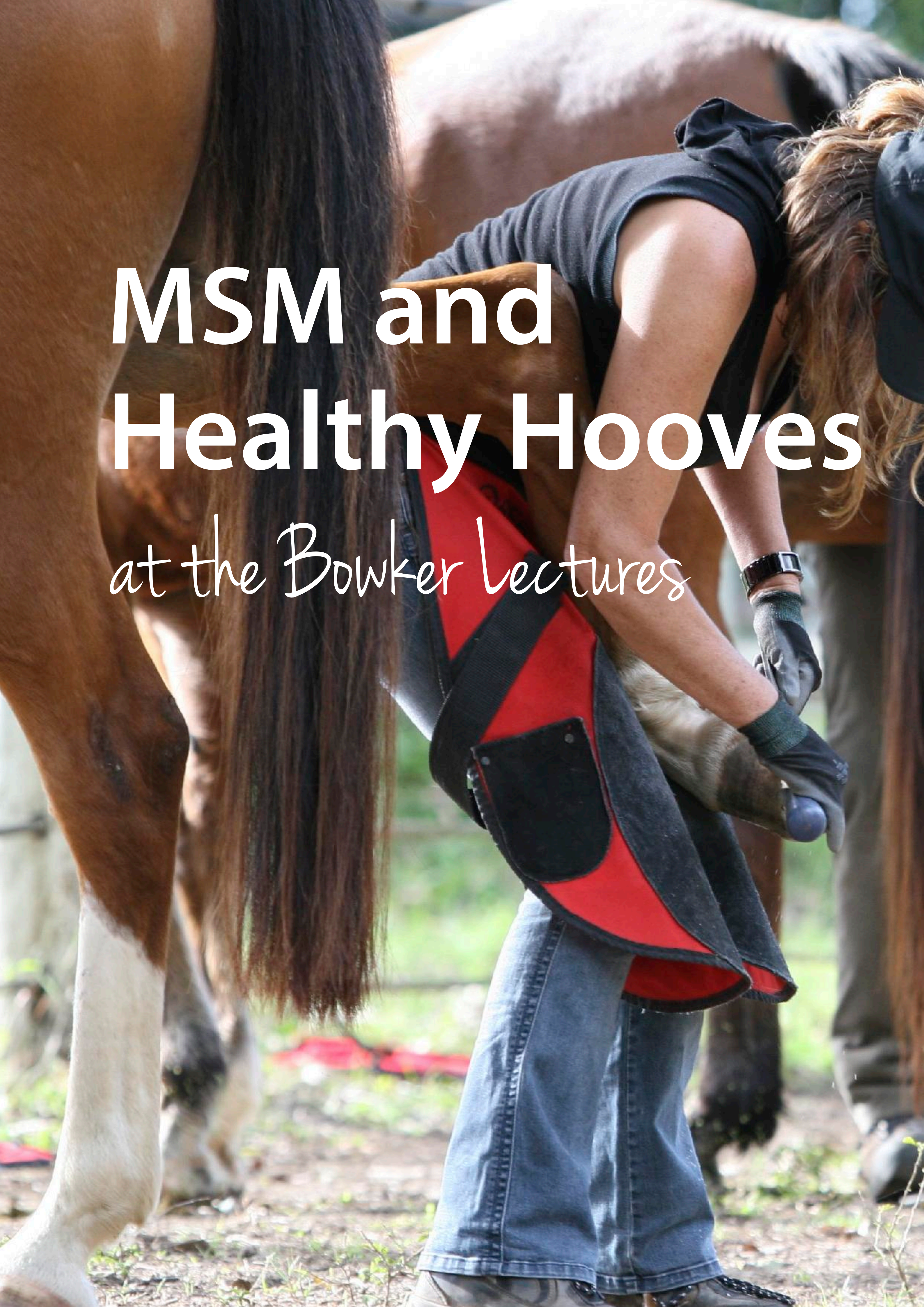
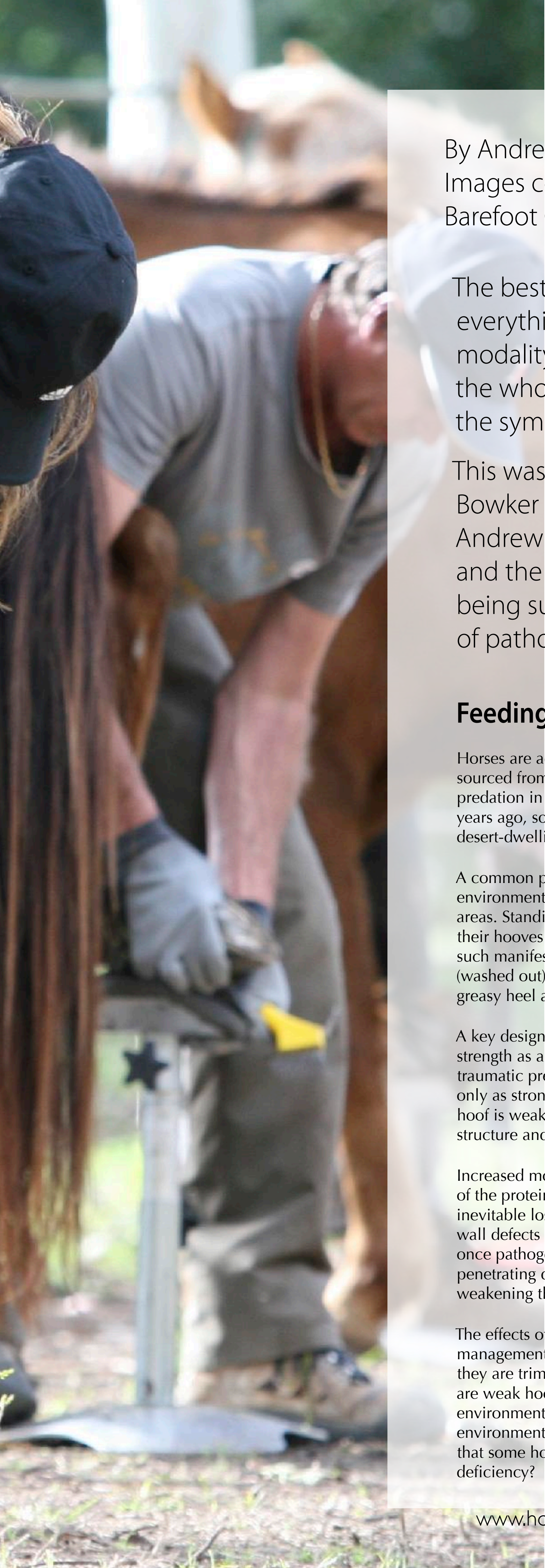
MSM and Healthy Hooves

