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Trace Element Supplementation of Dairy Cattle: **Selling or Science?**

Identifying the trace element needs of dairy cattle is not simple. At first glance, it would seem obvious that we can calculate trace element requirements by:

- 1) feeding a standardised diet to the target animals,
- 2) varying the concentration of the trace element that we are interested in,
- 3) measuring the response we want.

The point at which increasing the trace element intake no longer affects the response is then defined as the 'requirement' of that trace element.



However, there are lots of hidden assumptions in that three-point list. Firstly, under New Zealand conditions feeding a standardised diet can often be easier said than done. Secondly, we need a response measure that is sensitive to changes in the trace element we are interested in – if we choose a response measure that is insensitive, we will not be able to accurately determine what our requirement is. Of course, just because one response measure has a particular requirement doesn't mean that another response will have the same requirement. This means that to properly determine requirements we need multiple sensitive responses. Too often those sensitive responses are surrogate endpoints such as gene expression or enzyme activity, rather than direct measurements of performance such as growth or milk yield, which are generally less sensitive and less specific.

Perhaps the most underappreciated issues are those around accurately measuring the intake of trace elements. Dietary requirements of many trace elements are very low (e.g. Cobalt requirements in cattle at pasture are <0.1 mg/kg DM; less than 1 part in 10 million), so we need accurate, precise measurements to ensure that our requirements accurately reflect the underlying need. Not all of the analytical techniques we use for trace elements are as good as we need them to be. However, more important than simple intake is measurement of supply – i.e. the amount of available mineral. This is dependent on the proportion of the mineral which is absorbed. Small changes in mineral absorption rate can have major effects on the supply of a trace element, but source, diet, animal and their interaction can all affect absorption. This means we lack good quality reliable absorption data, and extrapolation from a study to an on-farm situation is quite likely to be invalid especially if there are significant differences between in diets, animals or mineral source.

We should always be very wary of the 'it hasn't been shown to work in New Zealand' argument, but for trace elements we do need to be circumspect when using data collected in intensive dairy systems (which is where most of the work on trace elements comes from). Cattle on grass-based diets that are producing ~5-6000 L of milk per year have different mineral requirements from cattle on a high dry matter total mixed ration diets that are producing 12-15000 L/year. Thus, the uncertainties around mineral recommendations, which are present in all dairy systems, are exacerbated in New Zealand because compared to many of the studies used to set recommendations, we have different diets, animals and mineral sources.

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The response to these uncertainties in all systems is to formulate diets with concentrations of trace elements that are higher (and often far higher) than recommendations. This excess supplementation leads to increased costs, potential toxicities, potential interactions between minerals, and expensive urine and faeces containing high concentrations of trace elements. Although the pasture-based system that prevails in New Zealand does increase the hassle of in-feed supplementation (the standard method of supplementation in most intensive systems), New Zealand is not immune, with oversupplementation of trace elements being very common.

At the farm level, direct measurement of trace element intake is relatively rare in New Zealand, principally because it can be costly to measure sufficient paddocks to calculate actual intakes (and result interpretation is not simple), so supplementation is usually guided by measuring trace element status at the animal level. The same issues apply to animal status as apply to recommended intakes – optimal animal status varies depending on a wide range of factors including diet, lactation stage, season, age, performance and breed. So, in order to ensure that performance is not suboptimal, supplementation is usually designed to ensure that animal status is increased above recommended targets (often far above). However, in contrast to 'requirements', markers of animal status such as serum or liver concentration are generally set with a built-in margin – the marginal range, with animals above the upper threshold of the marginal range (i.e. animals with adequate status) being very unlikely to respond to supplementation. In this case, increasing intakes to increase animal status is likely to simply result in expensive urine and faeces and no improvement in performance.

However, on too many occasions New Zealand dairy farmers are sold minerals on the basis that adequate status isn't sufficient and that they should be feeding far more than they currently are even though laboratory testing suggests they are receiving sufficient trace elements. These suggestions can come from veterinarians, consultants or from nutritionists working for feed companies, all of whom can have a vested interest in selling products rather than in identifying whether they are needed or not. The strong suspicion in these cases is that the advice is based on selling products not on following the science

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A recent example in October 2024 exemplified this approach. A dairy farmer was concerned about their herd's milk production and having discussed it with a nutritionist, and, separately their main veterinarian, decided to sample their lactating cows to see whether additional trace element supplementation would likely be of value. The test results are presented in Table 1.

average for New Zealand. Farmers often agree to supplementation on the basis that 'it can't hurt' and that if they supplement and performance isn't as good as they hoped then it would have been worse if they hadn't supplemented. This is the insurance theory of supplementation. But too often what the farmers are buying is insurance for a Ferrari when they have the

Table 1: Serum copper, iodine and selenium concentrations from 10 dairy cows

ANIMAL ID	SERUM COPPER (UMOL/L) 31/10/24	IODINE* (UG/L) 01/11/24	SERUM SELENIUM (NMOL/L) 31/10/24
582	10.3	76	290
131	11.5	74	370
345	10.8	82	280
83	11.4	69	230
266	13.5	72	320
123	9.7	103	200
494	12.7	100	260
543	14.7	66	190
672	13.9	69	350
388	12.0	94	270
Means	12.1	81	276
Adequate range	(8.0 - 20.0)	(65 - 300)	(150 - 3500)

Why recommend cobalt and zinc in a bespoke supplement on the basis of testing Cu, I and Se? What's the rationale for recommending the more expensive 'organic' forms of zinc and Cu?

