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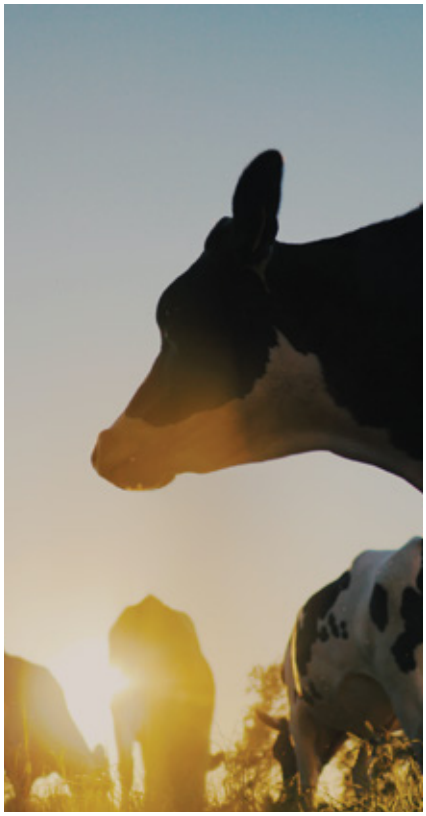


Time to Rethink the Use of Sulphates In Animal Nutrition

Time to Rethink the Use of Sulphates in Dairy Rations

A mineral source that is less reactive in the rumen can be more available for absorption in the lower gastrointestinal (GI) tract. In addition, a mineral source that is less reactive and more predictable helps provide the optimal balance of minerals in the ration.

A primary difference between sulphate trace minerals and organic trace minerals or hydroxy trace minerals (IntelliBond®) is the type of chemical bond that is formed. Sulphates have an ionic bond, which breaks apart in water and can release free metal ions to interact with other essential nutrients in the ration or the microbes in a cow's rumen. The weaker bonds are less stable and can generate more oxidation while reducing absorption. Organic trace minerals and hydroxy trace minerals contain covalent bonds. The covalent bonds keep the metal atoms from being released too early into the digestive tract or reacting with nutrients in the ration.

Hydroxy trace minerals (IntelliBond®) were developed in the 1990s to provide a trace mineral source that provided equivalent or greater trace metal absorption compared with better quality organic trace minerals, but at a much lower price point. This provided nutritionists with the ability to cost effectively replace all inorganic trace minerals in the ration, with a more available and predictable source of trace mineral nutrition. [Figure 1]

In dairy cows, every point of neutral detergent fiber (NFD) digestibility improvement can mean an additional 250g of 4% fat-corrected milk (Oba & Allan, Michigan State Univ). Exchanging inorganic trace minerals for hydroxy trace minerals (IntelliBond®) can add about three or four points of digestibility. This shift could mean up to an additional kilogram of 4% fat-corrected milk per cow per day during transition and periods of higher lactation.

The amounts of soluble metal found in the rumen were significantly lower for steers getting hydroxy chloride (IntelliBond®) additives. The increased levels of minerals present when sulphate minerals were used meant that more copper, zinc and manganese were free to attack ruminal bacteria and as a result, larger amounts of these metals were unavailable for absorption by the animal.

This overview of internal research, conducted by multiple leading universities, confirms that there is credible evidence of the risks associated with using sulphate-based trace minerals in ruminants. There is also credible evidence of the benefits of replacing sulphates with hydroxy chloride trace minerals (IntelliBond®) on nutrient stability, feed stability, rumen function, mineral bio availability and the impact on the environment.

The role that the source of trace minerals plays in dairy cow performance

This article highlights the role that the source of trace minerals plays in dairy cow performance and draws on research conducted internally and with multiple universities. Various trials and studies found that replacing sulphate sources of trace minerals with hydroxy chloride-based trace minerals (in all of these trials and studies, **IntelliBond®**) improved the stability of nutrients in the ration, optimised rumen function and improved trace metal absorption. The switch from sulphates also limited the negative influence of sulphate-based trace minerals on feed intake as a result of their poor palatability in calves.