at the Bowker Lectures





By Andrew Bowe, Master Farrier
Images courtesy of Mayfield
Barefoot Care Centre

The best therapists don't just strive to learn everything possible about their own particular modality, they also seek a working knowledge of the whole equine. They aim to heal, not just treat the symptoms.

This was the underlying theme of the recent Bowker Lectures in Victoria, where Master Farrier Andrew Bowe spoke about his interest in MSM, and the reported correlation between horses being supplemented with MSM and the absence of pathogenic hoof disorders.

Feeding MSM for healthy hooves

Horses are adapted to semi-arid prairies. Domestic horses were originally sourced from a remnant population of wild horses that survived human predation in the harsh Steppe country of central Asia. That was only 5,000 years ago, so domestic horses still carry the same genetic blueprint as their desert-dwelling ancestors.

A common problem for many domestic horses is that they are kept in environments they are not genetically adapted to, particularly high rainfall areas. Standing in consistently damp, soft ground results in the weakening of their hooves and subsequent invasion by opportunistic pathogens that cause such manifestations as seedy toe, white line disease, frog thrush, retracted (washed out) soles, canker and adjacent pathogenic skin conditions, such as greasy heel and mud fever.

A key design feature of the equine hoof when fully functional is its great strength as an architecturally tight unit, so that it can accommodate the traumatic pressure of continually striking hard ground at speed. It is, however, only as strong as its weakest link. If one component is weak, the whole hoof is weak, and any disunity between components destabilises the whole structure and leads to hoof capsule breakdown.

Increased moisture results in a significant decline in the tensile strength of the protein structures that make up the hoof capsule. This leads to an inevitable loss of hoof capsule integrity via either laminar separation or hoof wall defects and subsequent pathogenic incursion. A vicious cycle begins once pathogens gain entry into a hoof because they consume hoof tissue, penetrating deeper and becoming harder to treat - not to mention further weakening the hoof.

The effects of a wet environment seem to override every other aspect of hoof management. It doesn't matter how often hooves are trimmed or even if they are trimmed exactly to physiologically correct parameters - wet hooves are weak hooves which invite pathogenic invasion. However, whilst a wet environment is the overriding common factor, the cause cannot be 100% environmental. In the absence of other possible variables, could this indicate that some horses with problematic hooves have an unidentified mineral deficiency?