All animals were in the adequate range for all three trace elements. The standard interpretation of these results would thus be that, at the time of testing, the supplementation regime on the farm (which was principally water-based) was providing sufficient quantities of these trace elements and that the risk of under-performance due to insufficient copper (Cu), iodine (I) or selenium (Se) was very low. The outcome would thus be to continue the current supplementation regime.

However, the nutritionist stated that the average for both the Cu and I were "OK", but that there were some "low individuals", and stated that they were really concerned by the low Se. They thus recommended supplementation with a custom mix containing cobalt, I, Se, organic zinc, and organic Cu.

This is not an uncommon situation, especially in herds where milk production is higher than the

bovine equivalent of a Toyota Corolla. It is important to stress with this analogy that the Corolla may not be as exciting as a Ferrari, but it has been one of the best-selling cars in the world for the last 50 years because it is reliable and economic to run (just like most New Zealand dairy cows).

In this case, I think it's fairly clear that this is about selling supplements rather than responding to the results. Why recommend cobalt and zinc in a bespoke supplement on the basis of testing Cu, I and Se? What's the rationale for recommending the more expensive 'organic' forms of zinc and Cu? But what about the recommendations for Cu, I and Se – can they be justified on the basis of these results?

Copper supplementation

In ruminants, Cu is one of the most complex minerals to deal with. To properly discuss all the nuances of diagnosing the need for Cu supplementation is beyond the space available here, but the key points are:

- 1) Blood Cu concentration (measured in serum or plasma) is probably the best simple test we have to determine the availability of Cu at the critical sites (such as the hypothalamus) and thus the risk of Cu deficiency-related disease.
- 2) Because it is closely related to the maintenance of Cu at critical sites, blood Cu concentration is maintained until Cu reserves in the liver (the main storage organ) are depleted.
- 3) Adequate blood Cu thus does not confirm whether or not supplementation at the current rate will prevent under-performance due to insufficient Cu.

Variation of blood Cu within the adequate range thus does not identify animals that need supplementation. Cattle with lower Cu concentrations than herd average (e.g. cow 123 in Table 1) are most likely to simply be cattle whose individual 'normal' concentration is lower than the average. The low value is not evidence they need more supplementation.

Iodine supplementation

We lack nice, simple, easily interpretable measures of functional I status in cattle. The standard serum I test is not a measure of function, it's a measure of intake. For animals that are being routinely supplemented, and which are not reliant on the I naturally present in their feed, it's a good measure as their intakes should be relatively consistent. In such cases there is no evidence, under New Zealand conditions, that increasing supplementation to ensure that all cattle have serum concentrations higher than the current target of 65 µg/L (for example 80 µg/L) results in any benefits to cow performance.

So, for both I and Cu, the results in Table 1 don't support increasing supplementation rates above what they currently are. To be as certain as possible that this is the correct conclusion, the recommendation would be to measure liver Cu concentration in at least 12 cows to confirm there has been no depletion of Cu reserves and



Further reading

Suttle N, Mineral Nutrition of Livestock 5th Edn. CABI, 2022

This is absolutely one of the best textbooks ever, written by one of the best animal scientists ever. It contains fantastic summaries of the science for every major and minor trace element including the philosophy of mineral supplementation. It should be on the shelf (or e-book reader) of every farm veterinary practice. The e-book version can be purchased at [Cabi digital library](#)

Key quotes:

"Suppliers of inappropriately named 'organic' minerals sources have exploited the 'mineraleome' for all its worth... My view remains that the pursuit of hyper-availability through chelation continues to waste research resources and farmers' money"

"Livestock can satisfy most of their needs for minerals from those naturally present (inherent) in feeds and forages but are still rarely allowed to do so by 'fail-safe' commercial practices that outsource responsibility to suppliers of mineral supplements"

Grace N, Knowles S, Sykes A. Managing Mineral Deficiencies in Grazing Livestock 2nd Edn. NZSAP, 2009.

A New Zealand classic, written by highly knowledgeable authors with a practical understanding of the New Zealand system. Neville Grace's knowledge, enthusiasm and practical understanding are still much missed. This book is still an essential resource for every farm veterinary practice in New Zealand. [Link at NZSAP](#)

Key quotes:

"Too often, on-farm decisions regarding mineral nutrition still draw on non-scientific, rural press, promotional advertising and anecdotal sources... [This] has led to many ineffectual and uneconomic choices in the prevention and management of deficiencies"

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"The research in [intensive systems] on trace element nutrition has determined dietary requirements and established diagnostic criteria that suit those circumstances. The results are not always applicable to the New Zealand situation ... Local recommendations should be supported by local data as much as possible"

Both of these books are written by authors that are focused on evidence-based practical mineral nutrition ('putting animals before diets' to quote Neville Suttle). This is different from the US approach where the 'more is better' mantra appears to hold sway. A good recent review from a US perspective is that by Weiss and Hansen (2024).