Trace minerals like zinc, **copper, manganese and selenium** are essential elements in rations for dairy cattle and other ruminants. These trace minerals support multiple essential functions including reproduction, immune response, protein synthesis, hoof and skin integrity, and animal longevity. Providing trace minerals in the wrong form and amount - either too low or too high - can generate negative outcomes for animal performance, reproduction, disease response and potentially increase mortality. Trace mineral premixes can be used to provide the optimal amount of trace minerals at the herd level. However, the source of the trace minerals included in the premix needs to be carefully considered to avoid unintended negative consequences.

Trace metals like zinc (Zn), manganese (Mn) or copper (Cu) deliver nutritional value to the dairy cow only when they are absorbed through the intestinal wall and move into the blood stream. At that point, the cow directs how and where the metals will be used to support numerous physiological functions. **A mineral source that is less reactive in the rumen can be more available for absorption in the lower GI tract. In addition, a mineral source that is less reactive and more predictable helps provide the optimal balance of minerals in the ration.**

The evolution of trace mineral types

In the 1930's, trace minerals were added to animal diets using an oxide form. While oxide sources were the initial mineral supplements established for animal feed, they have the lowest level of absorption compared with all trace mineral currently used. Sulphate-based sources became available in the 1940s and 1950s as a more available source of trace metal absorption. Comparisons of the absorption rate of copper oxide (cupric oxide) and copper sulphate (cupric sulphate pentahydrate) revealed that copper sulphate is 5-times more absorbable by cows when added to a ration, while zinc sulphate is 2-times and manganese is 4-times more bioavailable. Oxide-based additives are traditionally made for use in other industries and the process used can alter how much of the mineral is available to the cow. One study comparing zinc sulphate with multiple sources of zinc oxide manufactured via different processes found that the availability of the zinc oxide varied from a low of 20% (relative to zinc sulphate) to a high of 80%. Given that it is extremely difficult to know which manufacturing process is used, it becomes extremely challenging to predict how much of the mineral is available to the animal.

In the 1970s, organic sources of trace mineral were developed to improve nutrient bioavailability ***[Figure 1]***. However, due to their high price and low mineral concentration, most producers chose to replace only a small portion of the required trace minerals with organic sources.

Hydroxy trace minerals (IntelliBond®) were developed in the 1990s to provide a trace mineral source that provided equivalent or greater trace metal absorption compared with better quality organic trace minerals, but at a much lower price point. This provided nutritionist with the ability to cost effectively replace all inorganic trace minerals in the ration, with a more available and predictable source of trace mineral nutrition. ***[Figure 1]***

