ROLE OF BIOTIN IN PREVENTION OF LAMENESS IN DAIRY CATTLE

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Lameness is a multifactorial disease or abnormality that causes the cow to change the way it walks. Nutritional management continues to be a major focal point in the attempt to reduce lameness in dairy cattle. Scientific research is reporting significantly improved hoof health with dietary biotin supplementation. Biotin is a B-complex water-soluble vitamin that is essential nutrient for all animals. Biotin is possibly the vitamin of greatest importance to the keratinization process involved in pathways for amino acid metabolism, cellular respiration, gluconeogenesis, and fatty acid synthesis. It is involved in the differentiation of epidermal that will become the hoof horn, in the production of keratin and intracellular cementing substance. Although biotin is present in many feedstuffs, scientists do not know how much of it is actually available to meet the cow's needs. There have been few studies in any species on the bioavailability of the biotin found in feedstuffs. Increasing the bioavailability of biotin improves its utilization and thus contributes to an improved integrity of claw. Ruminants produce biotin as a result of bacterial fermentation, however ruminants receiving proportionately high-grain thus predisposing them to lactic acidosis which reduced the microbial synthesis of biotin tend to have more hoof problems especially during periparturient period and in early lactation. More recent studies have shown that in dairy cattle fed 10-20 mg per head supplemental biotin daily, hoof health was improved and the incidence of the common hoof problems was reduced.

Keywords: Lameness, Biotin, Keratinization, Integrity of claw, Ruminants

Lameness is a disease or abnormality that causes the cow to change the way it walks (its gait). Although many factors have long been recognised as contributing to lameness (Livesey and Fleming, 1984; Peterse et al., 1984; Manson and Leaver, 1989), as it is a multifactorial disorder like physiological, nutritional, managemental, environmental, genetic factors etc. The losses incurred due to lameness are so high that it ranks just after reproductive failure and mastitis (Baggott 1982; Esslemont and Kossaibati 1997). Affected animals show a marked decline in body weight, milk yield and reproductive efficiency (Garbarino et al., 2004). With added costs of treatment, culling and replacement, the total loss may be around 4–5% of a typical farm income (Enting et al., 1997).

Nutritional management continues to be a major focal point in the attempt to reduce lameness in dairy cattle (Nocek, 1997). Recent scientific research is reporting significantly improved hoof health with dietary biotin supplementation. Other studies have found greater milk production and improved reproductive efficiency with dietary supplementation of this B vitamin (Bergsten et al., 1999; Fitzgerald et al., 2000; Midla et al., 1998; Zimmerly and Weiss, 2001; Singh and Lathwal, 2009). Biotin is a B-complex water-soluble vitamin also called vitamin H that is essential nutrient for all animals. Although ruminants produce biotin as a result of bacterial fermentation, the requirements for biotin and other B-group vitamins in cattle have been reevaluated (Girard, 1998). Biotin is essential for ruminants and studies have been conducted on biotin synthesis,
absorption, and balance in lactating and nonlactating cattle (Miller et al., 1986; Frigg et al., 1992; Kluenter et al., 1993; Steinberg et al., 1995). In this regard, biotin supplementation has been used successfully for many years to improve claw and hoof health in pigs and horses (Brookes et al., 1977; Geyer and Schulz, 1994). Indications that biotin insufficiency might affect foot and hoof health first appeared in research with biotin-deficient poultry and swine. In those studies, dermatitis, loss of feathers or hair, and softening of normally hard tissues such as claws all pointed to a role in production of proteins such as keratin. However, for several decades very little research was published on the effects of biotin in cattle. It has been presumed that microbes in the gastrointestinal tract normally synthesize enough biotin to meet the requirements of ruminants and the inability to produce clinical biotin deficiencies in functioning ruminants and by the consensus that adequate biotin was in normal feedstuffs or was synthesized by bacteria in the rumen and lower intestines. However, the latest research indicates that biotin supplementation may be beneficial in cattle with a history of hoof problems, especially in times of stress. Most of the recent research has centered on the effects of biotin on hoof health of dairy cows (Bergsten et al., 2003; Fitzgerald et al., 2000; Midla et al., 1998). All these studies reported a positive response on some measure of hoof health to supplemental biotin. Many studies have investigated the biological effects of biotin on hoof health, including keratin protein synthesis and formation of the intercellular cement, which influence horn formation of the hoof, hoof strength, and claw integrity (Whitehead, 1988; Sarasin, 1994; Hochstetter, 1998; Fitzgerald et al., 2000; Hedges et al., 2001; Koester et al., 2002). Many of the studies reported positive biological effects of biotin treatment on hoof strength (Distl and Schmid, 1994; Hagemeister and Steinberg, 1996; Midla et al., 1998; Campbell et al., 2000; Fitzgerald et al., 2000; Hedges et al., 2001; Bergsten et al., 2003; Potzsch et al., 2003). There were, however, limited randomized controlled studies on the clinical effect of biotin supplementation to improve hoof health and reduce the risk of lameness in dairy cows.