A clue to identifying the underlying cause of this phenomenon comes from the fact that not all horses in a mob have problem hooves, even when they share the same paddock and are managed the same. The incidence of hoof problems also varies between properties - some are worse than others and a 'bad' property can be just over the fence from a 'good' one. Another clue is that bad properties are more likely to appear over-grazed and 'horse sick'. The environment is the same, but there is possibly a significantly differing nutrient status. Furthermore, it doesn't seem breed specific, as the author has seen problematic hooves on all breeds and can't correlate bad hooves to any particular breed, not even thoroughbreds.

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Ley *et al.* (1998) found that nutritional regimes had a great effect on the mineral composition of hooves. Mineral deficiencies that affect hooves are not uncommon and are well documented. Magnesium deficiency is linked to flat, thin soles and sub-clinically laminitic hooves (Moore 2013), calcium deficiency has shown to be a factor in brittle hooves (Kempson 1987), and horses low in zinc and copper are more likely to develop white line disease (Hihami, 1999).

'Complete' hoof supplements have been designed which address these known mineral deficiencies. Unfortunately, they are not always effective at fixing weak, dysfunctional hooves. If hoof problems persist in the face of 'complete' mineral supplementation, this is surely suggestive of a significant mineral deficiency that has been overlooked?

If we go down the list of the most abundant minerals in the equine body, we very quickly come to sulphur, which is the third most common mineral. More significantly, it is the most prevalent mineral in the hoof capsule, making up about 4% of the dry matter of hoof protein (Briggs, 2007).

That is a lot of sulphur.

It would seem entirely feasible to ask the question: could sulphur deficiency be the underlying issue in weak hooves that don't respond to 'complete' hoof supplements?

However, even though sulphur is a significant component of a diverse range of tissue types, it is not even thought of as an important mineral (Briggs, 2007). In traditional texts, sulphur often doesn't even rate a mention. It is thought that most feeds contain enough sulphur to meet equine needs.

This is despite the fact the actual physiological requirements of sulphur by horses has not yet been quantified (Lewis 1995, National Resources Council 2007, Merck Sharp & Dohme Corp. 2014), nor have the exact functions of sulphur been fully defined (Kerrigan 1986); whilst Werbach (1999) labelled the limited understanding of the sulphur cycle in mammals as a blindspot in nutrition and medicine.

Research into other species has determined that sulphur deficiency decreases appetite, hair and wool growth, and milk production and leads to weight loss in mature animals (Lewis 1995, Briggs 2007). Why would horses be less affected by sulphur deficiency than other species?

Amidst the cacophony of references to the contrary, there is some evidence suggesting sulphur deficiency in equines is indeed possible. Sulphur deficiency has been indirectly linked via methionine deficiency that manifests in poor quality hooves (Kellon 1998). More specifically, Ley et al (1998) found that the tensile strength of equine hooves is positively associated with sulphur content; and the concentration of sulphur in arthritic cartilage has been shown to be one third the level of normal cartilage (Rizzo et al 1995).

Further potential for sulphur deficiency can be found by looking at pasture, in particular the soils that Australian pastures are growing in. There is thought to be widespread sulphur deficiency in Australian soils; more so in high rainfall areas due to sulphur being easily leached and more so again from lighter, sandier soils, even under moderate rainfall conditions. Unfortunately, this is only anecdotal because general data regarding the sulphur content of Australian soils is scant.

In domestic horse pasture, there is the added effect of the continual removal of manure from paddocks. Although this is considered good husbandry for the control of internal parasites, this surely is a drain on the mineral reservoir of the soil, particularly sulphur.

Whilst on the subject of soils and minerals, it would be pertinent to question the profile of central Asian soils where the domestic horse originated. Do those soils have adequate sulphur? Is it because the equine species evolved in a dietary regime that contained such a constant supply of sulphur that their physiology did not need to genetically adapt to cope with sulphur deficiency and the development of a sulphur storage mechanism was not required? Horses do not store sulphur. Rather, sulphur is water soluble and is excreted daily, which is why it must be ingested daily.

The role of sulphur

Sulphur is involved in both the formation of structural compounds and participation in metabolic processes.

In terms of hoof structure, sulphur is a significant component of several of the amino acids that join together to form proteins. Hoof strength arises from the degree to which strands of protein are bonded to each other - bonds which are basically between sulphur atoms. Therefore, a surplus of sulphur-containing proteins would, in theory, allow the strongest possible structure to be built.

