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Understanding Basic Mineral and Vitamin Nutrition

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UNDERSTANDING BASIC MINERAL AND VITAMIN NUTRITION

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In a typical cow-calf operation in the Great Plains, the nutritional focus is on supplying protein and energy to the cows. That focus is appropriate since these two nutrients comprise the major portion of the annual feed cost of maintaining the cow herd. Recent concerns regarding trace mineral deficiencies has resulted in more producers now asking questions about the mineral and vitamin portion of the cow herd nutrition program.

The common sense approach to supplying minerals and vitamins to beef cows should be very similar to the one used in supplying energy and protein to the cows. In other words, determine the animals requirements and then attempt to, in the most economical and efficient manner possible, try to meet those requirements. What minerals and vitamins need to be considered? Let's examine the key ones.

Salt

The one mineral that should always be supplied to cows, and at all times, free-choice, is salt. The typical range cow's consumption of salt will be 20 to 30 lbs/cow/month or .05 to .1 lb/cow/day. Salt is the only nutrient that cows have the nutritional wisdom to consume at a level to meet their requirements.

Magnesium

In areas of the country where grass tetany is a problem, magnesium supplementation in the spring of the year should be practiced. A safe procedure is to start the cows on a magnesium supplement prior to spring grazing and maintain them on the magnesium supplement the first 30 days. To adequately ensure the cows are protected, a targeted magnesium consumption of 1 to 3 ounces per cow per day is recommended. The simplest system to accomplish this is the inclusion of magnesium oxide in a conventional mineral mix.

Phosphorus

Phosphorus supplementation is important in most areas of the United States, but it becomes more important in areas of the country where cattle are maintained on grazed forage year around. Thus, in areas such as Arizona, New Mexico, Texas, and Oklahoma phosphorus deficiency is more likely to be observed than in areas such as Nebraska, Colorado, Wyoming, or South Dakota where cows are routinely maintained on summer grass and then fed harvested forage during the winter months. Since phosphorus is the major cost in a mineral mix, determining what level is needed has major economic merit.

Research work on the merits of phosphorus supplementation in the Great Plains is somewhat limited. The most extensive recent work was a three-year USDA-ARS North Dakota study (Karn, 1992) that evaluated no phosphorus supplementation versus cows receiving phosphorus ad libitum during the summer months. This work failed to show any beneficial response in reproductive performance or calf weaning weights. Part of this is explained by the fact that even though the forage contained only .08 to .33% phosphorus (ave = about .12%), the cows consumed forage (extrusa) averaging about .23% phosphorus which means the cows were consuming 20 to 25 grams of phosphorus per day (80-100% of their needs).

It appears that most producers take one of two approaches towards phosphorus supplementation. Some producers supply phosphorus year around in mineral mixes that contains approximately 10 to 12% phosphorus. In contrast, a number of producers will simply only utilize a salt or salt/trace mineral mix.

What's the most practical approach to supplying phosphorus? Maybe the most practical and economical approach to supplying phosphorus is to make sure phosphorus is fed at critical times such as 30 days pre-calving through at least half the breeding season. Base phosphorus supplementation on the animal's requirements, level of phosphorus in the roughage, and how much roughage is being consumed.

Table 1. Phosphorus Requirements of an 1100 pound cow

Stage of Production	Daily Requirements of Phosphorus--Grams
Pregnant	
Mid Stage	17 grams
Late Stage	20 grams
Lactating	
10 lbs/day	22 grams
20 lbs/day	28 grams

Adjust the phosphorus requirement by 2 gram per 100 lb of change in cow body weight and .5 gram per pound of milk change.

The next step in formulating phosphorus requirements is understanding the phosphorus content of the forage.

Table 2. For Example--Average Phosphorus Content*-North Dakota Range Data (3-yr avg)

Time of Year	Native Range - Phos %
May	.15
July	.125
September	.108

*Karn-1992, J Prod. Agric. 5:409.

The last step will be calculating how much phosphorus the cows are consuming based on actual intake and phosphorus content in the forage.

Table 3. Projected Phosphorus Intake as Influenced by Time of Year and Forage Phosphorus Content (Assumes an 1100 lb Cow)

Time	Intake (% of Body Wt.)	% Phos. in Grass*	Daily Phos. Intake (grams)
Spring	3.0	.2	30
	2.4	.2	24
Fall	2.4	.15	18
	1.8	.15	13.5
Winter	2.1	.08	8.4
	1.5	.08	6

*Allows for a higher phosphorus intake due to selective feeding.