**BIOCHEMISTRY OF BIOTIN**

Biotin is involved in pathways for amino acid metabolism, cellular respiration, gluconeogenesis, and fatty acid synthesis. There are four biotin-containing enzymes found in mammalian cells—acetyl-CoA carboxylase, B-methylcrotonyl-CoA carboxylase, propionyl-CoA carboxylase, and pyruvate carboxylase. All four enzymes require biotin to become activated (Weiss and Zimmerly, 2000). Biotin is covalently linked to each of these enzymes and transfers a carbon unit from the substrate to the product. Although acetyl-CoA carboxylase and pyruvate carboxylase require biotin, it is unlikely that supplemental biotin affects the activity of those two enzymes. Both of those enzymes are extremely important, are tightly regulated, and have a high priority for biotin. Activity of those enzymes is probably not reduced until a clinical biotin deficiency develops and since a clinical deficiency of biotin has not been produced in ruminants, the activity of those enzymes is probably not influenced by feeding supplemental biotin to dairy cows. The other two biotin-containing enzymes (B-methylcrotonyl-CoA carboxylase and propionyl-CoA carboxylase are less tightly regulated and respond to differences in biotin status in humans and laboratory animals suggesting that cattle may respond to biotin supplementation. B-methylcrotonyl-CoA carboxylase is an enzyme involved with breaking down the amino acid, leucine, into products that can be used as energy sources. When biotin is limiting in humans, other metabolites are produced and excreted in the urine (Mock, 1996). If the activity of this enzyme is limited by a marginal deficiency of biotin in cattle, a large response in production would not be expected when biotin is supplemented. Propionyl-CoA carboxylase is an extremely important enzyme for ruminants but is relatively unimportant in nonruminants. This enzyme is involved with the pathway that converts propionate to
Fig 1: An overview of the pathways that involve biotin-containing enzymes.

Glucose. In mice, the activity of this enzyme is reduced when biotin is clinically deficient (Mock, 1996). In rats fed a low biotin diet, but without clinical signs of biotin deficiency, activity of propionyl-CoA carboxylase appeared to be reduced (Kramer et al., 1984). Propionate is a minor metabolite in nonruminants but is the major glucose precursor in ruminants. Lactating cows must synthesize large amounts of glucose from propionate and if the activity of propionyl-CoA carboxylase is limited by biotin availability, a response to supplemental biotin in glucose production and milk production is possible. The effects of supplemental biotin on the activity of this enzyme in cattle have not been investigated. However, ruminants receiving proportionately high-grain diets lack sufficient biotin in their rumen leads to lactic acidosis which is main contributing factors in lameness of dairy cows (Nocek, 1997).