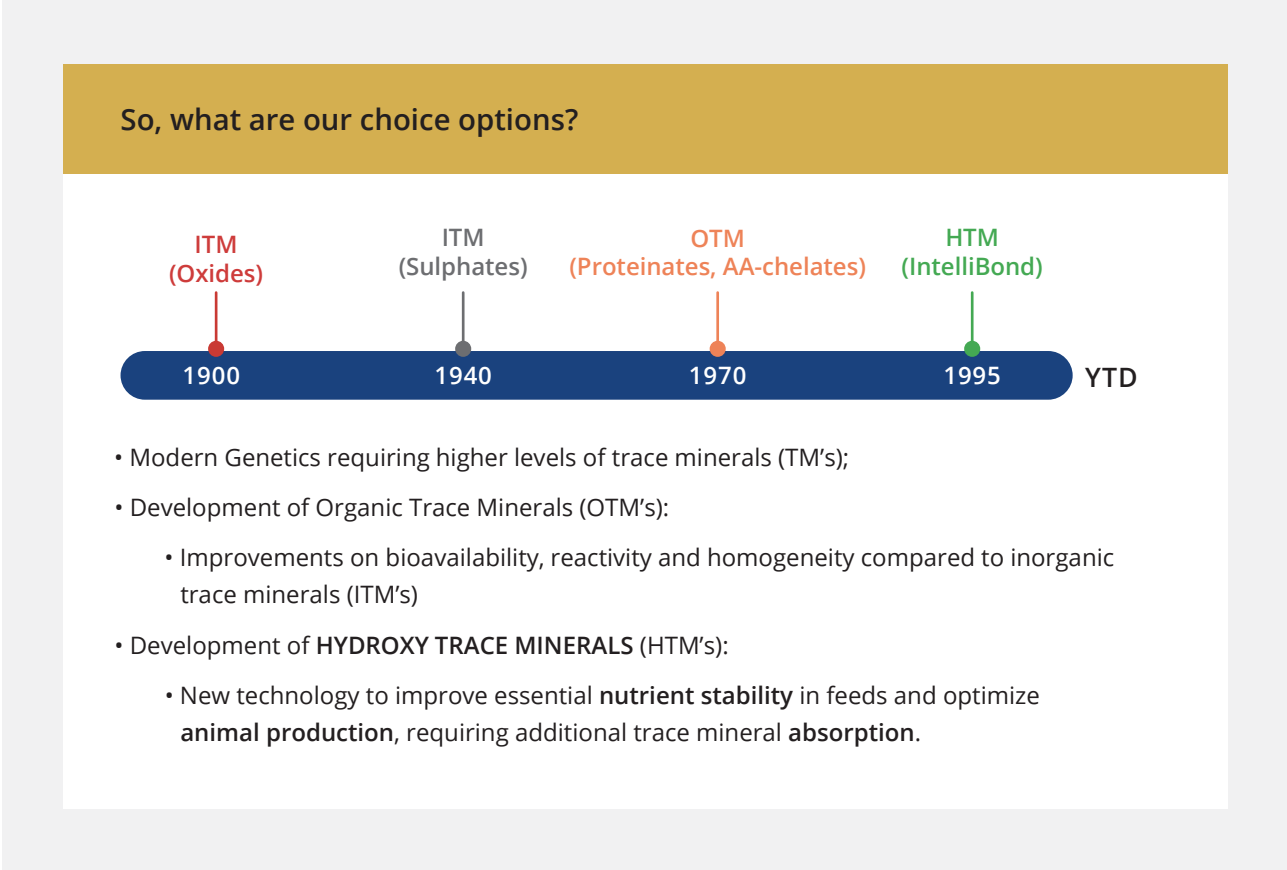


Figure 1

Bonding makes all the difference

A primary difference between sulphate trace minerals and organic trace minerals or hydroxy trace minerals (IntelliBond®) is the type of chemical bond that is formed. Sulphates have an ionic bond, which breaks apart in water and can release free metal ions to interact with other essential nutrients in the ration or the microbes in a cow's rumen. The weaker bonds are less stable and can generate more oxidation while reducing absorption. Organic trace minerals and hydroxy trace minerals contain covalent bonds. The covalent bonds keep the metal atoms from being released too early into the digestive tract or reacting with nutrients in the ration.

Research shows sulphates may do more harm than good

Analysis of multiple studies and several years of research results has identified several concerns regarding sulphate minerals in the dairy ration. These include additional production costs incurred by reducing the stability and availability of ration ingredients or limiting the function of added vitamins and enzymes. The continued use of sulphates may also reduce the amount of milk that cows produce and negatively influence the development of embryos. Additionally, as environmental considerations gain prominence in production practices, removing sulphates may reduce the level nutrients like phosphorus that are monitored in the environment.

Absorbing trace minerals

Multiple factors influence the efficiency of trace metal absorption, including nutritional status, mineral solubility, available antagonist, physiological stress, species, gender, age and intestinal and rumen micro-flora. To improve the precision of cattle diets, more predictable forms of trace mineral are needed. However, in a set of studies looking at uptake of hydroxy trace minerals **(IntelliBond®)** researchers found that hydroxy trace minerals are a more predictable mineral source. During controlled research evaluations, cattle receiving hydroxy copper absorbed approximately twice as much copper and zinc from the hydroxy source compared with the sulphate-based source.

Sulphate use reduces some feed ingredient stability

A study examining the use of either 200 parts per million (ppm) copper sulphate or 200ppm of copper hydroxy chloride **(IntelliBond C®)** in stored feed for 40 days found that vitamin E activity fell 32% by day 10 and 70% by day 20 in the feed that included copper sulphate. In diets that contain a nonprotected fat ingredient like soybean meal, DDGS or rapeseed meal the sulphate sources may increase the rate of oxidation. Diets with an unprotected fat source and added dietary vitamin E, trigger the vitamin to engage as an anti-oxidant, to offset oxidation rather than being available for the animal. In a series of reaction studies, IntelliBond C outperformed copper sulphate in terms of the stability of in-feed vitamin A, riboflavin and Vitamin E ***[Figure 2]***. The feeds with the hydroxy trace minerals additive also demonstrated reduced lipid oxidation and improved phytase activity, which has positive environmental implications.

