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Effect of supplementation of zinc methionine on claw characteristics in crossbred dairy cattle

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ABSTRACT

Lactating dairy cows (28) selected from a commercial dairy herd were stratified into 2 groups of 14 animals each by keeping approximately equal number of animals with different lameness scores in both the groups. Fourteen animals in the treatment group were supplemented with zinc methionine (ZM) for 5 months in a controlled study keeping the other 14 as untreated control. Hoof trimming was undertaken in all the dairy cows before and after the trial period. Claw lesions were examined to evaluate the effect of ZM on the frequency and severity of claw lesions. It was observed that supplementation of ZM resulted in significant decline in disease score owing to heel erosions and sole avulsions. White line hemorrhages though present in small number disappeared totally after supplementation. ZM caused a nonsignificant impact on the recurrence of overgrown soles and significant effect on corkscrew hooves. However, there was not much improvement in lameness score and rear leg view conformation. On the whole, a significant decline in number of heel erosions, sole avulsions, resolution of all the white line hemorrhages and a control on the reoccurrence of overgrowths resulted in significant decline in overall disease score in cows fed ZM. Trace mineral analysis of hooves before and after supplementation of ZM revealed a non-significant increase in hoof sole zinc status with no change in sole copper, manganese and iron levels.

Key words: Foot lesions, Heel erosions, Overgrown soles, Sole avulsions, Zinc methionione

Incidence of lameness varies from 2 to 69% in different countries (Hedges 2001, Jubb and Malmo 1991). Randhawa (2006) revealed 9% clinical lameness in lactating cattle and 2% in lactating buffaloes however the subclinical lesions affecting hooves may reach 40 to 50% in both. Early detection of subclinical laminitis is critical allowing the livestock owners to implement practices to quell lameness outbreaks. Among the various predisposing factors responsible for causing lameness in animals, nutrition is of great importance and within nutrition, trace elements like zinc, copper, manganese and iron play an important role in minimizing laminitis through their roles in immune function, the production of horn tissue and maintenance of epithelial and connective tissue. Zinc is the trace mineral that has received the most attention. Biotin supplementation improved the claw integrity in dairy cattle (Randhawa *et al*. 2008b). However amino acid complexes of trace minerals are found more bioavailable (Paripatananont and Lovell 1995, Wedekind *et al*. 1992) and are better retained by the body (Nockels *et al*. 1993) than inorganic sources of trace minerals. Feeding cattle specific amino acid complexes of zinc reduced SCC, increased milk production (Kellogg *et al*. 2004) and improved claw integrity (Moore *et al.* 1989, Nocek *et al*. 2000). Cows fed on additional 200 mg of zinc/day in the form of zinc methionine (ZM) had fewer cases of foot rot, heel cracks, interdigital dermatitis and laminitis than cows not fed ZM (Moore *et al*. 1989). Also the incidence of ulcers and white line disease tended to decrease. The objective of this experiment was to characterize the type and severity of clinical digital abnormalities in the commercial dairy herds and to evaluate the effect of supplementation of ZM on the prevalence of digital abnormalities.

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MATERIALS AND METHODS

Holstein crossbred dairy cows (28) from a commercial dairy farm of Punjab were stratified into 2 groups of 14 animals each by keeping approximately equal number of animals with different lameness scores in both the groups. The animals in the treatment group received 3 g of 12% ZM/ animal supplying 360 mg of zinc daily, in addition to routine mineral mixture for the trial period (5 months). However, those in the control group received only routine mineral mixture for the same period.

Animals and their management: All the animals were in the age group of 3–7 years with average weight between 400–500 kg and normal history of parturition but 10 animals having history of retained placenta at calving. All the animals in their second and third trimester of their lactation and having average lactation yield up to 4000 kg. They were given concentrates @ 400 g /kg of milk produced in addition to 2 kg for maintenance as well as 35–40 kg of green fodder daily. They were kept tied on cemented brick floor during the day time in the barn and left loose for 4 h after morning milking and 8 h after evening milking on the kacha floor.

Lameness scoring and rear leg view conformation: Gait of each animal was examined by 2 examiners simultaneously by allowing it to walk on a flat surface up to 30 m and rated jointly on the numerical scoring scale from 0 to 4 (Wells *et al*. 1993). Score 0 is assigned for 'No gait abnormality visible at walk', 1 for 'Mild lameness, with variation from normal gait symmetry at walk, 2 for 'Moderate lameness, with moderate and consistent gait asymmetry, 3 for 'Severe lameness, with marked gait asymmetry or severe symmetric abnormality' and 4 for 'Non-ambulatory or recumbent animals'.

The rear leg view was recorded in squarely standing dairy cows by observing the position of hocks i.e. narrow hocks (cowhock rear leg view) or straight hocks (normal rear leg view).