A strategic approach to supplying phosphorus is to make sure the cows requirements are met at least 30 days prior to calving and through the breeding season. If this approach is followed, the need for phosphorus supplementation during other times of the year can be at the discretion of the manager.

Trace Elements

The trace elements most likely to influence production in a typical Great Plains cow herd are copper, iodine, cobalt, selenium, zinc and manganese. Other elements such as iron and molybdenum can be important considerations, but seldom from a deficiency standpoint. In both cases, excess can have an impact on the animal, most notably by their negative impact on copper utilization.

What is the typical trace element content in forages? In a recent NAHMS beef survey, 352 forage samples were provided by producers in 18 states. A summary of the trace mineral classification used and the results are shown in Tables 4 and 5.

Table 4. Classification of Trace Elements Relative to Their Ability to Meet Either Dietary Requirements or Cause an Antagonistic Problem with Other Trace Elements

Nutrient	Deficient	Marginal	Adequate
Copper	below 4	4-7	7+
Iron	below 50	200-400*	50-200
Manganese	below 20	20-40	above 40
Molybdenum	---	1-3 or above**	below 1 (ideal)
Zinc	below 20	20-40	above 40
Cobalt	---	below .1	.1 - .25

* Above this level can cause a copper tie-up.
**Above 1 ppm can cause copper tie-up--ratio of copper to molybdenum should be 4.5: or above.

Table 5. Trace Mineral Classification for the 352 Forage Samples

Trace Element	Adequate	Deficient	Marginal	Marginal Level Causing Interference With Other Element	Very High
Copper	36%	14.2%	49.7%		
Manganese	76%	4.7%	19.3%		
Zinc	2.5%	63.4%	34.1%		
Cobalt	34.1%	48.6%	17.3%		
Iron	62.8%	8.4%	--	17%	11.7%
Molybdenum	42.2%	--	--	48.6%	9.2%

The most notable trace mineral deficiency was the fact that only 2.5 percent of the forage samples contained a level of zinc at or exceeding 30 ppm which is classified as adequate. In contrast, 76% of the samples were classified as having an adequate manganese level. Only 14.2% of the samples were classified as copper deficient but, another 49.7% of the copper levels were in the marginal classification.

The above results are for a wide range of forages collected throughout the United States. Results more specific to the four states (Colorado, Wyoming, Nebraska and Kansas area) are shown in Table 6.

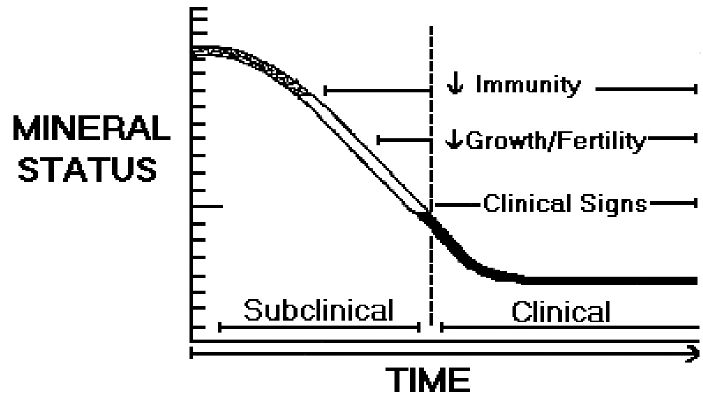
Table 6. Trace Mineral Content in Forage Samples Collected in 4-State Region (NAHMS Survey)

Forage	No. Samples	Crude Protein	ADF	Phos	Copper	Iron	Manganese	Moly	Zinc	Cobalt	Selenium
COLORADO											
Alfalfa	10	17.2	31	.21	6.8	164.6	41.8	2.8	18.1	.3	494
Native/Grass	5	15.4	34.7	.24	7.6	434	51.7	.9	16.5	.35	222.7
KANSAS											
Sudan	6	7.8	44	.22	4.9	237.7	46.6	1.4	16.2	.23	308.9
Native	6	10.5	42.8	.2	5.6	153.9	83.8	1.5	19.4	.2	581.4
Grass	6	12.8	40.2	.21	6	133.8	41.5	1.9	15.9	.26	114.6
Silage	5	6	38	.2	4.5	167.7	38.5	1.6	15.1	.42	187.6
NEBRASKA											
Alfalfa	22	18.6	40.4	.26	8	202.1	54.5	2.2	20.3	.25	368.9
Sudan	7	9.2	47.3	.27	6.1	211.4	50	1	38.6	.3	183.8
Grass	12	11.3	44.8	.18	5.1	213.5	64.1	1.6	17.9	.23	167.4
WYOMING											
Alfalfa	12	15.8	34.1	.2	6.1	114.4	35.5	1.8	15.9	.17	328.3
Native	8	8.4	38.1	.14	5	149.5	97.2	1.8	15.1	.13	254.1
Grass	13	8.6	37.7	.15	4.8	73.4	53.6	1.8	14.4	.16	175.8