Figure 2

Essential nutrient stability summary

Research Location	Tested	Compared	Test Measure	Parameter	Improvement Using IntelliBond C
PARC Institute	Feed	$CuSO_4$	21 days @ 37C	Vitamin A	**+6.2%**
PARC Institute	Feed	$CuSO_4$	21 days @ 37C	Riboflavin	**+3.8%**
PARC Institute	Broiler Livers	$CuSO_4$	21 days	Vitamin E	**+55%**
PARC Institute	Broiler Livers	$CuSO_4$	21 days	Vitamin E	**+16.9%**
Chinese Academy	Broiler Livers	$CuSO_4$	21 days	Vitamin E	**+22.1%**
Purdue University	In Vitro	$CuSO_4$	Phytate Hydrolysis	Insoluble Cu Phytate	**25.5% Less**
Purdue University	Broiler Feed	$CuSO_4$	7 days @ 40C	Phytase Activity	**+47.8%**
Auburn University	Layer Feed	$CuSO_4$	10 days @ 40C	Phytase Activity	**+67.8%**
Chinese Academy	Broiler Feed	$CuSO_4$	10 days @ 38C	Phytase Activity	**+78.5%**
University of Florida	Broiler Feed	$CuSO_4$	20 days @ 37C	Lipid Oxidation	**23.8% Less**

Sulphate use increases phosphorus waste

In addition to reacting with multiple ingredients in the diet, copper sulphate use can significantly increase the amount of phosphorus excreted into the environment. In a feeding trial where 125ppm copper sulphate was included in the diet, 42% of phytate was non-hydrolysed or not available for the cow to use. At the same inclusion level of copper hydroxy chloride (IntelliBond C), there was 0% non-hydrolyzed phytate ***[Figure 3]***. Sulphate use in rations can reduce phytate hydrolysis, limiting the amount of phosphorus available for absorption by the animal and therefore allowing more to be excreted into the environment. In a study comparing copper-chloride, copper-citrate and copper-sulphate to IntelliBond C, only the hydroxy chloride source supported the release of phosphorus.

Environmental matters

How much phosphorus is released in environment?

- The supplementation of copper sulphate led to more phosphorus being excreted to the environment
- At 125 ppm copper from CuSO4, over 42% of diet phosphorus wasn't hydrolyzed

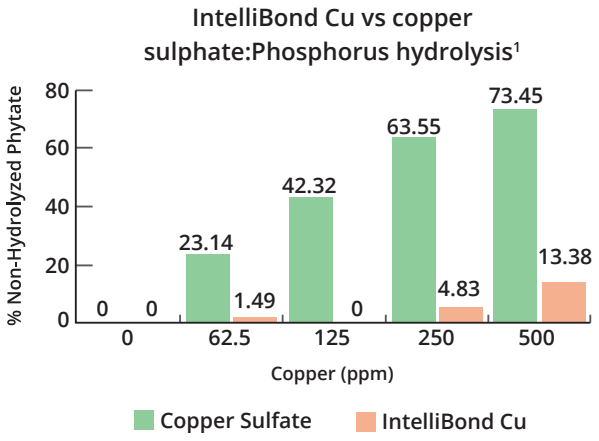
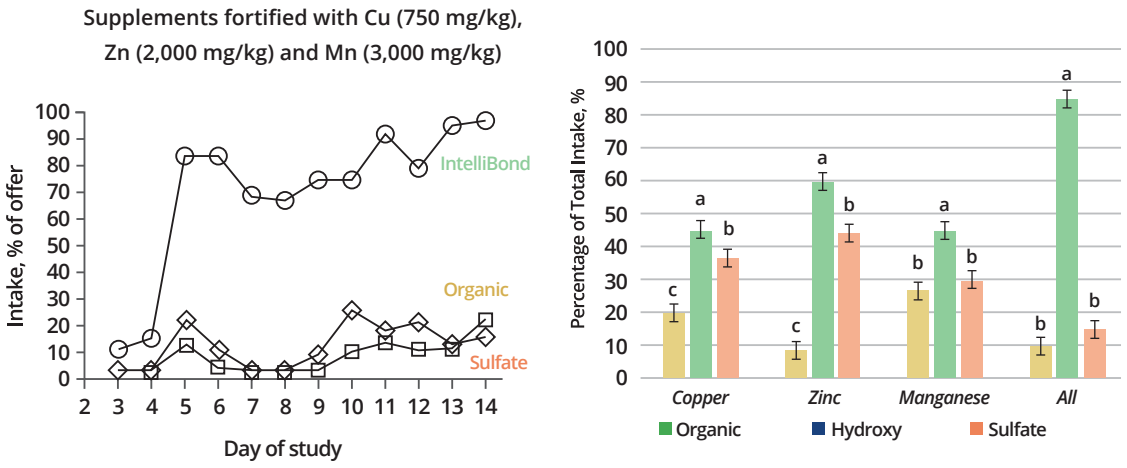


