Selenium Nutrition in Camelids – Part 2

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In the previous column the subject of selenium (Se) nutrition was introduced. Biologic role of Se in body functions and disease conditions resultant from either Se deficiency or toxicity were described. Selenium was identified as an essential nutrient that has a very narrow range between deficiency and toxicity. The objective of this column is to complete our understanding of Se nutrition by addressing appropriate supplementation practices and monitoring in keeping llamas and alpacas healthy.

Feeding Regulations

Due to toxicity concerns as previously discussed, addition of Se to animal diets is regulated as a food additive by the Food and Drug Administration. It was not until 1978, some 20 years after the discovery of Se essentiality that animal feed manufacturers were permitted to include supplemental Se in animal feed products. Being classified as a food additive, this means Se cannot be used as a medicine and veterinarians are not able to write prescriptions for higher level of use. Addition of Se was initially allowed for poultry and pigs at an incorporation rate of 0.1 parts per million (ppm) of the total diet. Over the next couple of years, this allowance for Se inclusion was expanded to include cattle, sheep, and goats.

Field experience with dietary Se supplementation was suggesting that the allowable level of 0.1 ppm was not sufficient to prevent deficiency disease problems. After considering the available scientific information, in 1987 the FDA increased the allowable supplemental dietary Se incorporation rate to 0.3 ppm of the total diet. Use of organic Se (selenomethionine) from Se-fortified yeast cultures was approved in 2000 for chickens and then other species over the next couple of years. Llamas and alpacas are not mentioned in any of these FDA regulations. By the letter of the law, this would mean supplemental Se cannot be legally added to their diets. However, this is not a situation the FDA would pursue as long as the current regulations for similar species are being followed.

Current FDA regulations allow supplemental Se to be added to the total diet at a level of 0.3 ppm. However, Se cannot be easily added to forage, thus making it difficult to supplement Se for animals consuming primarily forage-based diets. To address this issue, the FDA permits Se to be incorporated into mineral mixes for animals. Again, the Se concentration of a mineral mix is regulated to conform to expected total dietary intake of Se from the product. Mineral products formulated for sheep and goats are allowed to have a maximum of 90 ppm Se, while products for cattle can contain a maximum of 120 ppm Se. These Se concentrations are based on estimated mineral intake and the total amount of Se to be consumed to meet the 0.3 ppm of supplemental Se in the total diet.

For example, beef cattle are estimated to consume on average about 10 kg (22 lbs) of a forage diet per day. If one is to supplement Se at the legal level (0.3

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ppm), then a beef cow could consume 3 mg Se per day (0.3 mg/kg x 10 kg/day = 3 mg/day). If this 3 mg is to be packaged into a mineral product, the Se concentration of the mineral will need to be adjusted to expected mineral intake. For beef cows this is estimated between 0.75 and 1 oz per day. In completing the calculations to package 3 mg Se into 0.75 oz, this works out to 120 ppm Se in the salt (refer to Table 1A). Similar calculations were undertaken for sheep and goats on the basis of meeting the defined supplemental Se amount of 0.7 mg/day. Based on a lower expected mineral intake for sheep and goats, allowed maximal Se content of free choice mineral is 90 ppm Se. In allowing the use of Se-fortified mineral supplements, the expectation is the mineral will be the only source of supplemental Se in the animal's diet. To make this issue even more confusing, the allowable Se content for mineral mixes is a maximal value. Feed manufacturers can add any level of Se to their mineral products up to the maximal value for the given species of animal. Therefore, you will need to assess the feed tag information for your mineral product to determine Se content and expected intake rate. Compare expected intake to your animal's mineral intake to determine if the Se content is appropriate to meet daily need (use Table 1A for comparisons).

Requirements

Reports from the National Research Council (NRC), a scientific body that reviews available research to determine nutrient requirements for animals, consider the dietary requirement for Se to be between 0.1 and 0.3 mg/kg of dietary dry matter (DM). This requirement range was defined for all production animal species from pigs and horses to sheep and cattle. A new NRC report on small ruminant nutrient requirements (http://books.nap.edu/catalog.php?record_id=11654), which includes llamas and alpacas, recommends 0.74 mg Se/day, or 0.2 mg/kg of diet DM for llamas and alpacas. Unfortunately there are no feeding trial reports to document this requirement. This NRC recommendation is a minimal value and based on extrapolations from other species and information from a single published survey of Se supplementation in llamas (Herdt, 1995). In this survey, supplementation around 1 mg Se/day to adult llamas was associated with adequate blood Se concentrations and ability to maintain normal Se concentrations in crias born to these females.

