How to optimize mineral intake in livestock nutrition

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Complexities of mineral nutrition require balance and careful management to maintain animal health and productivity.

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AND THE ANIMINE
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Minerals are essential components of livestock nutrition, influencing various physiological processes crucial for animal health and performance. However, ensuring optimal mineral intake involves navigating complexities such as distinguishing between basic requirements and potential responses when consumed at rates above these requirements. This involves understanding absorption coefficients and considering factors affecting bioavailability in forages, concentrates and supplements.

Bioavailability can be influenced by several factors including the chemical form of the mineral, the presence of antagonistic or synergistic substances in the diet, and the animal's physiological status. Therefore, a comprehensive approach is necessary to manage mineral nutrition effectively, optimizing animal health and maximizing productivity.

Requirements and adequate intake

When formulating diets, it is important to differentiate between the National Academies of Sciences, Engineering and Medicine (NASEM) requirements and adequate intake (AI) levels for minerals. The NASEM guidelines are designed for an average animal of a defined specific weight and milk production fed a typical diet. This means they may not be adequate for about 50% of the animals in that group. For example, if a pen has cows with an average milk production of 50 kilograms, formulating a diet to meet the requirements of the average cow in the pen will result in about half the animals being deficient. In contrast, AI levels indicate the amount deemed sufficient for most cows based on current data, when precise data is lacking.

A more relevant comparison for practical diet formulation is between these requirements or AI levels and the potential responses observed when minerals are consumed at rates above these levels. For example, cows can maintain productive and healthy lives without additional supplementation of certain minerals such as chromium. However, enhanced performance, such as improved health or productivity, is often observed when chromium is provided in the diet, although it does not have a defined requirement. Other nutrients also elicit positive responses when fed above requirements. This highlights the importance of considering baseline nutritional needs and the potential benefits of higher intake in certain cases.

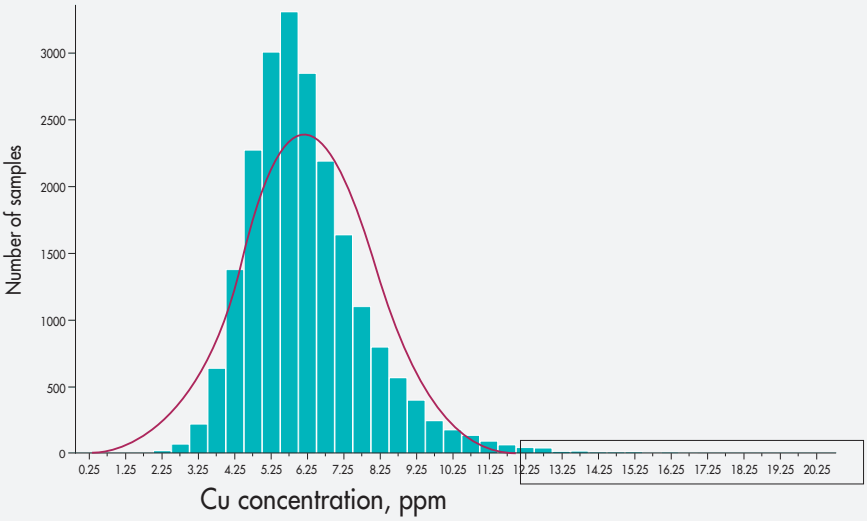
By understanding and utilizing the concept of nutrient responses — where animals show improved performance with higher nutrient intake — producers can better tailor diets to meet not only minimum needs but also to optimize overall animal health and productivity.

Absorption coefficient and relative bioavailability

Understanding absorption coefficients (AC) and relative bioavailability are key for assessing mineral nutrition. The absorption coefficient represents the proportion of a mineral that is absorbed from the diet and utilized by the animal. This metric is essential because it informs how effectively an animal can use the minerals provided in their feed, which directly impacts their health, growth and productivity. However, measuring AC is extremely challenging, leading to limited AC data for most minerals and feeds, including supplements.