Figure 3

Replacing sulphates improves feed palatability

In addition to reducing the interaction between trace mineral supplement and nutrient elements in a ration, a series of studies at the University of Florida found calves (<350 kg) preferred diets with hydroxy trace minerals (IntelliBond) to diets with sulphate trace minerals. When inorganic trace minerals were replaced with hydroxy trace minerals in creep feed, intake moved from 20g per day to 160g per day as calves appeared to find the feed with hydroxy chloride trace minerals more palatable. Similarly, in a voluntary selection trial, feed intake was 26% greater with feed containing hydroxy chloride trace minerals than feed containing sulphates sources ***[Figure 4]***.

Sulfate and Organic TM's reduced preferencial intake of calves receving supplements fortified with Cu, Zn and Mn



Source: Caramalacet al. 2017. J. Animal Sci. 95:1739-1750

Figure 4

Damage to ruminal function, digestibility and VFA production

Copper sulphate products are known to be highly soluble and have antimicrobial properties in their ionic form, which is why they are utilised in foot bath applications. However, when included in feed, those properties may limit rumen functionality by reducing the function of ruminal bacteria due to the antimicrobial activity of the trace metal.

In a study conducted at Colorado State University in the U.S., steers received diets without supplemental copper, zinc or manganese, followed by a rumen bolus dose of 20ppm Cu, 60ppm Zn and 40 ppm Mn from either sulphate or hydroxy chloride (IntelliBond) feed additives ***[Figure 5]***. **The amounts of soluble metal found in the rumen were significantly lower for steers getting hydroxy chloride (IntelliBond) additives. The increased levels of minerals present when sulphate minerals were used meant that more copper, zinc or manganese was free to attack ruminal bacteria and, as a result, larger amounts of these metals were unavailable for absorption by the animal.**