Trimming and identification of various foot lesions: Each animal was restrained in the cattle crate and all the hooves were first examined for gross lesions such as overgrown hooves, overgrown soles, corkscrew hooves, slipper/slatted foot (slipper hoof is a flattened, broadened slipper shaped overgrowth of the hoof. It is very rare condition but do occur in cattle and buffaloes) and skin lesions like interdigital dermatitis, interdigital necrobacillosis (foul in the foot), papillomatous digital dermatitis and interdigital hyperplasia. Trimming of hooves was then undertaken as per Toussaint Raven (1989) by removing about 1 to 2 mm of hoof tissue to examine the heel erosions, sole hemorrhages, sole ulcers, sole avulsions, white line hemorrhages, white line fissures, toe hemorrhage, abaxial wall overgrowth, abaxial wall degeneration, underrun soles and double soles.

Heel erosions, sole hemorrhages, sole avulsions (Randhawa *et al*. 2008a) and white line hemorrhages were identified according to their severity. Heel erosions were categorized as severity 1: pitting of the heel; severity 2: formation of small craters and severity 3: completely eroded heel or big v-shaped craters whereas sole hemorrhages as severity 1: general reddening of sole or small petechial or ecchymotic hemorrhages; severity 2: visible hemorrhages distributed in half of the sole or bright red spots in a particular area and severity 3: visible hemorrhages distributed in more than half of the sole or dark red spot in a particular area. Sole avulsions were categorized as severity 1: small powdery cavity in less than or equal to one third of the sole area; severity 2: cavity in less than or equal to two third of the sole area and severity 3: cavity formation in whole of the sole area or completely eroded sole whereas white line hemorrhages as severity 1: hemorrhage in the one-third portion of the white line; severity 2: hemorrhage in two third portions of the white line and severity 3: hemorrhage in whole of abaxial and axial white line. The rest of the foot lesions were categorized as 1 when present, otherwise 0.

Calculation of overall lameness score and overall disease score

Overall lameness score= (number of animals with LS0×0) + (number of animals with LS1×1) + (number of animals with LS2×2) + (number of animals with LS3×3).

Overall disease score= (Number of lesions with severity 1 × 1) + (Number of lesions with severity 2×2+ (Number of lesions with severity3×3).

Analysis of minerals: Half gram of hoof sole sample from zone 4 and 5 of the sole (six zones as per recommendations of VIth Symposium on the Diseases of the Ruminant Digit, Liverpool 1990) of 10 treated and control animals each was taken and kept overnight in 8 ml of distilled concentrate nitric acid in a conical flask. Next morning, samples were digested on a hot plate first at light heat and then at maximum heat. When 1–2 ml of solution was left, it was removed from the hot plate and 2 ml of perchloric acid was added and heated at maximum heat until 1 ml solution was left. The final volume was made up to 10 ml with distilled water. Minerals were estimated as per standard procedure with the help of atomic absorption spectrophotometer.

Data analysis: The data was analyzed using z-test for difference of two proportions by testing of hypothesis with the help of GSTAT software developed by Department of Maths and Statistics, PAU, Ludhiana.

RESULTS AND DISCUSSION

Various foot lesions and overall disease score in ZM supplemented and control animals are given in Table 1. A significant decline was observed in severity 1 heel erosions leading to significant decline in disease score owing to them. This might be due to increased rate of epithelial tissue repair thereby improved claw integrity in these cattle. Less severe heel erosion were observed in cows fed complexed trace minerals (CTM) than cows fed mixture having sulfates of Zn, Mn, Cu and Co (Siciliano–Jones *et al*. 2008). Supplementation of mineral complexes (zinc, copper, manganese and cobalt) during stress periods was beneficial in reducing oxidative stress (Miller *et al.* 1993). Moreover, zinc is also required for the synthesis and maturation of keratin that is the main protein of the hoof tissue (Smart and Cymbaluk 1997). A nonsignificant effect of ZM supplementation on the sole hemorrhages was observed in

Table 1. Lesions and overall disease score in zinc methionine supplemented (zinc methionine feeding + trimming) group and control (trimming) group of dairy cows