**Sources of Biotin**

Biotin is naturally present in plants and thus in the diets fed to dairy cows. Biotin is present in many foods and feedstuffs. Biotin is found in nature as free and protein-bound forms. Proteases in the digestive system degrade the bound form, releasing biocytin (the vitamin coupled to lysine). This bond can be degraded only under the action of a very specific enzyme (biotinidase), which is found in the pancreatic secretions and brush-border membrane, releasing biotin in its free form. (Santschi et al., 2005). However, not all of this biotin is bioavailable. Although biotin is present in many feedstuffs, scientists do not know how much of it is actually available to meet the cow’s needs. There have been few studies in any species on the bioavailability of the biotin found in feedstuffs. In research with poultry, however, scientists have reported that less than half of the microbiologically determined biotin in feedstuffs is biologically available. It is also known that only d-biotin is biologically active. Feeds commonly fed to dairy cows contain variable concentrations of biotin. Generally higher protein feeds contain more biotin than feeds with low concentrations of protein. Feeds that are byproducts of fermentation such as brewers and distillers grains contain high concentrations of biotin (Weiss, 2001). Molasses can contain very high concentrations of biotin. For typical mixed diets, biotin concentrations range from 0.2 to 0.4 mg/kg of dry matter. Those concentrations will result in intakes of dietary biotin from unsupplemented diets of 4 to 10 mg of biotin/day for average lactating dairy cows. Bacteria in the rumen and large intestine can synthesize biotin that can then be absorbed by the cow. However,
data on the quantity of biotin synthesized by ruminants are extremely limited and variable. No data are available with lactating dairy cows.

In ruminants, microbial synthesis of biotin occurs in the rumen and digestive tract. Historically, it has been assumed that the mature ruminant animal does not require biotin supplementation because its ruminal microbes are able to synthesize enough of these compounds to avoid deficiency symptoms (McDowell, 2000). However high-concentrate rations may decrease biotin synthesis by microbes of the rumen. High proportions of readily fermentable sugars and starch in the ration produce acidic conditions in the rumen that result in imbalances among microbial species. Abel and Gomez (1997) reported that acidic rumen conditions reduced the microbial synthesis of biotin. This may help explain why higher-producing dairy cattle, which are more likely to receive high-concentrate rations, tend to have more hoof problems than other cows. Also, changes in the forage to concentrate ratio of the diet are known to alter the microbial activity of the rumen (Allison 1965; Institut National de la Recherche Agronomique 1978) and are therefore likely to affect the amount of vitamins produced. This suggests that rumen synthesis may be insufficient, particularly around calving or during early lactation. Moreover, getting a precise idea of the amount of each vitamin being synthesized in such a dynamic environment as the rumen is difficult, due to the continuous flow of digesta.

**ARCHITECTURE OF HOOF**

The hoof is an extremely important structure in an animal’s body. Although an animal with hoof problems may be able to function, chances are that optimal animal production and performance will be reduced depending upon the severity of the problem (Blowey, 1993).

The horn is a hard surface, structurally similar to the human fingernail, but functionally like the epidermis of the skin.

Table 1: Sources of Biotin

<table>
<thead>
<tr>
<th>Feed</th>
<th>Biotin, mg/kg of dry matter</th>
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<tbody>
<tr>
<td>Starchy grains</td>
<td>0.090</td>
</tr>
<tr>
<td>Soybean meal</td>
<td>0.270</td>
</tr>
<tr>
<td>Wheat midds</td>
<td>0.330</td>
</tr>
<tr>
<td>Hay crop forages</td>
<td>0.450</td>
</tr>
<tr>
<td>Distillers/brewers grains</td>
<td>0.600</td>
</tr>
<tr>
<td>Cane molasses</td>
<td>0.800</td>
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Keratin is a family of fibrous structural proteins found in horns or hooves of all animals. Hoof quality is a fairly sensitive indicator of overall nutritional state. Although it can be modified by genetic factors or extremes of environmental conditions, if one or more key “ingredients” needed for growing healthy hooves is inadequate, hoof quality will suffer. Slight imbalances in hoof nutrition and structure can cause a breakdown of integrity and function. Many of these claw abnormalities occur in early lactation (Green et al., 2002) and may be the result of nutritional deficiencies or hormonal changes occurring in dairy cattle at this stage of lactation. Many physiological changes occur in late gestation and into early lactation of the dairy cow that affect nutrient uptake and flow. During the process of keratinization, epidermal cells rely upon the dermal layers for the supply of nutrients, macro and trace minerals, and vitamins. This supply must be provided entirely via diffusion from blood vessels in the underlying dermis because the epidermis is an avascular tissue (Mulling et al., 1999). Hendry et al., (1999) reported that little is known about the control mechanisms for nutrient flow and rate of hoof keratinization. Correct nutritional management is known to have a critical influence on horn quality. The architecture of these cells is typical of strong durable horn. Biotin is key nutrient that positively influences horn quality. Biotin optimises the production of keratin and the process of keratinisation – keratinisation is the process of producing strong fibrous proteins to create tough body structures (such as hooves), the presence of biotin increases the efficiency of this process.