The results from these 4-states support the national survey which indicates that most forage samples are marginal to deficient in zinc, and a fairly high proportion of the forage samples contain an adequate amount of manganese. Copper levels varied from marginal to adequate, which is compounded by the high iron content (above 350-400 ppm) and the relatively high levels of molybdenum (above 1 ppm) in many of the forage samples. These two antagonists can reduce the availability of copper.

How likely will the trace mineral deficiency impact productivity? Probably in the majority of the herds, productivity is seldom impacted by a trace element deficiency. More recently, however, veterinarians, nutritionists and producers are reporting isolated incidences where a trace element deficiency **is** impacting the production efficiency of an operation. In extreme cases, reproductive performance and/or weaning weights may be impacted. But, a more likely occurrence is an increased incidence of health-related problems often associated with a trace mineral deficiency. Although it is difficult to clearly confirm that the trace mineral deficiency directly contributes to the health-related problems, excellent research data does support the fact that there can be a relationship between trace element deficiency and health-related problems. The following illustration by Wikse (1992) shows how a trace mineral deficiency can contribute to both health and production-related problems.

FIGURE 1. EFFECTS OF TRACE MINERAL DEFICIENCIES ON IMMUNE FUNCTION IN COWS AND CALVES



Source: Wikse, 1992, TAMV Beef Cattle Short Course

What is a common sense approach to meeting the trace mineral requirements of cattle? Probably the most important part of a common sense approach to meeting the trace mineral requirements is to not "shot gun" by adding trace elements randomly to a mineral mix--only add trace elements when there is justification based on some diagnostic procedures. What are some diagnostic steps that could be followed to determine **if** a trace mineral deficiency exists. The following steps should be considered.

1. **Take forage or pasture samples.** Collecting a forage sample can be a very helpful diagnostic aid. Remember, your analysis is only as good as your sample. An example of how to use a forage trace mineral analysis is the interpretation of the results in Table 7.

Table 7. Analysis of Western Kansas-Nebraska Roughage Samples

Nutrient	Cane Hay Western Kansas	Grass Hay Western Kansas	Sandhills Nebraska Hay*
Protein, %	11.6	6.3	---
TDN, %	58.9	---	---
Phosphorus, %	.17	.12	.11
Copper, ppm	8.2	**2**	**3.25**
Zinc, ppm	26.7	**16.2**	**10.4**
Manganese, ppm	109.8	23.3	37.6
Molybdenum, ppm	**3**	**2.7**	.45
Iron, ppm	2344	166.9	74.1

*Source: Rush, 1994 -- 8 samples

Interpretation of these 3 roughage samples:

Cane hay--good quality cane hay except extremely high iron and molybdenum level could make copper unavailable to the animal.

Grass hay--typical grass hay except copper and zinc levels are very low and molybdenum levels very high.

Sandhills hay--manganese, iron and molybdenum levels acceptable, but copper and zinc levels are very low.

Pasture samples. Collecting range or pasture samples has merit. It is important to collect samples representative of the forages which are being grazed; therefore, careful attention should be given to not include weeds or other plants which are not selected by grazing cattle.

When evaluating clipped pasture samples it is important to realize that, when given a choice, animals will select a higher quality forage in terms of protein, calcium, and phosphorus. In a recent trial, we have found that this is not the case for trace elements (Table 8). We compared clipped vs. steer selected forage at a common location and found the clipped samples gave a good indication of the trace mineral content of the forage being selected by the grazing animals.

Table 8. A Comparison of the Trace Mineral Content of Hand-Clipped vs. Grazed Forage Samples[a]

Collected Method	Iron	Copper	Zinc	Manganese
Steer Selection	152.7±16.8	10.65±0.56	20.42±0.54	11.32±0.59
Hand-Clipped	154.8±23.7	11.49±0.79	19.50±0.76	12.84±0.84

[a]Results are expressed as the mean mineral content ± SE; all results are expressed as mg/kg.

2. **Serum samples.** As a preliminary screen of the trace mineral status in animals, serum samples may be used. The reliability of serum analysis, to estimate the trace mineral status of animals, is limited for some elements such as copper. The desired serum levels are shown in Table 10.