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Sulphur is also needed for the formation and fortification of joint cartilage. The basic molecules that form joint cartilage are long chains of glycosaminoglycans (polysaccharides such as chondroitin sulphate and hyaluronic acid) that are linked together by strong bonds between two sulphur atoms that reduce flexibility of the chains, and makes cartilage firm and resilient.

Metabolically, sulphur is contained in hormones, enzymes and antibodies. It helps to facilitate the transport of oxygen across cell membranes, is involved in cellular regeneration, assists with a body's bacteriostasis via increased production of immunoglobulins which boost immunity, and is an important component of insulin and, therefore, the energy generating Krebs cycle (Evans et al 1993). Sulphur is also thought to keep muscles healthy (and properly rested when not contracting) by helping to transport oxygen and remove toxins.

For sulphur to enter the body, it is thought to pass through the digestive wall where it is incorporated into serum proteins, but for this to occur, it needs to be present in simple organic molecules, such as MSM. This may well be the elephant in the sulphur room. Sulphur may be in adequate supply in the diet, but it may not be in a form that is digestible because it is so unstable it breaks down during processes, such as the maturation of pastures and the drying of hay (Briggs, 2007).

For this reason MSM may prove to be a valuable supplement.

MSM (methylsulfonylmethane)

MSM - $(CH_3)_2SO_2$ - is a naturally-occurring organic molecule found in fresh raw foods. MSM contains one third sulphur by weight. It is thought to be a very effective way of delivering sulphur to the body in a useable format. Indeed, Magnuson (2007) found that most MSM was excreted through the urine and only 3% was passed through the faeces, which suggests it is highly and readily absorbed. It must be first in the blood before it can end up in the urine.

Although MSM, as a naturally-occurring molecule, is normally ingested in very small quantities, it has been historically fed in significant doses for joint supplementation. It is an effective natural analgesic that blocks the inflammatory process by regulating muscle nerve impulses and proceeding to active joints, where it is thought to strengthen connective tissue by maximising sulphur bonding and increasing viscosity of joint fluid (Usha & Naidu 2004).

Even if a higher concentration of sulphur increases the tensile strength of hooves, there must be a physical limit to how much extra disulphide bonding can be produced. Beyond the point of saturation, what becomes of any extra sulphur? Will the equine body's tissues collect and hold sulphur beyond optimum concentration? Is it possible that a body's resilience against pathogenic invasion can be fortified by having excess sulphur circulating in the system and acting bacteriostatically?

If consensus suggests there is no sulphur deficiency in the equine species, can the anecdotal benefits being noted with MSM supplementation be due to bio-accumulation?

Bioaccumulation is the concentration and storage of substances in living tissues beyond levels of their immediate need and is usually referring to harmful contaminants, such as heavy metals and pesticides, but organisms can also accumulate beneficial compounds and minerals needed for their survival. Fat-soluble organic substances may be stored in adipose tissue and thereby remain in the body for long periods of time. Unfortunately, sulphur containing compounds, such as MSM, are water soluble and are, therefore, not persistent nor bio-accumulative (Koleva 2012).

What about short term accumulation? It is known that plasma concentrations of sulphur respond to fluctuations in dietary intake (Lewis 1995). MSM has also been shown to accumulate in human tissue (Lin et al 2001) and MSM is detectable in serum for up to two days following oral ingestion (Magnuson et al 2007). Richmond (1986) determined that MSM was indeed incorporated into serum proteins, but only 1% remained circulating in the body. Increases in serum sulfate may explain some of the therapeutic effects of MSM (Parcell 2002).

There have been numerous human studies seeking to quantify the benefits of MSM. For example, chronic daily oral supplementation of MSM has alleviating effects on known markers of oxidative stress following exercise (Nakhostin-Rooshi et al 2011). There are fewer studies of MSM and horses, but Maranon et al (2008) demonstrated that MSM could offer some protection against oxidative and inflammatory exercise-induced injury in horses. The author could find no rigorous scientific studies linking MSM to hoof improvement in horses, only anecdotes.

On the balance of available evidence, the author theorises that MSM is possibly beneficial to equine hooves by ensuring an adequate supply of sulphur is available for production of

structural and metabolic compounds. It is also feasible to suggest that the benefits of MSM come via horses' bodies being more muscularly relaxed, with less stress, lower cortisol levels, less laminitic pressures and stronger tissue connections.