**BIOLOGICAL FUNCTIONS OF BIOTIN**

Biotin, however, is involved in many metabolic pathways directly involved with milk synthesis. Because of the ever increasing productivity of dairy cows, the effects of supplemental biotin on milk production and metabolism of dairy cows was extensively studied (Bergsten et al., 1999; Fitzgerald et al., 2000; Singh et al., 2011). Biotin plays a key role in the synthesis of glucose (an important energy source), protein and fat, and is involved in a diverse array of critical metabolic pathways. Biotin is a cofactor for microbial enzymes involved in propionic acid synthesis (Baldwin and Allison, 1983) and is also present in carboxylase-containing enzymes critical to gluconeogenesis and other metabolic roles in mammals (Mock, 2005). Amino-acid metabolism, cellular respiration, gluconeogenesis, and lipogenesis involve enzymes that require biotin (Mock, 1996). Biotin acts as a co-factor in carboxylase enzymes and thus plays an important role in both gluconeogenesis and fatty acid synthesis.

With regard to keratin formation, biotin-dependent enzymes are directly involved in the synthesis of lipids and glucose, with particular importance placed on synthesis of long-chain fatty acids (Meyer et al., 1998; Weiss and Zimmerly, 2000). In this regard, significant differences in the fatty acid profile of horn tissue of cattle with claw lesions have been observed (Offer and Logue 1998). The hypothesis is that biotin improves the quality and quantity of lipids in the intercellular matrix that in turn improves membrane structure and function. Biotin is essential for the formation and integrity of the keratinized tissues (claws, and footpads) (Maynard et al., 1979). It is involved in the differentiation of epidermal cells, and in the production of keratin and intracellular cementing substance (Mulling et al., 1999). Biotin is necessary for synthesis of keratin, a hard structural protein involved in horn production. Healing has to be done from the inside. Protein, not biotin, is the primary constituent of the structural and protective tissues of the hoof. The role of biotin is to help break down the protein (amino acids) for faster action. This is why mega doses of protein with a few milligrams of biotin plays an important role in hoof health. The faster the amino acids work, the quicker the hoof heals. Mulling et al., (1999) demonstrated that biotin was essential for the formation of complex lipid molecules in the intracellular cementing substance (ICS). They also demonstrated, in biotin-deficient calves, that biotin deficiency affected keratinizing epidermal cells, as well as the composition of the intercellular cement (Mulling et al.,
The first signs of biotin deficiency appear as dermatitis and softening of normally hard tissues such as horn. Research in pigs and horses has shown that biotin positively influenced the integrity of the hoof horn (Geyer, 1998).