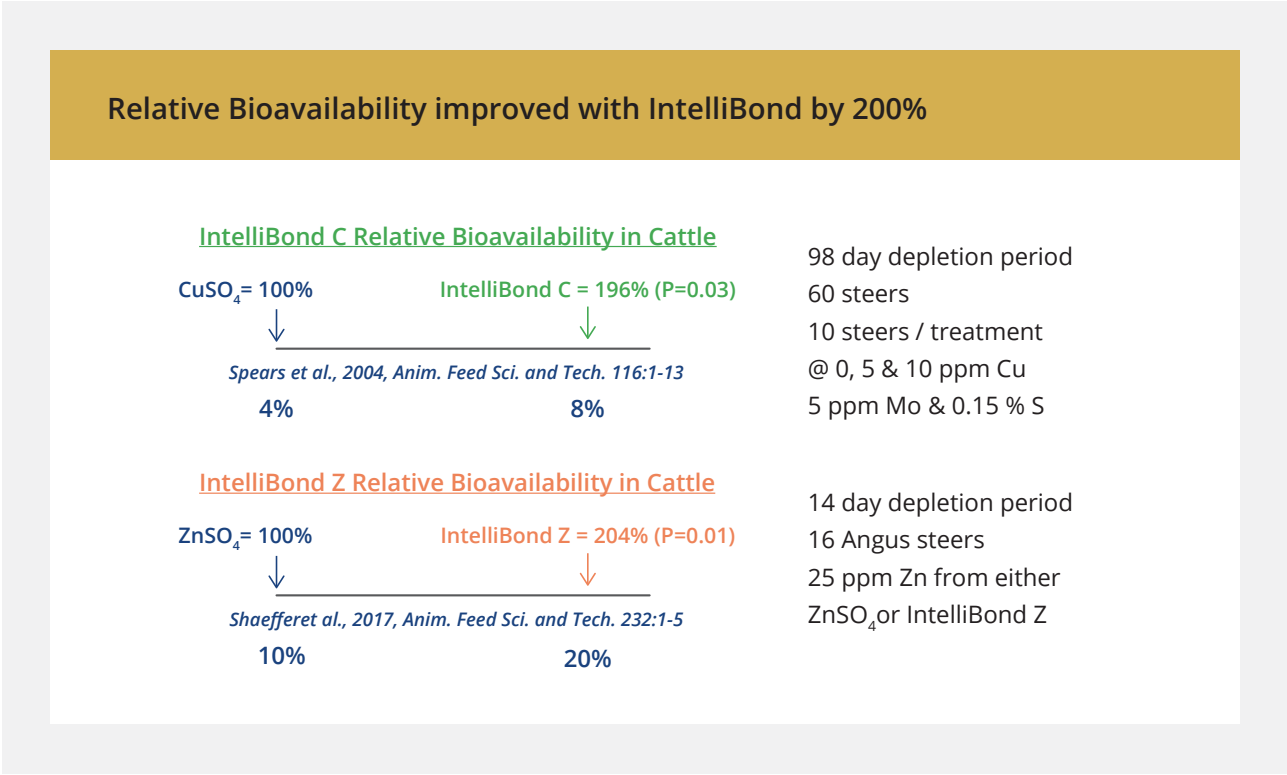


Figure 5

Microbial activity in the rumen generates volatile fatty acids (VFA), which are utilised by the cow. Introducing 90ppm zinc sulphate into a diet, compared to 90ppm of zinc hydroxy chloride **(IntelliBond Z®)**, reduced total production of volatile fatty acids from 90 millimolar (mM) to 62mM. Similarly, a series of 10 studies examining trace mineral use and the digestibility of neutral detergent fiber (NDF) found that fiber digestibility increased when hydroxy mineral sources were used ***(Figure 6)***. This improvement in digestibility provides more energy for the cow, which enables increased milk production, improved growth or better body reserves – depending on the cow's stage of growth or production.

In dairy cows, every point of NFD digestibility improvement can mean an additional 250g of 4% fat-corrected milk (Oba & Allan, Michigan State Univ). Exchanging inorganic trace minerals for hydroxy trace minerals (IntelliBond Z®) can add about three or four points of digestibility. This shift could mean up to an additional kilogram of 4% fat-corrected milk per cow per day during transition and periods of higher lactation.

NDF Digestibility: IntelliBond versus Sulphates

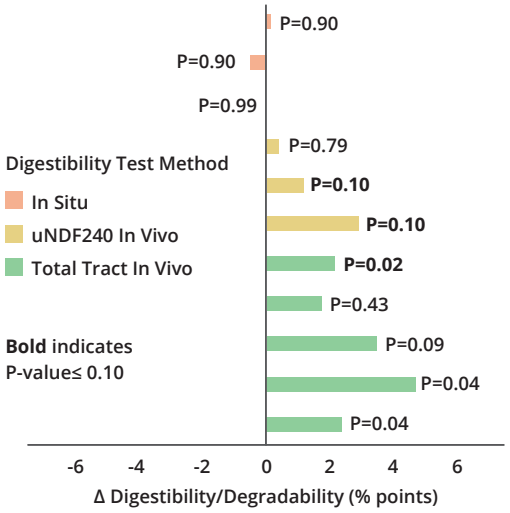


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Figure 6

Developing the next generation

Trace minerals have a role to play in dairy cow health along with their production. During a study at Cornell University, cows received diets with only sulphate trace minerals, combined inorganic and organic trace minerals and hydroxy chloride trace minerals **(IntelliBond®)** starting at 28 days prior to calving through to 84 days in milk. Samples of the blood plasma metabolism were examined. **Cows receiving the hydroxy trace minerals (IntelliBond®) supplement had lower plasma marker levels, indicating significantly lower oxidative stress in turn resulting in cows that were metabolically healthier and had produced greater milk and component yield.**