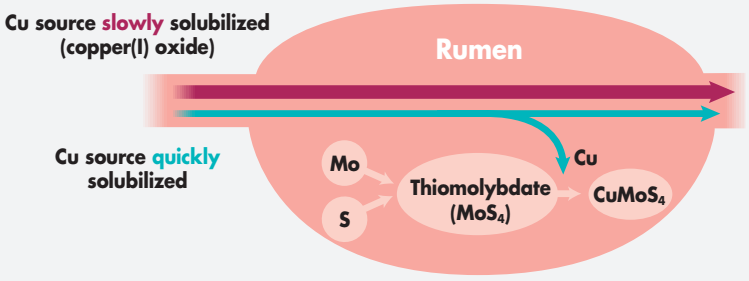
Relative bioavailability, on the other hand, compares the effectiveness of different mineral sources, providing insights into which sources might be more beneficial for meeting the animals' nutritional needs. Several factors influence AC and relative bioavailability, making it vital to consider the interactions between different dietary components.

Distribution of copper concentration (Cu, ppm) in corn silage



Graphic 1. It can be observed that the median value for Cu concentration is 6 ppm; approximately 75% of the samples exceed 5 ppm (highlight in the black square). This can indicate soil contamination by Cu, which can reduce the absorption coefficient of Cu. Despite the high Cu level in these forages, the Cu will not be absorbed. *Knapp and Weiss 2016*

Interactions between sulfur (S), molybdenum (Mo) and copper (Cu) in the rumen



Graphic 2. A slow solubilized Cu source would be slowly released in the rumen, avoiding complexations with Mo and S. On the other hand, fast solubilized Cu sources have higher probability of forming a complex with these elements. *Animine*

Bioavailability of minerals in forages

Forages constitute a primary mineral source in livestock diets, with macro minerals often meeting or exceeding supplementation levels. However, the bioavailability of trace minerals can vary significantly, influenced by factors such as soil contamination and diet composition. Soil contamination can introduce unwanted elements that interfere with mineral absorption. Additionally, high sulfur levels in forages or in water can act as major antagonists to trace mineral absorption. Adjustments to absorption coefficients are crucial in these scenarios to ensure accurate assessment of mineral availability. This is particularly important in feeds prone to soil contamination such as forages, where minerals may be less bioavailable. Graph 1 illustrates copper concentrations in corn silage.

Approximately 75% of the samples have high copper levels, suggesting a potential soil contamination or a naturally high copper content in the soil. Forages with high concentrations of trace minerals caused by soil contamination always have lower AC than those grown in soils naturally high in trace minerals. To better account for variability, it is recommended to use mean feed composition values rather than relying on single-sample values.

Safety factors for mineral formulation

When formulating diets, incorporating reasonable safety factors (SF) is essential to reliably meet animal requirements while avoiding deficiencies and excesses. It's important to remember that while deficiencies and excesses of minerals can cause problems, for most minerals, a modest deficiency is often more detrimental than a modest excess. However, sulfur presents a unique case where even a modest excess can be problematic, leading some experts to suggest feeding on average slightly below the requirement.

Safety factors should be based on various factors, including the variability of diet supply, the variability of requirements, the presence of potential antagonists, and regulatory considerations. Under typical conditions an SF of about 20% of NASEM requirements is appropriate for most minerals, but certain conditions will dictate greater or lesser SF. For example, if dietary sulfur, including the sulfur in water, exceeds about 0.25% of the diet, an SF of 20% probably is not adequate and should be increased for those minerals (if regulations allow). Certain minerals like phosphorus, sulfur, iodine and selenium should be fed at NASEM without SF. These exceptions arise due to more accurate estimates of requirements or specific regulatory considerations.

By carefully considering these factors and incorporating appropriate

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safety margins, livestock diets can be formulated to optimize animal health and performance while minimizing the risk of nutrient imbalances.

Adjustments for specific minerals

Adjustments for specific minerals require meticulous attention due to various common factors influencing its absorption. For instance, copper demands careful management due to the antagonistic effects of molybdenum and S in the rumen. These elements can form insoluble complexes with copper, significantly reducing its absorption and leading to deficiencies even when dietary copper levels appear adequate (Graph 2).

Nutritionists must adjust for depressed absorption of copper but they also need to be concerned about copper toxicity, which can occur at fairly low dietary copper concentrations. Even in the presence of antagonists, diets rarely should provide more than copper about 1.5 times NASEM requirements.

Conclusion

The intricate nature of mineral nutrition in livestock underscores the importance of a comprehensive approach to diet formulation. Understanding absorption coefficients and considering factors affecting bioavailability of the forages, concentrates and supplements are essential in mineral nutrition, as well as the interactions between minerals in the rumen. ■

References available upon request.

Editor's note: This is the fifth installment in a six-part series of articles.

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