Another fundamental challenge in defining Se requirement for camelids is the documented difference in dry matter intake compared to other species. Llamas and alpacas consume less food per unit of body weight compared to sheep, goats, and cattle. This results in a disconnection between dietary requirements and conforming to current FDA regulations. In using the current daily (0.74 mg/day) and dietary content (0.2 mg/kg) recommendations, predicted total intake would be 3.7 kg (0.74 mg/day ÷ 0.2 mg/kg = 3.7 kg/day). This intake greatly exceeds any estimated intake for llamas in the NRC report. These differences underscore the need for further research on mineral requirements for llamas and alpacas. Dietary Se content issues must be resolved; however, the recommended daily amounts of Se to supplement, between 0.74 and 1.0 mg/day, are reasonable guidelines to incorporate into one's feeding program.

Feeding Recommendations

To this point I have discussed supplemental Se in the diet. Inherently there is some Se content to feed ingredients. With llamas and alpacas, the primary feed ingredient is forage with supplemental

concentrate (pellets, mineral, or both). Forage Se content is extremely variable across all of North America and dependent upon soil conditions. Selenium content of the soil is variable (ranging from < 0.1 to > 80 ppm) and soil acidity, rainfall amount, and other factors can greatly influence its availability to plant tissues. Acid soil conditions, heavy rainfall, and presence of inhibiting substances (iron and aluminum) will result in very low plant Se content. Essentially the eastern coast, north to south, over to the Great Lakes region and the entire western coast areas are low (< 0.1 ppm) in forage Se content. Most all Canadian provinces are low in Se. Only the central plains states up into Manitoba and Saskatchewan have moderate to high soil Se and variable to high plant Se content. Although difficult, forage Se content can be determined at some forage testing laboratories. Unless you have forages from these Se-adequate areas, you should ignore the Se contribution from forage and add the maximal amount of supplemental Se via mineral or pellet products.

As previously described, free choice mineral products can range widely in Se content; from minimal (10 ppm) up to the legal maximum. What you are interested in is the total amount consumed. To assess mineral adequacy relative to Se, one needs to determine the Se content of the mineral and daily animal intake. Mineral Se content can be determined from the feed tag with the product. Selenium content may be expressed as ppm (mg/kg) or as a percent (%). To convert percent to ppm, move the decimal point to the right 4 places. For example, 0.005% Se is the same as 50 ppm. The bigger challenge is determining average daily mineral intake. Mineral intake is controlled by salt content of the mineral product. Most products will have some intake guidelines on their feed tag. However, expected intake is often over estimated.

Mineral intake will be variable over time, but typically llamas and alpacas can be expected to consume between 0.25 and 0.33 ounces per day. Again, it is best to determine this for your animals. Also, do not have both white salt and a trace mineral salt available for the animals to choose. They only seek out a salt source. Armed with intake and Se content information, you can then use Table 1A to assess Se adequacy. In reviewing this table, the highlighted cells show the combination of mineral Se content and intake that achieves at least 1 mg Se intake per day. From these data it can be seen that only mineral that has at least 90 ppm Se will achieve near 1.0 mg Se intake with a daily mineral intake less than 0.5 oz per day. Many of the commercial mineral products contain less than 90 ppm Se.

Another method of supplementing Se is through the pellet or grain supplement. Using the data shown in Table 1B, one can determine a reasonable Se concentration for their pellet or grain product. If we set 1.0 mg Se/day as the goal (highlighted row in Table 1B), read across the row to see how many pounds of concentrate would need to be fed to achieve this Se intake amount. The variation is due to the different concentration of Se in the pellet or concentrate product. In this table the Se concentration of the pellet or concentrate is varied from 0.3 to 8 ppm. It is only when you have a Se concentration of 2.0 ppm or greater where you would be feeding 1 lb or less of the pellet or concentrate product to achieve the desired 1.0 mg Se/day delivery rate. These two examples demonstrated how one could provide the entire supplemental Se allotment from either mineral or pellet sources. Be careful not to provide both sources and potentially double the amount of supplemental Se.