3. **Liver biopsy.** In herds where trace minerals appear to be deficient as indicated by herd history or blood levels, several animals can be selected for liver biopsy based upon their clinical signs, stage of production, reproductive history, pasture location, or previous blood work. it is important to not biopsy just those animals which show overt signs of deficiency. A random assortment of animals should be chosen to represent the herd as an average. The biopsy is taken from the right side of the animal in the 11th intercostal space on a line from the hooks to the elbow. Table 11 gives levels for the normal range of liver trace elements.

4. **Animal requirements.** Since some requirement criteria must be utilized as a starting point in formulating diets for grazing cattle, Table 9 contains the author's dietary trace mineral requirements. They are a slight modification from the NRC (1984) guidelines and considers papers published by Petersen (1992), and Doyle and Huston (1993). Since trace minerals are traditionally supplied in free choice mineral mixes, Table 8 also illustrates the concentration of trace minerals that would be required in a mineral supplement to meet 50 or 100% of the requirements of cattle.

   Remember excess molybdenum (above 1 ppm) and iron (above 350 ppm) increase the level of copper needed. The ratio of copper to molybdenum should be greater than 4.5:1 especially if sulfur levels exceed 0.25%.

Table 9. Trace Mineral Requirements and the Level Needed in a Mineral Mix to meet 50 or 100% of the Animal's Requirement*

Element	Estimated Requirement (ppm)**	Percentage of Mineral in Supplement for Following Percent of Requirement	
		50%	100%
Cobalt	0.10	0.0005	0.001
Copper	10	0.05	.1
Iodine	0.5	0.0025	0.005
Iron	50	0.25	0.5
Manganese	50	.25	.5
Selenium	0.10	0.0005	0.001
Zinc	40	.2	.4

* This concentration is based on the average of 100 g/day of mineral mixture for beef cattle with a 10 kg consumption of dry matter.

** Requirements modified from Doyle and Huston article--Vet. Therapy, 1993 and NRC, 1984.

Table 10. Essential Trace Mineral Levels in Serum (ppm; wet weight)

Mineral	Adequate	Deficient	Potential Toxic
Cobalt[a] (ppm)	0.15	< 0.09	> 0.40
Copper[b] (ppm)	0.80 - 1.50	------	> 4.0[c]
Iodine (µg/100 ml)	10 - 40	< 5	> 70
Iron (µg/100 ml)	130 - 250	< 130	> 400
Manganese (ppm)	0.006 - 0.070	< 0.005	> 0.080
Selenium[b] (ppm)	0.080 - 0.300	< 0.025	> 2.50
Zinc[d] (ppm)	0.80 - 1.40	< 0.60	> 2.00

[a]Vitamin B_{12} levels in serum are a better indicator vs serum Co

[b]Serum levels are not a reliable indicator of mineral status in the animal
[c]Cu levels as low as 0.60 ppm can be toxic under high Se supplementation
[d]Serum levels slightly higher than plasma

Table 11. Essential Trace Mineral Levels in Liver (ppm; dry weight)[a]

Mineral	Normal Range
Cobalt[b]	.07 - .3
Copper	90 - 350
Iron	160 - 1000
Manganese[b]	9 - 21
Selenium	.9 - 1.75
Zinc	90 - 350
Molybdenum	.5 - 5

[a]Because level of dehydration will vary among samples, liver biopsy results should always be compared on a dry matter basis. To convert to dry basis multiply wet weight by 3.5.
[b]Liver levels are not a reliable indicator of this trace mineral in the animal.

The economics of meeting the trace mineral requirements. Probably the most important consideration in meeting the trace mineral requirements is the fact that an excellent trace mineral program can be used to meet the cow requirements at a cost of approximately $1-3 per cow. High cost supplementation is not required and, in most cases, not needed. Simply fine tuning the mineral mix will usually be adequate.

Vitamin A

Although many vitamins are known to be important to cattle, the one that is addressed most commonly in cow-calf nutrition is vitamin A. All cattle require a dietary source of vitamin A because it is needed for proper maintenance and function of epithelial tissues of the body.

Research has indicated that cattle are quite capable of protecting or storing large quantities of vitamin A in the liver during periods of high intake. In plants vitamin A occurs in a precursor form as carotene, which is also often stored in body fat. Thus, in most systems liver storage is adequate. When depletion does occur and a serious deficiency develops, symptoms included respiratory infection, reproductive disorders, night blindness, rough hair coat, slow growth, muscular incoordination, and even excessively watery eyes.