Improved mineral absorption may have implications for improved reproduction in high production dairy cows. A study conducted by U.C. Davis, California was conducted to track cows receiving hydroxy chloride trace minerals (IntelliBond) or an inorganic and organic combination of trace minerals for 10 weeks immediately following calving. Cows were super-ovulated at 50 days in milk. At 65 days in milk, embryos were collected through uterine flushing and evaluated. The number of high-quality embryos collected when compared with all collected ova and fertilized ova was significantly increased for cows receiving the hydroxy chloride trace mineral treatment.

In conclusion, this overview of internal research, conducted by multiple leading universities, confirms that there is credible evidence of the risks associated with using sulphate-based trace minerals in ruminants. There is also credible evidence of the benefits of replacing sulphates with hydroxy chloride trace minerals (IntelliBond®) on nutrient stability, feed stability, rumen function, mineral bio availability and the impact on the environment.

7 Research Takeaways:
Time to Rethink the Use of Sulphates in Dairy Rations

Research takeaway 1:
Sulphate sources of trace minerals in the ration present multiple concerns

Multiple studies have identified concerns regarding sulphate minerals in the dairy ration. These include additional production costs incurred by reducing the stability and availability of ration ingredients or limiting the function of added vitamins and enzymes. The continued use of sulphates may also reduce the amount of milk cows produce and negatively influence the development of embryos. Additionally, as environmental considerations gain prominence in production practices, removing sulphate sources of trace minerals may reduce the level of nutrients like phosphorus that are monitored in the environment.

Research takeaway 2:
Sulphate sources of trace minerals may reduce mineral absorption compared to other sources

Nutritional status, mineral solubility, availability to antagonists, physiological stress, species, gender, age and intestinal and rumen microflora are all factors that may influence the efficiency of mineral absorption. To improve the precision of cattle diets, more predictable forms of trace mineral are needed. In a set of studies looking at uptake of hydroxy trace minerals (IntelliBond), researchers found that hydroxy trace minerals were a more predictable mineral source than sulphate sources. During controlled research evaluations, cattle receiving hydroxy copper absorbed approximately twice as much copper and zinc from the hydroxy source compared with the sulphate-based sources.

Research takeaway 3:
Sulphate sources of trace minerals may increase oxidation

A study examining the use of either 200 parts per million (ppm) copper sulphate or 200ppm copper hydroxy chloride (IntelliBond C®) in stored feed for 40 days found that vitamin E activity fell 32% by day 10 and 70% by day 20 in the feed that included copper sulphate. In diets that contain a non-protected fat ingredient like soybean meal, DDGS or rapeseed meal, the sulphate sources may increase the rate of oxidation. Diets with an unprotected fat source and added dietary vitamin E trigger the vitamin to engage as an antioxidant to offset oxidation rather than being available for the animal. In a series of reaction studies, copper hydroxy chloride outperformed copper-sulphate in terms of the stability of in-feed vitamin A, riboflavin and Vitamin E [Figure 2]. The feeds with the hydroxy trace minerals additive also demonstrated reduced lipid oxidation and improved phytase activity, which has positive environmental implications.

Research takeaway 4:
Sulphate trace minerals may increases phosphorus waste

In addition to reacting with multiple ingredients in the diet, copper sulphate use can significantly increase the amount of phosphorus excreted into the environment. In a feeding trial where 125ppm copper sulphate was included in the diet, 42% of phytate was non-hydrolysed or not available for the cow to use. At the same inclusion level of copper hydroxy chloride (IntelliBond C®), there was 0% non-hydrolysed phytate [Figure 3]. Sulphate use in rations can reduce phytate hydrolysis limiting the amount of phosphorus available for absorption by the animal and allowing more to be excreted into the environment.

