Dairy Cows Need Adequate But Not Excessive Amounts of Trace Minerals

Dairy January 05, 2015

> *This article is part of our series of original articles on emerging featured topics. Please* ***check here*** *to see other articles in this series.*

Providing the correct amounts of bioavailable trace minerals in diets is necessary for healthy, productive dairy cows. Negative impacts relative to the cow, environment, and profitability can occur when inadequate or excessive amounts of bioavailable trace minerals are fed. The 2001 Dairy NRC (*Nutrient Requirements of Dairy Cattle, 7th Revised Edition*) established requirements for cobalt (Co), copper (Cu), iodine (I), iron (Fe), manganese (Mn), selenium (Se), and zinc (Zn); since 2001, substantial research has been conducted regarding chromium (Cr) supplementation of dairy cow diets. The mineral requirement in most, if not all, U.S.-based nutrition models comes directly from the NRC.

Please check this link first if you are interested in organic or specialty dairy production.

Estimating Requirements

The requirement for a trace mineral can be defined as the amount that must be absorbed daily to keep the cow healthy, maintain and optimize milk production, allow for efficient reproductive performance, and at the same time, maintain proper body stores of the mineral. Although this definition is widely accepted, quantifying actual requirements is extremely difficult, and substantial errors (both over- and underestimating requirements) can exist. Milk yield is often not useful in determining trace mineral requirements because it is often insensitive, at least in the short term, to extreme changes in dietary trace mineral supply. Measuring changes in body stores of trace minerals can be difficult (e.g., changes in liver copper concentrations). Quantifying dietary effects on cow health and reproduction is imprecise and usually requires a very large number of animals.

Another major area of uncertainty regarding trace mineral requirements is the bioavailability coefficients used to calculate absorbed trace minerals. Measuring the bioavailability of trace minerals is extremely difficult. Many of the

values that are used were determined a long time ago using isotopes under very limited conditions. Because some of the absorption coefficients are extremely small (e.g., ~5% for several sources of Cu and 0.75% for many Mn sources), small differences in absorption coefficients can have substantial effects on the calculated dietary requirements. For example, if the actual absorption coefficient for Cu under a specific situation was 2.5 percentage units lower than the assumed 5%, the diet would need to contain twice as much Cu to provide adequate absorbed Cu. The difference between an absorption coefficient of 5% and 7.5% may not even be detectable using our current ability to measure absorption.

Lastly, several common dietary conditions can greatly influence absorption of trace minerals. For example, high dietary or water sulfur can reduce Cu and Se absorption markedly. Using the standard absorption coefficients in that situation may lead to Cu and Se deficiencies.

Trace Mineral Supplementation

Because of the substantial uncertainties associated with trace mineral requirements and supply, nutritionists need to consider the costs of underfeeding versus overfeeding trace minerals when formulating diets. Underfeeding trace minerals can result in increased health problems, such as retained placenta and mastitis, poorer reproduction, and reduced milk yields. Overfeeding trace minerals can increase feed costs, increase the amount of trace minerals in manure (an environmental issue), cause excessive concentrations of minerals in animal products consumed by humans, interfere with absorption of other minerals, and result in mild to severe toxicity. Because of the potential problems associated with both under- and oversupplementation of trace minerals, most diets should not deviate greatly from NRC requirements.

