the treatment groups were analysed by one way ANOVA.

RESULTS AND DISCUSSION

The present study analysed the mineral composition of 19 elements in the distal phalanx of the left lateral claw in the hindlimb across the four animal groups. The analysis did not detect the presence of arsenic (As), cadmium (Cd), cobalt (Co), chromium (Cr), lithium (Li), mercury (Hg), nickel (Ni), selenium (Se) and antimony (Sb) in the examined samples.

Calcium (Ca)

No significant variations were detected in the Ca content within the distal phalanx among the four distinct animal groups. The distal phalanx of cows affected with CHDL exhibited the highest Ca concentration, while heifers had the lowest Ca levels (Table 2).

Copper (Cu)

Significant differences were observed in the Cu composition of distal phalanx among the four different groups. The distal phalanx of cows affected with CHDL exhibited the highest Cu concentration, while heifers had the lowest Cu levels. The observed values in the present study were much higher than those reported by Ammerman *et al.* (1974) and Nour and Thonne (1988).

Iron (Fe)

Iron content within the distal phalanx among the four animal groups did not exhibit any significant difference. The distal phalanx of heifers exhibited the highest Fe concentration, while cows beyond their third parity had the lowest Fe levels. The observed values in the present study were much higher than those reported by Ammerman *et al.* (1974) and Nour and Thonne (1988).

Lead (Pb)

The present study showed presence

Table 2. Comparative analysis of mineral composition (Mean ± SE) of distal phalanx across various animal groups in the study (ppm)

Mineral	Group	Mineral composition in ppm (Mean ± SE)	F value
Calcium (Ca)	Heifers	82990.17 ± 14956.48^{a}	3.420^{NS}
	Cows of parity C1 to C3	116376.50 ± 21774.16^{ab}	
	Cows of parity above C3	127260.17 ± 8288.90^{b}	
	Cows affected with CHDL	143902.67 ± 2667.92^{b}	
Copper (Cu)	Heifers	12.75 ± 1.61^{a}	105.606**
	Cows of parity C1 to C3	13.70 ± 1.16^{a}	
	Cows of parity above C3	22.88 ± 3.14^{a}	
	Cows affected with CHDL	194.83 ± 16.98^{b}	
Iron (Fe)	Heifers	124.92 ± 9.42	1.579^{NS}
	Cows of parity C1 to C3	103.37 ± 8.87	
	Cows of parity above C3	102.90 ± 8.94	
	Cows affected with CHDL	110.00 ± 4.48	
Lead (Pb)	Heifers	1.03 ± 0.11	2.433^{NS}
	Cows of parity C1 to C3	2.10 ± 0.53	
	Cows of parity above C3	1.98 ± 0.35	
	Cows affected with CHDL	1.05 ± 0.36	
Magnesium (Mg)	Heifers	2282.3 ± 140.10^{a}	7.142**
	Cows of parity C1 to C3	2114.57 ± 141.22^{a}	
	Cows of parity above C3	2451.33 ± 259.46^{a}	
	Cows affected with CHDL	3172.33 ± 120.44^{b}	
Molebdenum (Mo)	Heifers	0.75 ± 0.16^{b}	6.417**
	Cows of parity C1 to C3	0.72 ± 0.07^{b}	
	Cows of parity above C3	0.33 ± 0.10^{a}	
	Cows affected with CHDL	0.24 ± 0.03^{a}	
Manganese (Mn)	Heifers	3.92 ± 0.44^{c}	14.014**
	Cows of parity C1 to C3	2.43 ± 0.68^{b}	
	Cows of parity above C3	0.78 ± 0.11^{a}	
	Cows affected with CHDL	0.60 ± 0.17^{a}	
Phosphorous (P)	Heifers	5868.0 ± 514.23^{a}	10.228**
	Cows of parity C1 to C3	9081.68 ± 1112.84^{b}	
	Cows of parity above C3	10864.17 ± 438.28^{b}	
	Cows affected with CHDL	9617.33 ± 277.18^{b}	
Strontium (Sr)	Heifers	57.43 ± 4.40	0.493^{NS}
	Cows of parity C1 to C3	58.00 ± 9.80	
	Cows of parity above C3	56.67 ± 6.80	
	Cows affected with CHDL	67.17 ± 5.96	
Zinc (Zn)	Heifers	38.73 ± 1.69^{a}	10.359**
	Cows of parity C1 to C3	47.88 ± 2.60^{b}	
	Cows of parity above C3	53.28 ± 4.01^{b}	
	Cows affected with CHDL	62.00 ± 3.32^{c}	

Means bearing different superscript differs significantly at 0.01 level of significance; NS - Non-significant of trace amounts of Pb in the examined bone samples. No significant variations were detected in the Pb content among the four animal groups.

Magnesium (Mg)

The Mg composition of distal phalanx among the four groups of cattle exhibited significant difference. The highest Mg concentration was observed in cows affected with CHDL and the lowest in cows of parity from first to third.

Molybdenum (Mo)

Significant variations were detected in the Mo content within the distal phalanx among the four distinct animal groups that were investigated. The distal phalanx of heifers exhibited the highest Mo concentration, while cows affected with CHDL had the lowest Mo levels.

Manganese (Mn)

The distal phalanx showed significant differences in the Mn composition among the four groups of cattle. The highest Mn concentration was observed in the distal phalanx of heifers and the lowest in cows affected with CHDL.

Phosphorous (P)

Significant variations were detected in the P content within the distal phalanx among the four animal groups. The distal phalanx of cows of parity beyond third exhibited the highest P concentration, while heifers had the lowest P levels.

Strontium (Sr)

No significant differences were observed in the Sr composition of distal phalanx among the four groups of cattle.

Zinc (Zn)

The Zn composition of distal phalanx among the four groups of cattle exhibited significant differences. The distal phalanx of cows affected with CHDL exhibited the highest Zn concentration, while heifers had the lowest Zn levels. The observed values in the present study were lower than those reported by Ammerman *et al.* (1974) and Nour and Thonne (1988).

SUMMARY

The current study provides a preliminary insight into the elemental profile of the distal phalanx in crossbred cattle under different parity and health conditions. Cows affected by CHDL demonstrated elevated concentrations of calcium, copper, magnesium, strontium and zinc compared to healthy counterparts. Although these findings suggest a possible association between altered mineral levels and CHDL, the absence of a clear trend and lack of comparable literature limit definitive conclusions.

Future studies involving larger sample sizes and histomorphometric correlation of mineral density with severity of hoof lesions may offer deeper insights into the pathophysiological mechanisms of CHDL and contribute to the development of nutritional or management-based prevention strategies.

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