Evidence for the effectiveness of MSM

Anecdotally, MSM appears to produce both a tighter laminar connection and a mechanically stronger hoof (evidenced by the hoof capsule texture becoming more like polished marble).

Whilst the changes are not sharp and sudden, and are subtle in healthy hooves, the worst hooves appear to change the most tangibly, especially hooves with separated quarters and sensitivity caused by white line disease.

MSM dosage rates

The recommended dosage of MSM seems variable according to either the company that packages it or the therapist who prescribes it - anything from 7g to 36g daily.

A detailed study by Riegel (2001) compared the difference between daily supplementation of 10 and 20g of MSM and found that Standardbreds supplemented 20g of MSM daily showed faster race times, quicker muscle recovery (measured thermographically), better appetite and faster hoof growth than those given 10g.

He treated the 20g as a loading dose, and after six weeks went back to 10g as a maintenance dose and found no regression. Likewise, he found no apparent side effects of 20g daily and suggested even higher doses of MSM be investigated.

An Australian authority on MSM, Sharon May Davis has prescribed its long term use as a joint supplement for performance horses. She would give a rounded tablespoon (about 18g) am and pm to a 500kg horse in regular work (eventing) or a 450kg horse in heavy training (endurance marathons), and would allow a month to build up to this level from an initial dose of one teaspoon (about 5g) am and pm to avoid digestive upset. Sharon adds that she would also consider the rider's weight, equestrian discipline and training hours when allocating dosage.

Similarly, at Mayfield Barehoof Care Centre, MSM is routinely added at the rate of 1 tablespoon once a day to 'sound' horses (ponies are given relatively less), but horses undergoing lameness rehab, especially those with inflammation, will be fed 1 tablespoon twice a day.

Most hoof problems are seasonal, so a valid question to ask is, what about seasonal loading? MSM may only need to be fed at higher doses leading up to and including the wet season. Further study is required to determine this.

Possible contraindications of MSM

There is little or no evidence to determine the effects of long term use of MSM, because it is considered to be one of the least toxic biological substances known, similar in toxicity to water (Usha and Naidu 2004).

In terms of excess sulphur, there is only one recorded episode of poisoning due to (accidental) consumption of very large amounts (200-400g) of pure inorganic sulphur by a group of horses (Corke 1981). Compared to this, a high daily dose (2 tablespoons, approx. 36g) of MSM would deliver about 12g of organic sulphur. In any

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case, the equine body should be able to efficiently eliminate any gross MSM excess. It is efficiently absorbed and easily excreted.

Sulphur is known to bond readily with almost every other mineral and will readily form organic compounds (sulphates, sulphites and sulphides) that may prevent other minerals being absorbed from the hindgut. However, as previously mentioned, MSM has been shown to be readily absorbed into the blood stream, well before it bonds with other compounds.

Importantly, the author found no evidence linking MSM to bladder stones or enteroliths.

It is often said that too much sulphur in a horse's digestive system can block copper absorption and, ultimately, lead to copper deficiency symptoms, including a decrease in the tensile strength of connective tissue, but the author was unable to locate any solid references to this. In fact, the connection might be erroneously drawn from bovine studies where chronic consumption of excess sulphur has long been known to lead to copper deficiency via the production of copper sulphides in the rumen that prevent copper from being absorbed (Mason 1978, Ward 1978). Or was it the finding that copper deficiency due to excess sulphur in Przewalski's Gazelle in the Qinghai Lake area of China (near Mongolia) was linked with naturally high concentrations of sulphur in their natural forage (Li Ye Zhou et al 2009)? Both are ruminants. Horses are monogastrics, not ruminants.

It has actually long been known that the likelihood of sulphur-related copper deficiency in equines in minimal (Suttle 1974, Strickland et al 1987).

There is also the belief that excess sulphur in a horse's diet may adversely affect selenium levels. Whilst there is a known antagonistic relationship between sulphur and selenium in ruminants, whereby cattle ingesting a sulphur rich diet need to be supplemented with selenium (Weiss, 2014), the author did not locate any recorded instance of sulphur derived selenium deficiency in equines.

Ruminant digestion is significantly different to monogastric digestion. In this regard, horses should not be compared to cattle.

Anecdotally, at least, it appears that MSM acts unilaterally and can be added to a horse's diet without affecting other minerals to any significant extent. However, it would be wise to proceed with caution and observe for signs of copper or selenium deficiency. If a 'complete' hoof supplement is already being fed, the MSM can simply be added to it.

