A Comparative Study on some Claw and Blood Mineral Contents in Buffaloes and Cows

El – Ghoul, W. S.

Department of Surgery, Anaesthesiology and Radiology
Faculty of Veterinary Medicine
Cairo University, Giza, Egypt.

Summary

Calcium, magnesium, copper and zinc contents were determined in the claw horny materials and serum of 10 healthy buffaloes, 10 healthy Egyptian cows, 10 healthy friesian cows and 10 friesian cows suffered from claw affections. The results showed that the claw calcium, magnesium, copper and zinc contents were significantly higher in buffaloes than cows. The average calcium, magnesium and zinc were significantly lower while the copper content was significantly higher in cows suffered from claw affections. Claw magnesium and copper contents were significantly higher in the hind claws than the fore ones whereas, insignificant differences were found between medial and lateral claws. The serum calcium was insignificantly higher whereas the magnesium was significantly higher in buffaloes than cows. The average serum calcium, magnesium and zinc concentration were insignificantly lower in cows suffered from claw affections. In conclusion, it can be said that the presence of macro- and micro-elements in an optimal contents is very important and facilitates a correct keratinization and cornification of the claw which are prerequisites for an optimal horn quality and the prevention of claw affections. There is a strong correlation between claw and serum mineral contents and the buffalo claws were of higher quality than friesian cows, a result which should take in consideration in animal breeding program in Egypt.

Keywords: Buffaloes, cows, claw, claw affections, mineral contents.

Introduction

Claw lameness in dairy cattle is a major cause of financial loss to the farmers and of pain and discomfort to the cattle. The claw horny material is largely responsible for protecting the claw from external influences such as hard abrasive surfaces, noxious substances or infectious agents. The ability of the claw horn to withstand the environment depends mainly an its physical properties, in particular its hardness, toughness and viscoelasticity which in turn are determined by the structure and chemical composition of the keratin forming the horn (Baggott et al., 1988).

The bovine claw is a modified epidermal structure indicates the health of domestic animals and reflecting a physiological adequate supply of nutrients, vitamins, minerals (calcium and phosphorus) and trace elements (zinc, copper and magnesium). The claw's, health depends an the optimal horn quality which is determined by the horn cell structure (Mülling et al, 1999). The claw horn is made up of keratin which is basically protein linked by disulphide bonds and bound by small amounts of fat and minerals (Ca, P, Na, K, Mg, Cu, Fe, Zn, Se and S) and a variable amount of water (Baggott et al, 1988).

The horn quality is influenced by organic and inorganic components of the keratin, the intercellular cementing substance, and the architecture of horn cells in tubular and intertubular horn. Differences in the structure and composition of these factors determine the different degrees of claw horn quality. Horn of poor quality would be liable to more rapid abrasion from wear and tear and may reduce the protection offered to the solar region predisposing to claw affections (El-Ghoul, 1991 and Mülling et al., 1994).
Deficiency of various macro- and microelements has been implicated in the pathogenesis of claw affections as these minerals are required for the production of healthy high quality claw horn. The most important minerals in relation to claw affections are calcium, magnesium, copper and zinc (Faye and Lescoureet, 1989 and Johnson and Schugel, 1994). Mineral supplementation seems to be very beneficial to the claw health of dairy cows (Demertzis and Mills, 1973).
Claw horn hardness was differed among different breeds and specially the pigmented and unpigmented horny material which may be attributed to the difference in the chemical composition of the claw horn (Feder, 1969; Hubert, 1993 and Hong et al, 1996). A high incidence of claw affections was seen in friesian cows than in buffaloes and Egyptian cows (El-Ghoul, 1991).
The horny tissue indicates a state of continous turnover and so a detailed knowledge of the mineral composition of claws may be important in cattle production (Hidiroglou & Williams, 1986). Determination of claw mineral composition was used as a tool for selecting bulls with high claw quality (Sugg et al., 1996).

The aim of the present work was to determine some inorganic elements of the claw horn and serum of normal buffaloes, Egyptian cows, friesian cows and friesian cows suffered from claw affections to search in the relation between claw mineral contents and the occurrence of claw affections. Also to search in the correlation between mineral contents in the claw and those in the serum.