Research takeaway 5:
Replacing sulphate mineral sources with no-sulphate trace minerals improves feed palatability

In addition to reducing the interaction between trace mineral supplement and nutrient elements in a ration, a series of studies at the University of Florida found calves (<350 kg) preferred diets with hydroxy trace minerals (IntelliBond®) to diets with sulphate trace minerals. When inorganic trace minerals were replaced with hydroxy trace minerals in creep feed, intake moved from 20g per day to 160g per day as calves appeared to find the feed with hydroxy chloride trace minerals more palatable. Similarly, in a voluntary selection trial, feed intake was 26% greater with feed containing hydroxy chloride trace minerals than feed containing sulphates sources [Figure 4].

Research takeaway 6:
Sulphate sources of trace mineral may harm ruminal function, digestibility and VFA production

Copper sulphate products are known to be highly soluble and have antimicrobial properties in their ionic form, which is why they are utilised in foot bath applications. However, when included in feed, those properties may limit rumen functionality by reducing the function of ruminal bacteria due to the antimicrobial activity of the trace metal.

In a study conducted at Colorado State University (U.S.), steers received diets without supplemental copper, zinc or manganese, followed by a rumen bolus dose of 20ppm Cu, 60ppm Zn and 40 ppm Mn from either sulphate or hydroxy chloride (IntelliBond®) feed additives [Figure 5]. The amounts of soluble metal found in the rumen were significantly lower for steers getting hydroxy chloride additives. The increased levels of minerals present when sulphate minerals were used meant that more copper, zinc or manganese was free to attack ruminal bacteria and that larger amounts of those metals were not available for absorption by the animal.

Microbial activity in the rumen generates volatile fatty acids (VFA), which are utilised by the cow. Introducing 90ppm zinc sulphate into a diet, compared to 90ppm of zinc hydroxy chloride (IntelliBond Z®), reduced total production of volatile fatty acids from 90 millimolar (mM) to 62mM. Similarly, a series of 10 studies examining trace mineral use and the digestibility of neutral detergent fiber (NDF) found that fiber digestibility increased when

hydroxy mineral sources were used. This improvement in digestibility provides more energy for the cow, which enables increased milk production, improved growth or better body reserves – depending on the cow's stage of growth or production. In dairy cows, every point of NFD digestibility improvement can mean an additional 250g of 4% fat-corrected milk (Oba & Allan, Michigan State Univ). Exchanging inorganic trace minerals for hydroxy trace minerals can add about three or four points of digestibility. This shift could mean up to an additional kilogram of 4% fat-corrected milk per cow per day during transition and periods of higher lactation [Figure 5].

Research takeaway 7:
Sulphate sources of trace mineral may harm ruminal function, digestibility and VFA production

Improved mineral absorption may have implications for improved reproduction in high production dairy cows. A study conducted by U.C. Davis, California, was conducted to track cows receiving hydroxy chloride trace minerals (IntelliBond®) or an inorganic and organic combination of trace minerals for 10 weeks immediately following calving. Cows were super-ovulated at 50 days in milk. At 65 days in milk, embryos were collected through uterine flushing and evaluated. The number of high-quality embryos collected when comparing all collected ova and fertilized ova were significantly increased for cows receiving the hydroxy trace mineral treatment.

IntelliBond®

Selko®

The most researched hydroxy trace mineral

Still feeding sulphate trace minerals?

That could be causing more harm than good.

With a weak chemical structure, sulphate trace minerals break down too early in the digestive tract, creating potentially destructive reactions with other feed ingredients, interfering with ideal rumen function and preventing absorption of vital nutrients.

Replacing sulphate trace minerals with IntelliBond in the ration supports:

- **Improved stability:** IntelliBond's low reactivity in feed ensures more essential nutrients are available to the animal
- **Higher bioavailability:** Supporting optimal animal productivity and well-being
- **Optimised rumen function:** Maintains a healthy rumen environment supporting optimised fibre digestibility
- **Cost-effective:** An industry leading, cost-effective alternative to provide optimal trace minerals supplementation

Smart minerals, smart nutrition...smart decision

To read more about the dairy producer's guide to trace mineral supplementation follow the QR code.

Westside Enterprises is the sole distributor of the IntelliBond Product Range in Southern Africa.

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