**ROLE OF BIOTIN IN HOOF HEALTH**

Biotin is possibly the vitamin of greatest importance to the keratinization process. Several studies have shown that biotin can increase horn quality and promote horn formation (Hochstetter, 1998; Higuchi and Nagahata, 2001) and thus increase resistance against (Midla et al., 1998; Campbell et al., 2000; Fitzgerald et al., 2000) and improve healing (Lischer et al., 1996) of claw lesions in cattle. The hoof of cattle contains the structural protein keratin, which forms an internal support lattice, similar to steel girders inside a building. Likewise, the cells that form the hoof horn are bonded together by a cementing substance similar to mortar in a brick wall. Biotin is specifically required for production of keratin, a tough, insoluble protein that is the chief structural component of horn tissue (and of human fingernails as well) and the cementing substance of hoof horn. Biotin is essential for the formation and integrity of the keratinized tissues (skin, hair, claws, and footpads) in mammals and birds (Maynard et al., 1979). It plays an important role in differentiation of the epidermal cells that will become the hoof horn. More recently, biotin supplementation has also been reported to stimulate the production of intracellular cementing substance (ICS), a combination of glycoproteins and complex lipids that bond horn cells and harden the horn tissue. Biotin has long been recognized as an essential nutrient for the formation of sound hoof horn, the modified epidermal tissue that forms the hard outer casing of the hoof wall and sole. The supply of nutrients during the horn-forming process has a major influence on horn quality. If the supply of nutrients to the corium is sub-optimal for whatever reason, horn quality will be compromised. The incidence of many common hoof disorders are strongly influenced by the strength of the horn capsule. The aim is to achieve horn of good quality that has good biomechanical properties. Poor quality horn with an impaired, weakened structure, increases susceptibility to hoof disorders. Results from histological and biochemical studies have indicated that there are improvements in the inter- and intracellular ultrastructure of horn as a result of dietary biotin supplementation (Hochstetter, 1998). Biotin supplementation created a more defined and cohesive structure (Fritsche, 1990). Indeed, when researchers have induced clinical biotin deficiencies in calves, the signs have included soft, crumbling hooves along with skin lesions and hair loss. Biotin deficiencies in swine, poultry and horses have resulted in dermatitis and cracks and fissures in the feet and toes.

**EFFECTS OF BIOTIN ON RUMEN METABOLISM**

Biotin is synthesized in the rumen in varying amounts depending on the composition of the diet (forage:concentrate ratios; Abel et al., 2001). Microorganisms in the rumen synthesize biotin and other B vitamins, and an absolute biotin deficiency has not been demonstrated in ruminants (Roberts and Baggott, 1982). Estimates of ruminal synthesis of biotin ranged from 0 to 2 mg/day (approximately 0.8 mg/kg of digestible organic matter intake, Frigg et al., 1992). If those values are appropriate for lactating dairy cows, a typical cow consuming 20 kg of dry matter/day would synthesize 0 to 10 mg of biotin each day. Ruminal synthesis rate of biotin might be related to the diet. An in vitro study reported that biotin synthesis was reduced as the concentration of dietary forage was reduced (Da Costa Gomez et al., 1998). In that study, biotin synthesis was reduced by about 50% when the in vitro substrate was 50% forage and 50% concentrate compared to an in vitro diet with about 80% forage. A study with duodenally canulated steers, however, reported no difference in biotin flow to the small intestine when steers were fed diets with 90% corn grain or 70% alfalfa meal (Miller et al., 1986). If higher concentrate diets do indeed reduce ruminal biotin synthesis, then supply of biotin may be reduced when higher concentrate diets are fed to dairy cows. Mock (1996) reported that biotin deficiency was tied to insufficient
pyruvate-carboxylase activity and due to an insufficient conversion of lactate to pyruvate resulting in cellular lactic acidosis. It may be possible that ruminants receiving proportionately high-grain diets lack sufficient biotin in their rumen to convert lactic acid to pyruvate and then oxaloacetate, thus predisposing them to lactic acidosis. Canadian research suggested that cattle fed high grain diets are subject to potential biotin deficiency since the rumen microbes responsible for biotin synthesis are sensitive to low rumen pH (Girard, 1998). Nocek (1997) reported lactic acidosis as one of the possible contributing factors in lameness of dairy cows. Such conditions can occur in the periparturient period and in early lactation (Blowey et al., 2000; Da Costa Gomez et al., 1998; Roberts and Baggot, 1982).