Materials and Methods

Claw horny material examination

The study was carried out on 10 healthy buffaloes, 10 healthy Egyptian cows, 10 healthy friesian cows and 10 friesian cows suffered from claw affections. After the claw was cleaned and pared, about 2 gm of claw horny material was collected using claw knife from the sole of left fore and hind claws of each animal. The claw samples were taken from the same anatomical region in all animals.
The claw samples were rinsed with distilled water and dried at 115°C for 24 hours. The dried samples were ashed in a muffle furnace at 550°C for 18 hours and the ash content expressed as a proportion of the dry matter. The samples were prepared by wet ashing in 25% H_2SO_4 (Lepine et al, 1985). Calcium, magnesium, copper and zinc were then determined using atomic absorption spectrophotometer. All values were expressed as a proportion of the dry matter.

Blood examination

Blood samples were taken from all the examined animals for serum collection which analyzed for calcium, magnesium, copper and zinc using autoanalyser. The data were analyzed by t-test and one-way ANOVA using SPSS (Statistical Product & Service Solutions) (Kuehl, 1994). All data were presented as mean ± standard error, and $p< 0.05$ was considered significant.

Results

Claw mineral contents

The results showed that among the three examined species, the average claw horny material calcium and copper contents in buffaloes were significantly ($p < 0.05$ higher than those in friesian cows. The magnesium and zinc contents in buffaloes were significantly ($p< 0.05$) higher than those in friesian and Egyptian cows (Table 1).

Table 1: Claw mineral contents in healthy buffaloes, Egyptian and friesian cows

	Buffaloes	Egyptian cows	Friesian cows
Calcium (mg/kg DM)	1246.67 ± 56.91*	1170.36 ± 72.29	1119.26 ± 72.57
Magnesium (mg/kg DM)	321.03 ± 44.31*	248.93 ± 26.06	246.81 ± 23.86
Copper (µg/kg DM)	25.01 ± 4.56*	23.06 ± 5.82	13.62 ± 2.61
Zinc (µg/kg DM)	128.35 ± 8.04*	103.41 ± 9.62	105.96 ± 9.13

The average claw horny material content of calcium, magnesium and zinc were, significantly ($p < 0.05$) lower and the copper content was significantly ($p<0.05$) higher in friesian cows suffered from claw affections than in healthy ones (Table 2).

Table 2: Claw mineral contents in healthy and claw affected friesian cows

	Healthy friesian cows	Friesian cows with claw affections
Calcium (mg/kg DM)	1319.26 t±72.57	973.16 ± 81.42*
Magnesium (mg/kg DM)	246.81 ± 23.86	217.32 ± 29.79*
Copper (µg/kg DM)	13.62 ± 2:61	21.06 ± 4.19*
Zinc (µg/kg DM)	135.96 ± 9.13	71.14 ± 5.29*

In buffaloes hind claws, the magnesium and copper contents were significantly ($p<0.05$) higher than the fore ones and insignificant differences were found in the calcium and zinc contents. In the Egyptian cows, the magnesium and copper contents were significantly ($p<0.05$) higher and the zinc was significantly ($p<0.05$) lower in the hind claws than in the fore one. In friesian cows the magnesium content was significantly ($p<0.05$) higher in the hind claws than the fore one (Table 3).

Table 3: Claw mineral contents in the fore and Kind claws of healthy buffaloes, Egyptian and friesian cows

	Buffaloes		Egyptian cows		Friesian cows	
	Fore claw	**Hind claw**	**Fore claw**	**Hind claw**	**Fore claw**	**Hind claw**
Calcium (mg/kg DM)	1200.37 ± 26.68	1289.65 ± 107.64	1282.15 ± 103.56	1008.89 ± 69.17	1259.87 ± 86.49	1477.63 ± 97.44
Magnesium (mg/kg DM)	184.53 ± 19.15	468.04 ± 70.24*	191.23 ± 14.61	329.70 ± 49.90*	200.97 ± 10.23	327.02 ± 38.51*
Copper (µg/kg DM)	10.12 ± 1.97	41.05 . ± 6.90*	9.80 ± 2.19	43.70 ± 11.77*	12.37 ± 1.94	15.81 ± 6.86
Zinc (µg/kg DM)	136.15 ± 12.63	123.80 ± 10.48	134.18 ± 8.29	60.34 ±8.68*	139.08 ± 12.51	130.50 ± 14.14