1. NRC requirements are for total absorbed minerals. Both basal ingredients and mineral supplements contribute to total absorbed mineral supply, and the minerals provided by the basal ingredients should not be ignored. The NRC includes estimated absorption coefficients for trace minerals for basal ingredients and supplements. The absorption coefficients for trace minerals provided by basal ingredients are usually less than those for mineral supplements. Therefore, concentrations of trace minerals in forages and concentrates usually do not have to be discounted further. Trace minerals from forages that are contaminated with excess amounts of soil may need additional discounting. Soil contamination can increase concentrations of many trace minerals (especially Fe), but the trace minerals from soil are generally poorly absorbed. Haycrop feeds with more than about 9% ash and corn silage with more than about 5% ash are likely contaminated with soil. and trace mineral concentrations should be discounted.
2. Many specialty trace minerals (e.g., organic minerals) have been shown to have greater bioavailability than standard feed grade minerals. Take advantage of the higher availability (assuming the company has data on the specific product) by reducing supplementation rates to maintain adequate intakes of bioavailable mineral.
3. Because of regulations, diets cannot legally contain more than 0.3 ppm of **supplemental** Se. The NRC Se requirement basically follows the regulation; therefore, you cannot legally add a safety factor for supplemental Se.
4. Modest overfeeding of trace minerals is less costly than modest underfeeding, but it can still increase feed costs and mineral concentrations in manure. Formulating diets to provide about 1.2 times NRC requirements for most trace minerals (Se is an exception) is justified to reduce the risk of deficiencies and should have no negative effects on animals.
5. New data since 2001 bring the NRC requirement for Mn into question. Feeding at the 2001 NRC requirement can result in clinical Mn deficiency. Based on mineral balance studies, the actual requirement is 2.5 to 3.5 times the current NRC requirement. Negative effects on the animal are not an issue at these higher concentrations.
6. High concentration of Cu in the liver (greater than 150 ppm on a wet basis compared to an adequate concentration of about 35 to 50 ppm) is a risk factor for acute Cu toxicity. Excessive accumulation of Cu in the liver can occur over months or years by feeding what many may consider a safe concentration of dietary Cu. Feed proper amounts of trace minerals to the entire herd (replacements and mature cows), and consider the potential effects of overfeeding for a long period of time.
7. The 2001 NRC requirement for Cu (approximately 10 to 12 ppm) is likely adequate in many situations (12 to 15 ppm with modest safety factor). The NRC requirement is not adequate when high dietary or water sulfur with or without molybdenum is fed. See the article "Excess Sulfur and Potassium Can Cause Mineral Nutrition Problems with Dairy Cows" for additional information.
8. The 2001 NRC requirement (0.11 ppm) for Co may be too low. Some data showed improved vitamin B-12 status when diets contained $\geq$0.25 ppm.

9. The NRC did not establish a requirement for Cr in 2001. Since that time, several studies have been conducted, and many show increased milk yield in early lactation cows when supplemented with approximately 0.5 ppm Cr (currently the only FDA-approved source of Cr in the United States is Cr-propionate).

Table 1. Approximate 2001 NRC requirements for lactating cows and suggested safety factors for trace minerals.

Trace Mineral	**NRC Requirement[1]**	**Safety Factor[2]**	**Comment**
Chromium	Not established	NA	May increase milk yield in early lactation at ~0.5 ppm.
Cobalt	0.11 ppm	2 to 4 X	NRC recommendations may not maximize vitamin B-12 status.
Copper	10-12 ppm	1.2 to 3 X	1.2 X NRC should be fed to reduce the risk of deficiency because of uncertainty in supply and requirements. The safety factor must be increased as dietary (includes minerals from water) sulfur and Mo concentrations increase about 0.25% and 1 ppm, respectively. Cu should not exceed 3 X NRC.
Iodine	3.3 mg/100 lb BW	1 X	No new data justifying need for a safety factor.
Iron	15 to 18 ppm	1 to 1.2 X	No evidence that NRC level is not adequate; most basal diets contain more than adequate Fe.
Manganese	12 to 18 ppm	2.5 to 3.5 X	Studies have shown that NRC level is not adequate; studies suggest that 35 to 50 ppm is adequate.
Selenium	0.3 ppm (supplemental)	1 X	FDA regulations prohibit greater supplementation rates.
Zinc	43 to 50 ppm	1.2 X	1.2 X NRC should be fed to reduce the risk of deficiency because of uncertainty in supply and requirements.

[1] Requirement assumes typical absorption coefficients and typical dry matter intakes.

[2] Values expressed relative to NRC (2001) requirement. For example, if requirement is 12 ppm and safety factor is 1.25, diet should contain 12 * 1.25 = 15 ppm.

Author Information

Bill Weiss and Matthew Faulkner
The Ohio State University