The requirements for cows at various stages of production are shown in Table 12. The most common ways of supplying vitamin A in cow-calf operations are as follows:

1. The use of forages known to be high in vitamin A, such as alfalfa and other legumes.
2. Inclusion of vitamin A in mineral mixes and even protein supplements that are either self-fed or fed on a daily basis.
3. Injectable vitamin A administered either prior to calving or on occasion twice a year with cows given both fall and spring injections.

Table 12. Vitamin A Requirements

Cow Status	Daily Vitamin A Requirement
	I.U./Day
Pregnant Heifer	
700 lbs	20,000
900 lbs	24,000
Pregnant 1100 lb Cow	
mid gestation	25,000
late gestation	27,000
Lactating Cows	
below average milk (10 lb/day	38,000
average milk (20 lb/day)	40,000

Vitamin E

Recent research has done an excellent job of looking at the potential of vitamin E supplementation during the dry period with dairy cows. A recent study summarized and reported in a BASF proceedings, highlighted a 9-trial study that looked at the impact of vitamin E on reproductive efficiency in dairy cattle. This work showed that in 6 of the 9 trials there was no noted affect on reproductive efficiency. However, in all 6 of those trials an injectable vitamin E was given, while the 3 trials showing a beneficial response, vitamin E was fed approximately 30 days prior to calving. Equally, because of vitamin E's excellent role as an antioxidant, and because of evidence that it will improve passive immunity, the potential exists to utilize vitamin E approximately 30 days prior to parturition as a means of enhancing the calf immune system, and possibly enhancing the reproductive efficiency of the beef cow.

Specifically, recent work published in 1994 at Colorado State University showed that an injectable vitamin E given approximately 30 days prior to calving improved the calf serum IgM and IgG level by 60.7 and 46.7%, respectively. Any enhancement of the calves level of passive immunity offers excellent economic potential for the beef industry. Limited research work has been done with the beef cow looking at the potential of feeding vitamin E, and looking at potential ramifications for the calf and for the cow.

A recent research has done an excellent job of looking at the potential of vitamin E supplementation in the dry period of dairy cows. Specific recent work published 1994 at Colorado State University.

More recent research at Oregon, Alberta, and Kansas has evaluated the potential of vitamin E supplementation in beef cow diets. In work published by Nunn (1995) at Oregon, they evaluated the benefit of selenium boluses or vitamin E injections given to the calves at birth or at 2 or 4 weeks of age. Results of this study suggested that the calves immune system is enhanced with selenium and vitamin E injections. However, no distinct differences in the incidence of morbidity, mortality, or calf scours were seen in this study.

In the Alberta work (1995), scientists evaluated feeding either 80 or 1,000 I.U. of vitamin E/cow/day starting between 60 and 100 days prepartum with 134 crossbred cows involved in the study. Calf IgG levels at 48 hours postpartum were similar between the control and high vitamin E fed calves. However, the incidence of treatable scours was significantly less in the calves born to cows fed vitamin E prior to parturition (19.4% vs 7.4%). In work recently conducted in Kansas by Arthington and co-workers (unpublished data), heifers were fed either 0, 400, or 800 IU of vitamin E starting 36 days before calving. Since there was no incidence of calf health problems in any of the calves, there were no treatment effects on morbidity, mortality, or incidence of calf scours. However, there was evidence that feeding the high levels of vitamin E may effect immune function in newborn calves. At this stage, the potential merits of enhanced vitamin E supplementation in beef cows is somewhat speculative and more research is certainly needed. This is, however, an area that merits keeping an "eye" on in the future, as it may offer potential for enhancement of both calf health and reproductive function in beef cows.

The Merits of Force Feeding Minerals, Trace Minerals, and Vitamins

Traditionally, in supplying minerals, trace minerals, and vitamins to beef cows, they are included in mineral mixes and self-fed to the cattle. Unfortunately, cattle do not have the nutritional wisdom to consume the needed level of any of the minerals, vitamins, or trace elements other than salt. Subsequently, there's a wide variability in how cattle consume a mineral mix and whether the animal's requirements are being met.

Greatly overlooked in the cattle industry are the opportunities to add these minerals, trace minerals, and vitamins in grain or protein mixes being fed to the cattle during the winter months. Since one of the most critical times that these nutrients be supplied is 30-50 days pre-calving and through the breeding season, the concept of force feeding has considerable merit in the industry both from an efficacious and economical standpoint.

SUMMARY

By feeding minerals, trace mineral, and vitamins at strategic times and at proper levels, cow productivity and calf health can be maintained in a fairly inexpensive manner.