Weiss W and Hansen S. Invited review: Limitations to current mineral requirement systems for cattle and potential improvements. Journal of Dairy Science. 107, 10099-10114.

Available open access at <https://doi.org/10.3168/jds.2024-25150>

The first author, Bill Weiss (recently retired), has been the leading researcher on relationships between minerals and vitamins and health of dairy cows and in developing methods to incorporate cow and diet variability into ration formulation. Hugely knowledgeable and a fantastic speaker, he is definitely the best advert for the 'American approach'. This review summarises much of the science behind the development of mineral recommendations and sets out clearly what we know and what we don't. Although critical of 'more is better', he does exemplify the approach of finding evidence to support increasing thresholds.

Key quotes:

"Unless clinically deficient, production, reproduction, and health are not highly sensitive to changes in supply of most minerals; therefore, expensive experiments conducted under different conditions with large numbers of experimental units fed diets for long periods of time [are] needed"

"[Such data] could lead to a hybrid system for some minerals [e.g., Mn, Se, and Zn] that includes both a requirement model and a response model"

Finally, the most recent explanation of why Se requirements are different in New Zealand dairy cows was published in the NZVJ in 2020 (Hendriks and Laven 2020):

Hendriks S, Laven R. Selenium requirements in grazing dairy cows: a review. New Zealand Veterinary Journal. 68, 13-22.

Not putting this in any way at the same level as the other readings but it does contain a lot of links to previous research on Se in grazing cows (especially the fantastic research by Jeff Wichtel). As Weiss and Hansen state reproduction is not highly sensitive to changes in Se, but the combination of the huge difference between the Se requirements in the US and New Zealand and the large herd sizes mean that New Zealand is probably the best place to do such research.

Key quote:

"Proponents of the hypothesis that Se intakes in New Zealand dairy cattle should be increased by at least 10 times the current recommendations are ... not using the evidence base correctly." ■

to sample I status on multiple occasions to demonstrate that intakes are consistent and are thus likely to reflect actual I status. However, given the previous history of the herd, such testing is probably unnecessary.

For both Cu and I, the nutritionist agreed that the averages were 'OK', so perhaps it is unsurprising that the evidence supporting extra supplementation isn't strong. What about the Se which the nutritionist described as concerningly low especially during mating? What's the evidence there?

Se supplementation

Why mating specifically? The nutritionist made the claim that the low level of Se seen in these cattle was likely to increase early embryonic loss. This was argued on the basis of the importance of Se in the antioxidant system, which is undoubtedly true, and Se deficiency in sheep in New Zealand (and in cattle elsewhere) has been shown to be associated with embryo mortality, but it does ignore the New Zealand data that strongly suggests that reproductive performance is a very insensitive response measure for Se status and that, inherently, the antioxidant status of New Zealand dairy cattle is enhanced by their pasture-based diet, which has a high intake of vitamin E and less oxidation potential than grain-based diets.

So, it is plausible that improving Se status could result in better maintenance of the fertilised embryo. However, on this farm, for increasing supplementation to have an effect on embryo survival would require the upper threshold of the marginal range for serum Se to be far higher than it currently is, when we have good data showing that the current New Zealand thresholds are robust. It is a constant refrain from those who are selling trace element supplements in New Zealand that current recommended intakes of Se and measures of Se status are too low. They often reference US data and their recommendations, but Se is probably the trace element that is most affected by the differences between US and New Zealand dairy farming, and, at the same time, the trace element for which we have, under New Zealand conditions, the best evidence that our recommendations are correct.

None of this means that our Se recommendations are definitive; cows change, feeding changes and systems change. All of these could affect the optimal level of trace element supplementation, but even though 'nutrition experts' constantly recommend large increases in

Se supplementation, none of them have put their money where their mouth is and demonstrated that their increased supplementation is economically beneficial and not just an expensive method of increasing the amount of Se applied to the paddock. It is much easier to recommend excessive supplementation than to test such recommendations and, potentially, demonstrate that they are wrong.

Conclusions

Increasing trace element supplementation in herds where there are concerns about performance is an easy and profitable approach, especially compared to testing and concluding that extra supplementation is not needed. Across all dairy systems, excess supplementation is the norm with advice commonly being given to farmers by 'experts' with a vested interest in selling more (and more expensive) product. Too often the science is stretched and twisted to justify supplementation when simply supplementing half the herd and recording the response would be the best approach to confirm that supplementation was beneficial.

Across all dairy systems, excess supplementation is the norm with advice commonly being given to farmers by 'experts' with a vested interest in selling more (and more expensive) product.

The lack of reports of such tests demonstrates perhaps better than any number of articles in the veterinary press that the people selling the minerals are much more interested in the sales than the science.

As veterinarians we need to be aware that we don't become mineral salesman and that we always focus on the benefit to the farm. When we encounter what seems to be selling rather than science, our focus still needs to be on identifying what is best for the farm. In all cases, we need to balance risk management with costs and remember that excess supplementation wastes resources and damages the environment. 🌱