All the major cellulolytic bacteria in the rumen require biotin for growth (Baldwin and Allison, 1983). In two studies (Bentley et al., 1954; Milligan et al., 1967), supplemental biotin increased fiber digestion in vitro. Bacteria also require biotin to produce propionate. Propionate production by mixed ruminal bacteria was reduced in vitro when biotin was not included in the culture media. These data suggest that supplemental dietary biotin may alter ruminal metabolism and result in either increased fiber digestion (result in higher energy values of feeds) or in increased propionate production which could increase glucose production by the cow.

**EFFECT OF BIOTIN SUPPLEMENTATION ON HOOF HEALTH**

During the last few years, several studies have been published on the effects of supplemental biotin on lactating dairy cows (Bergsten et al., 1999; Fitzgerald et al., 2000; Midla et al., 1998; Zimmerly and Weiss, 2001). Most of these experiments were designed to determine the effect biotin has on hoof health. These studies and field observations led Distl and Schmid (1994) to assess the role of biotin as a nutrient for responsive claw disorders in dairy cows. Scientists have offered several possible reasons why unsupplemented cows would have a biotin insufficiency and thus reduced hoof strength. Hoof and foot problems were reduced when these species received biotin supplementation in various research studies (Zenker et al., 1995). More recent studies have shown that in dairy and beef cattle fed supplemental biotin, hoof health was improved and the incidence of the common hoof problems was reduced. In a clinical study with 100 first-lactation heifers, Midla et al., (1997) reported that 27 percent of the unsupplemented control heifers had rear lateral white line separation and 20 percent of the controls had rear medial white line separation. In the heifers receiving 20 mg biotin per head daily, however, only 10 percent of the animals had rear lateral white line separation, and only 2 percent had rear medial white line separation. Differences were significant 100 days after supplementation began (100 days into lactation). In a field study of 180 dairy cattle, Hagemeister and Steinberg (1996) reported that the animals receiving 10 mg per day of supplemental biotin had significantly less incidence of sole ulcers and heel erosion than unsupplemented controls. In studies that induced biotin deficiency in calves, the animals did indeed exhibit soft hooves that were prone to crack-along with poor weight gains, rough hair coats and scouring. In other studies (Hurstel, 1983), fattening veal calves fed supplemental biotin at 500 mg/kg of dry milk replacer showed improved growth rate, weight for age, and feed conversion compared to unsupplemented calves. Potzsch et al., (2003) reported biotin supplemented at 20 mg/d for longer than 6 months reduced white line disease in multiparous cows by 45% in 8.5 cases per 100 cow years. However, the effect of biotin in primiparous cows was not significant. The effect of biotin supplementation on various foot lesions and hoof ceramide composition of toe (wall) and sole portions of hooves was studied in crossbred dairy cattle. A significant decline was observed in heel erosions and sole avulsions along with total disappearance of white line fissures and double soles in the biotin supplemented cattle resulting in decrease in the overall disease score. (Randhawa et al., 2008). Singh and Lathwal (2009) reported that biotin supplementation had a significant (P< 0.01) effect on recovery period of hoof.
lesions as well as locomotion score. Above studies indicate that biotin reduced the incidence of white line abnormalities in particular and other claw diseases, such as sole hemorrhage, sole ulcers, digital dermatitis, and heel erosion.