Lesions		Treatment group (zinc methionine + trimming)						Control group (trimming only)					
		Pretreatment			Post treatment			Ist trimming			2nd trimming		
Severity of lesions		1	2	3	1	2	3	1	2	3	1	2	3
Heel erosions	TL	58	4	-	52	4	-	78	-	-	71	15	-
	DS		66			60*			78			101	
Sole haemorrhages	TL	11	10	-	10	4	-	14	2	2	9	1	2
	DS		31			18			24			19	
Sole avulsions	TL	2	2	49	39	6	-	2	2	38	68	13	2
	DS		153			51*			120			100	
White line haemorrhages	TL	9	4	-	-	-	-	3	1	-	6	3	-
	DS		17			-			5			12	
White line fissures	TL/DS		4			3			7			5	
Abaxial wall overgrowth	TL/DS		6			2			2			-	
Abaxial wall degeneration	TL/DS		-			-			2			-	
Underrun sole	TL/DS		6			8			14			8	
Double sole	TL/DS		-			-			-			-	
Overgrown hoof	TL/DS		3			2			2			-	
Overgrown sole	TL/DS		10			4			9			-	
Corkscrew hoof	TL/DS		4			-			-			-	
Slipper foot	TL/DS		-			-			2			-	
Interdigital hyperplasia	TL/DS		-			-			2			-	
Overall disease score			300			148*			267			245	

*, Significant at 5% level; TL, total lesions; DS, disease score. Disease score = (Number of lesions with severity 1 × 1) + (Number of lesions with severity 2×2) + (Number of lesions with severity 3×3).

this study. These findings were similar to the findings of Moore *et al*. (1989) on laminitic lesions in ZM supplemented cows. Non-significant effect on the sole hemorrhages in the present study might reflect the multifactorial nature of aseptic subclinical laminitis (Mortensen 1994, Vermunt and Greenough 1994). Sole hemorrhages are clinical manifestations of disturbances in the microcirculation of the corium of the claw with subsequent degeneration at the dermal epidermal junction (Lischer and Ossent 2002) and can be attributed to subclinical acidosis and less than desired cow comfort. Factors contributing to poor cow comfort include excess time away from the pen, rough and abrasive flooring and overcrowding or free stalls that are too narrow, too short and do not provide adequate cushioning (Cook and Nordlund 2009). Present study showed significant reduction in severity of sole avulsions. All the sole avulsions of severity 3 healed or traversed back to severity 1 leading to significant decline in disease score related to them. This improvement in the treatment group as compared to control might be attributed to the healthy hoof synthesis. It was evident from this study because all the sole avulsions of severity 3 resolved and most of the sole avulsions observed after 5 months of supplementation were of severity 1. Zinc plays a key role in the formation of the structural proteins during the keratinization process by performing catalytic, structural and regulatory functions (Cousins 1996). The significant improvement in sole avulsions which are observed as large powdery cavities might have occurred due to proper maturation of keratin proteins. Zinc might have supplemented the above effect by increasing the rate of epithelial tissue repair thereby synthesizing healthy hoof horn tissue and replacing the avulsed portion of the sole. In a study cows fed an additional 200 mg/day of zinc from ZM had fewer cases of foot rot, heel cracks, interdigital dermatitis and laminitis than cows not fed ZM with a trend towards improvement in sole ulcers and white line fissures (Moore *et al.* 1989). White line hemorrhages although less in number resolved completely whereas there was some decline in number of white line fissures and abaxial wall overgrowth lesions. The complete resolution of white line hemorrhages and reduction in number of white line fissures in the present study was similar to the previous findings (Moore *et al.* 1989) which could suggest that the trace element supplementation influenced tissue strength and possibly healing rate. Less improvement in white line fissures might be due to the fact that a longer period of supplementation might be required for filling the gap due to degenerated white line. In one of the study (Stern *et al.* 1998), beef cattle were fed zinc oxide, zinc amino acid and peptide chelate or zinc complexed with polysaccharide to determine effects on clinical claw status, microscopic horn quality of the cornary band and tensile strength. Feeding zinc amino acid and zinc polysaccharide

Table 2. Overall lameness score and rear leg view index in zinc methionine supplemented (zinc methionine feeding + trimming) group and control (trimm) group of dairy cows

Conformation/scoring		Treatment group (zinc methionine + trimming)		Control (C) (trimming only)	
		Pretreatment	Post treatment	Ist trimming	2nd trimming
Lameness score (LS)	0	8	5	6	5
	1	2	8	6	7
	2	2	1	2	2
	3	2	-	-	-
Overall disease score	LS	12	10	10	11
Rear leg view	Normal	6	12	8	10
	Cowhock	8	2	6	4

Overall lameness score = (Number of animals with LS0x0) + (Number of animals with LS1x1) + (Number of animals with LS2×2) + (Number of animals with LS3×3).

resulted in better clinical claw status, microscopic horn quality of the coronary band and tensile strength scores that the authors attributed to better absorption and bioavailability of the zinc. The resolution of white line lesions and reduction in the number of abaxial wall overgrowths could be due to improved horn quality and increased tensile strength scores due to proper maturation of keratin filaments in the keratinocytes. There was no improvement in under run sole lesions. This might be due to different pathological process responsible for their formation like the sole hemorrhages. This could further be attributed to comparatively short span of supplementation in the present study.