There have been (occasional) anecdotal reports of horses becoming more spirited after being supplemented with MSM. In the author's lifetime experience with handling horses, those animals that have been dull with chronic pain don't reveal their true temperament until such discomfort is removed from their daily existence.

What about MSM's first cousin DMSO?

DMSO (Dimethylsulfoxide) is a close relation and can be considered an unstable precursor to MSM. In fact, MSM is often referred to as $DMSO_2$. A major difference is that DMSO is a liquid at room temperature and MSM is a powder.

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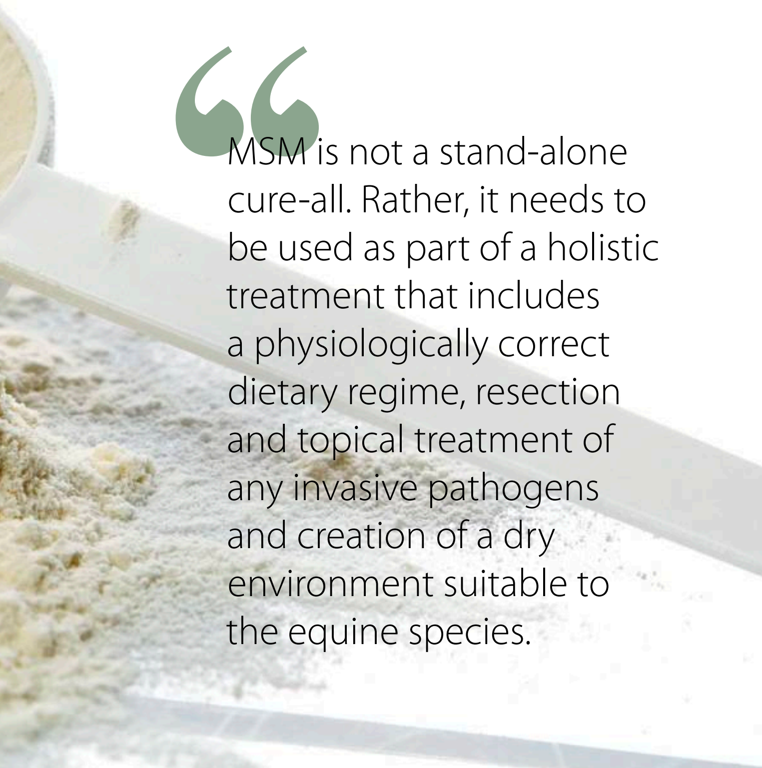

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DMSO is a very effective penetrant that is readily absorbed through cellular membranes, especially the skin, and will act as an agent to transport other chemicals through the external skin barrier.

Once inside an organism, DMSO acts by neutralising and excreting the free radicals, which are the primary trigger in inflammatory processes (Fox & Fox 1983). In addition to this, approximately 15% of DMSO is metabolised into MSM in the body (Hucker et al 1967).

DMSO has been used for many years in the horse industry, especially by racehorse trainers who have rubbed it daily into coronet bands in order to alleviate the inflammation arising from the effects of hard work on young bodies.

DMSO has also been used at Mayfield Barehoof Care Centre to help treat recalcitrant hoof infections, such as canker. Is it effective because it helps to transport other chemical agents into hoof tissue or is it simply adding usable sulphur into the local area? DMSO is known to inhibit a wide range of bacteria (Basch & Gadebusch 1968).

Because MSM is not active when applied topically, maybe it could be mixed with DMSO and applied topically at the coronet band so it may enter the hoof directly? More studies are needed to determine if this would be beneficial.

Conclusions

There is much anecdotal evidence that shows how MSM can assist hooves affected by wet environments that are suffering loss of structural integrity and subsequent pathogen invasion, but there is no rigorous scientific evidence to explain why it works.

How then does MSM work?

It is likely that it addresses a previously unknown but chronic sulphur deficiency. Maybe it saturates the hoof building sites with enough 'sulphur' amino acids to optimise hoof strength? Maybe the benefits arise indirectly due to the creation of healthier muscles and joints, which allow a horse to move and stand more comfortably? Maybe as a result of improved comfort there is more energy, less cortisol and a stronger laminar bond?

Maybe it is all of the above?

When considering the available evidence, it appears that MSM is safe and acts unilaterally and does not have any relevant antagonistic relationships with other minerals in equines. For horses with hooves that are challenged by a wet environment, MSM is certainly worth a try - at least for the duration of a season.

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