**EFFECT OF BIOTIN SUPPLEMENTATION ON PLASMA BIOTIN LEVELS**

Midla *et al.*, (1998) reported a decrease in plasma biotin levels of dairy cows 25 DIM, returning to constant levels from 100 DIM until the end of lactation. Roberts and Baggott (1982) reported that lame cows had lower plasma biotin levels when compared with cows with no history of lameness, and studies have shown that orally administered biotin raises plasma (Zinn *et al.*, 1987) and milk (Frigg *et al.*, 1992) biotin levels in dairy cows. Lactating dairy cows with a history of lameness have been found to have lower plasma biotin levels (Roberts and Baggott, 1983). Cooke and Brumby (1983) fed supplemental biotin at 20 mg/head/day for four months to a herd of Friesian cows with severe lameness, and the animals showed 50 percent reduction in lameness from hoof horn weakness. In this study, cows fed supplemental biotin also had significantly increased plasma biotin levels compared to controls. Results showed a significant impact on claw parameters in direct proportion to increased plasma biotin when the cows received the vitamin as an oral 20 mg/day supplement for 11 months. Frigg *et al.*, (1993) noted that feeding supplemental biotin at 20 mg/head/day increased serum biotin levels from 300-800 ng/l to 3,000-8,000 ng/l in yearling heifers. In these studies, increases in serum levels suggest that about 50 percent of supplemental biotin escapes rumen degradation and is bioavailable to the animal. Lischer *et al.*, (1996) reported a significant correlation between short-term healing of claw lesions and serum biotin levels, which had been elevated with dietary supplementation of 20 mg biotin per head daily. The rate of new horn formation over the lesions was significantly increased in supplemented cows. So it is hypothesized that biotin supplementation may benefit cows during the period of high demand on the cow, around calving, and during early lactation.

**RECOMMENDED DOSES OF BIOTIN SUPPLEMENTATION IN DAIRY CATTLE**

Although the evidence is beginning to suggest positive effects on hoof and claw health from biotin supplementation, there is still no standard recommendation for biotin use or levels for cattle. Scientists are looking to supplemental biotin, along with zinc and other trace minerals. Adequate biotin through dietary supplementation may help maintain harder hoof horn. Also, along with zinc, biotin is depleted under stress. At weaning and placement on feed, demand for micronutrients is greatest. The preliminary results of Bergsten *et al.*, 2003 studies show that yearling heifers receiving supplemental biotin at 10 mg per head daily had a lower incidence of sand cracks than unsupplemented animals (10% vs. 27%). Biotin and mineral imbalances must be corrected through the various seasons and production cycles. In the face of a zinc deficiency, biotin alone may help, but it may not help enough. Overall, the potential rumen shock from the switch to pasture with low fiber and high protein in the spring—after a winter of just the opposite—may be the most powerful stress factor to be controlled. Adding biotin, zinc and other nutrients to the ration may help minimize the effects of this stress on hoof health. The primary targets for dietary biotin supplementation are dairy herds with ongoing hoof problems and high producing cows fed high-grain rations. Bred replacements heifers should also be supplemented. Some studies have supplemented rations with 10 mg of biotin per head daily, but most have included 20 mg per head daily. It is recommended that heifers receive 10 to 20 mg of biotin per head daily, starting at 15 months of age as part of a heifer rearing program. It is recommended that cows receive 20 mg per head daily throughout lactation and 10 to 20 mg per head daily during the dry period.

**CONCLUSIONS**

Integrity of claw horn is one prerequisite for claw health, which in turn is the prerequisite
for overall animal well being, productivity, and potential profitability. Formation of keratin proteins is an essential part of a systematic process of cellular changes that transform living, highly functional epidermal cells into fibrous, structural horn cells with no metabolic activity. Biotin play important role in the production and maintenance of healthy keratinized tissues. It can be concluded that biotin concentration is altered by changes in forage to concentrate ratio, which suggests that the supply of this vitamins to dairy cows is influenced by the composition of the diet and rumen environment. A better knowledge of true requirements of ruminant animals for biotin is required to verify if ruminal synthesis provides optimal supply of these nutrients, under different dietary conditions. Increasing the bioavailability of biotin improves their utilization and thus contributes to an improved integrity of keratinized tissues, hoof and claw. Most of the studies have shown that in dairy cattle fed 10-20 mg per head supplemental biotin daily, hoof health was improved and the incidence of the common hoof problems was reduced.

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