Comparison of the mineral contents in the fore and hind claws in healthy and claw affected friesian cows revealed that the magnesium content was significantly ($p<0.05$) higher in the hind claws than the fore one. Insignificant differences were found in the average calcium, copper and zinc contents (Table 4).

Table 4: Claw mineral contents in the fore and hind claws of healthy and claw affected friesian cows

	Healthy friesian cows		Friesian cows with claw affections	
	Fore claw	**Hind claw**	**Fore claw**	**Hind claw**
Calcium (mg/kg DM)	1259.87± 86.49	1477.63± 97.44	1006.49±125.57	945.88 ±111.42
Magnesium (mg/kg DM)	200.97 ± 10.23	327.02 ± 38.51*	154.79 ± 44.07	265.43 ± 36.26
Copper (µg/kg DM)	12.37 ± 1.94	15.81 ± 6.86	23.60 ± 6.40	18.37 ± 5.47
Zinc (µg/kg DM)	139.08 ± 12.51	130.50 ± 14.14	67.62 ± 5.98	73.46 ± 7.88

Concerning the mineral contents in the medial and lateral claws insignificant difference were found in the average calcium, magnesium, copper and zinc contents among the three examined species and between clinically healthy and claw affected friesian cows (Table 5 & 6).

Table 5: Claw mineral contents in the medial and lateral claws of healthy buffaloes, Egyptian and friesian cows

	Buffaloes		Egyptian cows		Friesian cows	
	Medial claw	**Lateral claw**	**Medial claw**	**Lateral claw**	**Medial claw**	**Lateral claw**
Calcium (mg/kg DM)	1295.80 ± 90.06	1201.04 ± 72.16	1072.53 ± 109.35	1251.89 ± 93.86	1391.17 ± 96,81	1232.97 ± 10721
Magnesium (mg/kg DM)	345.87 ± 78.54	301.16 ± 51.20	197.89 ± 16.35	299.97 ± 45.81	250.21 ± 37.31	242.73 ± 32.19
Copper (µg/kg DM)	31.05 ± 7.06	20.18 ± 5.86	16.20 ± 6.09	30.55 ± 10.02	14.77 ± 4.20	12.25 ± 3.20
Zinc (µg/kg DM)	119.40 ± 9.31	137.73 ± 10.16	105.56 ± 16.22	101.27 ± 11.09	141.39 ± 12.79	129.45 ± 13.91

Table 6: Claw mineral contents In the medial and lateral claws of healthy and claw affected friesian cows

	Healthy friesian cows		Friesian cows with claw affections	
	Medial claw	**Lateral claw**	**Medial claw**	**Lateral claw**
Calcium (mg/kg DM)	1391.17 ± 96.81	1232.97± 107.2	975.57 ± 103.8	970.21 ± 136.0
Magnesium (mg/kg DM)	250:21 ± 37.31	242.73 ± 32.19	172.47 ± 37.18	266.26 ± 44.33
Copper (µg/kg DM)	14.77 ± 4.20	12.25 ± 3.20	19.51 ± 5.39	22.70 ± 6.62
Zinc (µg/kg DM)	141.39 ± 12.79	129.45 ± 13.91	65.41 ± 6.28	76.36 ± 8.34

Blood mineral concentration

The average serum calcium value was insignificantly higher and the magnesium was significantly ($p<0.05$) higher in the buffaloes than friesian cows. Insignificant changes were found in the serum copper and zinc concentration (Table 7).