We have highlighted potential problems with Se toxicity, is there a concern with oral supplementation? Nonruminant

animals such as pigs and horses absorb Se from the diet very efficiently and hence are susceptible to toxicity problems. The maximal tolerable level for Se in the total diet of nonruminants is 2 ppm or about 10x the requirement. Remember, this is the total diet consumed and not a single ingredient. In contrast, ruminant animals, including llamas and alpacas, are less efficient at Se absorption due to rumen alteration of the Se molecule. Though not determined directly for llamas and alpacas, maximum tolerable level for Se in ruminant diets is considered 5 ppm or even higher. This means that ruminant animals, including llamas and alpacas, are less susceptible to Se toxicity, but with excessive supplementation it can happen. There are still many questions to be answered relative to Se supplementation in llamas and alpacas.

Monitoring Se Status

One can do their best to provide a balanced diet that contains sufficient Se to meet current dietary recommendations. However, we cannot ensure that the animals consume the diet to be specifications we desire. To this end we should incorporate some method of evaluating nutritional status monitoring process to ensure neither deficiency or toxicity potential exists. Selenium content of the diet is difficult to determine and an expensive procedure. One is best served by monitoring Se content of supplemental feeds (mineral or pellets) and determine response of the animals.

Fortunately, Se is one of the nutrients that can be adequately assessed through the use of blood concentrations, though there is some debate on the preferred method. Selenium concentration can be determined in serum (without cells), whole blood (with cells), or in tissue (primarily liver) as a method of Se status assessment. Selenium status can also be assessed by determining glutathione peroxidase (GSH-Px) activity in blood. Laboratories that offer GSH-Px analysis are limited and it is a more expensive and technically difficult procedure. Liver Se content is a good determinate of Se status, but one must obtain a liver tissue sample either by biopsy on a live animal or from a dead animal. It is well worth the cost to have liver mineral analyses completed on any animal that dies (young or old) as a routine monitor of nutritional status.

Most laboratories will perform either serum or whole blood Se concentration analyses. Serum Se concentration reflects more acute or recent changes in Se nutrition, whereas whole blood Se reflects more chronic or historical Se status. This is a result of GSH-Px residing primarily in the red blood cell and each red blood cell lives for 105 or more days. However, llamas and alpacas are slightly different from other species. They have more GSH-Px outside the red blood cell and thus have generally higher serum Se concentrations compared to other species (Table 2). Many laboratories do not have extensive databases to determine appropriate reference values for llamas and alpacas. Therefore, interpretation from a given laboratory might vary given the reference values being used. Selenium concentrations in serum and whole blood will also vary by age of the animal. These are important considerations if one is to properly interpret laboratory results. These observations may partially explain some of the current issues of interpreting high (toxic) Se concentrations in llamas and alpacas that have not been known to be exposed to toxic intake or injections.

Probably, more than you really wanted to know about Se! Keep the questions coming for future columns!

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References

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Table 1. Calculated amounts of either selenium intake from free-choice mineral supplements (A) or selenium-fortified pellet supplement (B) needed to achieve specified levels of selenium intake.

A. Free Choice Mineral Supplements					
Selenium Mineral Content (ppm)	**Daily Salt Intake (oz)**				
	0.25	**0.33**	**0.5**	**1.0**	**1.25**
	Amount of Selenium (mg/day) consumed				
30	0.21	0.28	0.4	0.85	1.1
50	0.35	0.47	0.7	1.4	1.8
70	0.50	0.66	1.0	2.0	2.5
90	0.64	0.84	1.3	2.6	3.2
120	0.85	1.12	1.7	3.4	4.25
B. Selenium Containing Pellet or Grain Supplements					
Desired Selenium Intake	**Supplement Selenium Concentration (ppm)**				
	0.3	**1.0**	**2.0**	**4.0**	**8.0**
mg/day	*lbs supplement needed to be consumed per day*				
0.5	3.7	1.1	0.6	0.3	0.15
0.75	5.5	1.7	0.8	0.4	0.20
1.0	7.3	2.2	1.1	0.55	0.27
1.5	11.0	3.3	1.7	0.85	0.43
2.0	14.7	4.4	2.2	1.1	0..55
2.5	18.4	5.5	2.8	1.4	0.7

Table 2. Diagnostic criteria for evaluating serum selenium concentrations (ng/ml) in sheep, goats, and camelids (data based on Michigan State Nutrition Laboratory values).

Age Category	**Sheep/Goats**		**Camelids**	
	Deficient	**Adequate**	**Deficient**	**Adequate**
Neonate (1-9 days)	<25	45 - 80	<50	75 - 130
Suckling (10-29 days)	<30	50 – 90	<50	75 - 130
Weanling (30-150 days)	<40	60 – 90	<60	75 – 150
Yearling (151-500 days)	<50	70 – 110	<110	130 – 230
Adult (>501days)	<50	100 - 145	<110	130 - 230