There was nonsignificant decline in the reoccurrence of overgrown hoofs and overgrown soles but corkscrew hoofs observed in all the 4 animals before trial resolved completely after the trial. This might be due to increased compactness of the epidermis due to synthesis of healthy hoof horn tissue which might be less vulnerable to the overloading forces of the ground and had grown less comparative to their growth before supplementation. Zinc deficiency results in epithelial tissue disorders including parakeratosis, hyperparakeratosis and other epidermal changes associated with the claw horn and skin (Campbell and Miller 1998). The healing of above lesions resulted in significant decline in overall disease score in ZM treated group as compared to animals those were not fed ZM. This may be suggestive of the vital role of zinc in the maintenance of claw integrity. The reduction of overall disease score in ZM supplemented dairy cows might be attributed to increased hoof sole zinc levels in these cows.

The overall lameness score and rear leg view index are given in Table 2. A nonsignificant decline was noticed in the overall lameness score and rear leg view conformation in the treatment group as compared to control. The present finding may be suggesting that a longer period of supplementation is required for improvement in these conformational parameters though it was observed that more number of animals from the clinical lame group shifted to lower lameness scores and more number of animals shifted towards normal rear leg view conformation in the treatment group.

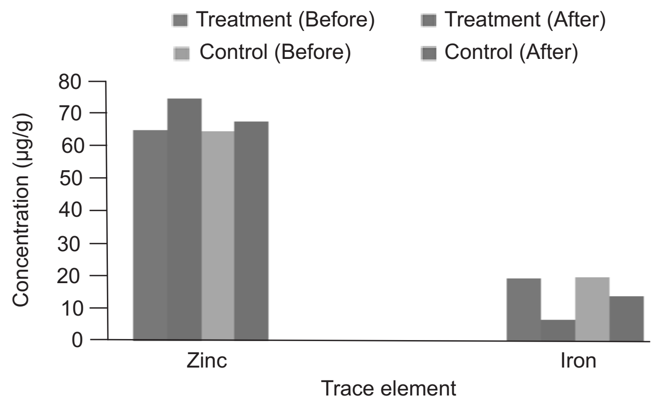

Fig. 1. Zinc and iron status of hoof sole in treatment and control group before and after treatment.

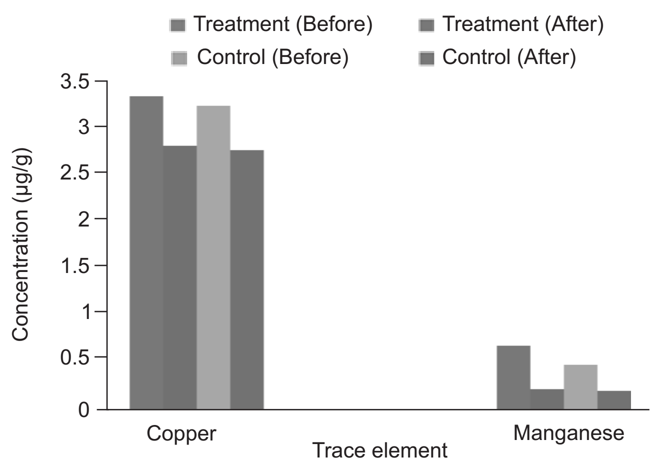

Fig. 2. Copper and manganese status of hoof sole in treatment and control group before and after treatment.

A comparative rise though nonsignificant was observed in the hoof sole zinc levels in the ZM supplemented cattle (Fig. 1) in the present study. This nonsignificant rise in the sole zinc levels could be due to short span of supplementation of ZM in the treatment group as compared to earlier studies.

There was absolutely no change in hoof sole copper, manganese and iron levels after treatment (Fig. 2) with ZM.

Decreased incidence of claw lesions with increased mineral availability is a reflection of the role of trace mineral in maintaining claw integrity. A general reduction in the incidence of digital disorders associated with laminitis was observed in cows fed a combination of complexed trace minerals (Nocek *et al.* 2000). The biological basis for Zn in maintaining claw integrity is related to the Zn-dependent enzymes, RNA nucleotide transferases, RNA polymerase, alkaline phosphatase, carbonic anyhydrase, and carboxypeptidase, which are integral in differentiation of keratinocytes (Cousins 1996; National Research Council 2001). The Zn-finger proteins (Cousins 1996) have an integral role in the formation of keratin filaments in the keratinocytes.

It was concluded that supplementation of ZM has a significant impact on heel erosions, sole avulsions, white line hemorrhages and corkscrew hoofs resulting in significant decline in overall disease score of the claws. There is not much improvement in the overall lameness score, rear leg conformation and hoof sole zinc status which may require a longer span of supplementation of ZM.

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