Table 7: Serum mineral concentrations in healthy buffaloes, Egyptian and friesian cows

Serum parameters	Buffaloes	Egyptian cows	Friesian cows
Calcium (mmol/l)	2.45 ± 0.023	2.39 ± 0.031	2.34 ± 0.020
Magnesium (mmol/l)	1.21 ± 0.022*	0.912 ± 0.014	0.875 ± 0.013
Copper (µmol/l)	10.43 ± 0.233	11.86 ± 0.135	11.28 ± 0.215
Zinc (µmol/l)	10.48 ± 0.276	10.52 ± 0.196	10.85 ± 0.293

It was found that the average serum calcium, magnesium and zinc values in cows affected by claw lesions were insignificantly lower than healthy ones (Table 8).

Table 8: Serum mineral concentration in healthy and claw affected friesian cows

Serum parameters	Healthy friesian cows	Friesian cows with claw affections
Calcium (mmol/l)	2.34 ± 0.020	2.10 ± 0.024
Magnesium (mmol/ l)	0.875 ± 0.013	0.794 ± 0.019
Copper (µmol/l)	11.28 ± 0.215	**10.78 ± 0.210**
Zinc (µmol/l)	**10.85 ± 0.293**	**9.46 ± 0.286**

Discussion

The results of mineral analysis of claw samples in healthy buffaloes, Egyptian cows and friesian cows indicated that the claw contents of calcium, magnesium, copper and zinc were significantly higher in buffaloes than cows. The difference in claw mineral contents in the three examined species indicated the role of genetic and breed difference in the predisposition to claw affections. The higher claw mineral contents in buffaloes may explain the high quality claw horny material which make the buffalo claw more resistance to the external and internal influences and decrease the incidence of claw affections. The lower mineral contents in the claws of friesian cows lead to structural alteration, production of soft low quality horny material predisposing to claw affections. This result was more or less in agreement with the findings of Bodurov et al. (1981) who found lower mineral contents in Black Pied breed that have higher incidence of claw affections. Meanwhile, Feder (1969) found insignificant differences in the claw wall contents of Ca, Mg, Cu and Zn of the normal claws of Schwarzbunt, Rotbunt and Angler cows.

Calcium plays an important role in the regulation of cellular differentiation and desquamation of epidermal keratinocytes and influence the hardness of keratins by virtue of its presence and the crystal structure of the complexes it form (Vicanova et al., 1998). Calcium is an essential element acting as an enzyme cofactor or activator during the process of keratinization. In this context, the calcium-dependent epidermal transglutaminase must be emphasized, since it plays a key role in the production of the cornified envelope protecting the horn cells against proteolytic enzymes. Copper is

important in the incorporation of disulphide bonds into the protein molecules which form a major part of the keratin matrix. Such bonds determine the physical properties of keratin. Zinc is known to be of importance in keratin synthesis and claw horn formation and it plays an important role in making the claw horn more resistance to stress (Banting, 1978).
Comparing the claw contents of calcium, magnesium, copper and zinc in healthy friesian cows in the present study with the previously reported analysis revealed similarities and differences among authors (Table 9).

Table 9: Claw sole mineral contents in healthy friesian cows comparing the present study with previously reported analysis

	Hidrioglou 8 Williams (1986)	Naumann et al (1987)	Baggott et al (1988)	Normal cows in the present study
Ca (mg/kg DM)	1565 ± 66.53	1200 ± 69.87	635 ± 25.0	1319.26 ± 72.57
Mg (mg/kg DM)	464 ± 22.45	800 ± 20.31	213 ± 11.1	246.81 ± 23.86
Cu (µg/kg DM)	2.8 ± 0.984	4.5 ± 1.01	6.28 ± 0.5	13.62 ± 2.61
Zn (µg/kg DM)	71.88 ± 8.14	110 ± 5.78	65.8 ± 1.7	135.96 ± 9.13

The average claw calcium, magnesium and zinc contents in cows suffered from claw affections were significantly lower whereas the average copper was significantly higher than those in healthy ones. This was similar to the findings of Demertzis and Mills (1973) who found zinc in reduced quantities in the claw horn of cows with claw disorders, whereas, copper content rises in inflamed tissues. Kovacs & Siliagyi (1974) reported that calcium content of affected horn was significantly higher compared with that in healthy one, the copper content was normal, while magnesium and zinc contents were slightly above normal. Baggott et al while the copper and zinc contents were significantly lower in claw affected cows. On the other side, Kerk (1970) and Bodurov et al (1981) found insignificant differences. Such differences in mineral contents between healthy and affected horn could arise from generalised cellular incompetence due to pathological changes, malabsorption of these elements from the diet, or defective metabolism (Baggott et al., 1988). The deficiency of one or more elements induces structural alterations. These in turn result in a greater or lesser reduction of the horn cell quality which serves as a major parameter of claw health. Therefore, the above mentioned mineral elements must be considered in feeding (Mülling et al, 1999).

In the present study, the magnesium and copper contents in the hind claws of the three examined species were significantly higher than those in the fore ones. Meanwhile Baggott et al (1988) found insignificant increase in Ca and Mg and insignificant decrease in Cu and Zn in the affected hind claws. This would suggest that the observed changes in mineral contents might have been a consequence of generalised differences in availability of the elements to the keratin forming cells. On the other side, Kerk (1970) found insignificant differences in the claw calcium, magnesium, copper and zinc contents between the affected fore and hind claws.

Insignificant differences were observed between medial and lateral claws in healthy buffaloes and cows and also in friesian cows suffered from claw affections. This was in agreement with the findings of Baggott et al (1988) who found that the normal cows showed insignificant differences for any of the examined mineral components between the medial and lateral claws. In contrast, the lateral claw of lame cows had higher magnesium content than the medial one. The changes in the lateral claw might be ei-

ther the result of claw lesions which occur predominantly in the lateral claw or the difference effects an medial and lateral claw, for example, excessive loading (Toussaint - Raven, 1994).

Regarding the serum concentration of calcium, magnesium, copper and zinc the results showed that the calcium was insignificantly higher and magnesium was significantly higher in buffaloes than friesian cows. Blood mineral concentration is an important indicator of the general nutritional status of the animal and the changes in its concentration may affect the claw mineral contents (Moor et al, 1975 and Smart et al, 1992). Minerals are essential for activation of enzymes that are a prerequisite for physiological keratinization and cornification of the claws (Mulling et al., 1999).

The average serum concentration of calcium, magnesium and zinc in cows suffered from claw affections were insignificantly lower than healthy one. This was similar to the findings of Demertzis (1978) who found that zinc deficiency in cattle causes parakeratosis, abnormal claw growth, excessive growth of soft horn and lameness. Zinc plays an important role in securing keratin formation and integrity of the skin as a great part of zinc in feed is diverted to the skin and its appendices for keratin formation (Signorini., 1964). Supplementation of zinc methionine and zinc sulphate significantly increase claw strength and integrity and control the prevalence and severity of claw affections (Demertzis and Mills, 1973 and Moor et al, 1975). An increase in claw lameness was noticed in calcium deficient cows or persistently negative calcium balance (Smith, 1975).

The results of mineral analysis in the three examined species indicated a strong correlation between calcium, magnesium and zinc in the serum and claw horny material.
In conclusion it can be said that the mineral contents of calcium, magnesium, copper and zinc in the buffaloes claw horny material were significantly higher than those in Egyptian cows and friesian cows claws; a result which may explain the low incidence of claw affections in buffaloes and the high incidence in friesian cows. The claw contents of calcium, magnesium and zinc were significantly lower and the serum concentration of calcium, magnesium and zinc was insignificantly lower in cows suffered from claw affections than healthy ones. A result which indicated a strong correlation between claw and serum mineral contents. The mineral contents of the claw are of central importance and play a key rote in synthesis of the keratinized claw epidermis. The presence of these minerals in an optimal contents facilitates a correct keratinization and cornification of the claw, which are presquities for an optimal horn quality adapted to the local mechanical stresses. The deficiency of one or more minerals induces structural alterations. These in turn result in a greater or lesser reduction of the horn cell quality which serves as a major parameter of claw health. It can be said that the buffaloes claw horny material is genetically harder and of high quality than the friesian cows and must be considered in the breeding program in Egypt.

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