CAMELID NUTRITION

Challenges of Feeding Llamas and Alpacas!

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Introduction

Nutrition? Just say the word and people start yawning! Who wants to talk about amino acids, vitamins, minerals and fats ..... ? How could anyone even imagine that nutrition is not only an exciting field, but an essential one? Nutritionists are always "debating" about the importance of nutrition - the classic statement, "You have to feed the animal correctly before you can breed it, work it and harvest any product from it!" The argumentative rebuttal is, "Yeah, but you have to breed an animal before you can have it to feed!" Ah yes - here we are back to the old proverbial "What came first the chicken or the egg!" My challenge today is to relay just how fascinating nutrition can be and how we can apply it to make a better life for our "silent friends."

Now, I could start talking about all of the nutrients. There are many articles and nutrition texts written on each of the nutrients and what they do, thus I will not follow that path. We do not know exactly what the nutrient requirements are for camelids. Though some work has been completed, limited scientific research has been done to specifically clarify them. At the current time, we have extrapolated "tentative nutrient requirements" from the Nutrient Requirements (NRC) of domestic livestock. I have given a brief summary of these in Table 1. I could also present potential feedstuffs for camelids. This too has been done at great length at other conferences and you can too find this information. Thus to avoid being redundant, I will take a different approach - and yet the same. When discussing how to feed any animal, I always pose a series of questions that need to be addressed before actually feeding that animal. In fact, I would advise researching the selected species before even procuring it. It is critical to fully understand "the nature of the beast" before starting and that includes how to feed it. As you go through these sections, you will find out how complicated nutrition can be; and you will see what I present in one area, could be presented in several. With that introduction, let me go ahead and list those questions that need to be considered, and address those issues as they relate to nutrition and how we feed these animals.

Questions To Be Answered

Identification "So "nutritionally", what are the llama and the alpaca?"

The llama and the alpaca are not ruminants but psuedoruminants. In much of the lay literature, I have seen the term "modified ruminant" used extensively. As a ruminant nutritionist, my preference is the term psuedoruminant, "pseudo" meaning false. Psuedoruminants chew their cud similar to that seen in a ruminant cow, sheep, goat, deer. However, the distinguishing factor between ruminants and pseudoruminants is the stomach, or perhaps more appropriately, the number of compartments in their stomachs. Ruminants have a single stomach with four compartments while the pseudoruminant has only three - Compartment I, Compartment II and Compartment 1II (really unique names !).

Compartment I is "almost" analogous to the rumen in a ruminant - "almost" that is the quantifier - the rumen is lined with finger-like projections called papillae. These papillae absorb volatile fatty acids (VFA) which are excretory products produced by the synergistic microbial population. Compartment I found in the SA camelids does not have papillae. It does have the same synergistic microbial population; however, the walls of Compartment I are lined with gastric pits. The gastric pits produce digestive enzymes and buffers that aid in microbial fermentation. The VFA produced by the microbes are absorbed through the walls of Compartment I and the top four fifths of the Compartment IH. The second compartment, Compartment 11, is a further source of glandular secretions used in the digestive process. Compartment II also is the location of the residual esophageal groove that directs milk from the mouth of the nursing cria to Compartment IH. Compartment IH is a long tubular organ, the top four fifths secreting glandular secretions as well as mucous. The bottom fifth of this last compartment is the true or gastric stomach - that part analogous to the stomach of any non-ruminant or the abomasum of the ruminant. This portion of the stomach produces the hydrochloric acid and proteolytic enzymes critical in the digestion process. (Fowler, 1989; Johnson, 1989; Johnson, 1991; San Martin and Bryant, 1989)

Even though they are called a pseudoruminant, some of the digestive upsets found in ruminants are rare in the camelid species. Camelids can develop lactic acidosis, but they have to overeat a very large amount of grain, and clinical symptoms may not occur for 12-36 hours after gorging themselves (Fowler, 1989). Bloat too is possible, but rare in camelids (Fowler, 1989). Colic is a digestive disorder associated with horses, but colic can also occur in psuedoruminants. Ruminants are not as expressive of pain as are horses or camelids, and if a llama or alpaca suffers from colic - you will know it - they will groan, grind their teeth, get up and down, rolling and other displays of pain similar to that found in the horse (Fowler, 1989). Another anatomical difference between ruminants and non-ruminants would be the camelid spiral, a colon not as emphasized in traditional ruminants. This spiral colon could potentially become impacted. There are also dental differences between camelids and ruminants (Fowler, 1989; Johnson, 1989; Johnson 1991), but that will not be discussed in this dialogue.

Origin "Where is this animal from and what did they consume in their native habitat?"

We know that both the llama and alpaca came from the mountainous regions of South America including Peru, Bolivia and Chili. The animals are browsers - meaning that they selectively consume sparse woody plants and forbs, often traveling long distances to find that. Those woody plants are usually high in fiber and of low quality. The combination of having to expend a significant amount of energy to acquire a low quality diet in a potentially hostile environment, and often times working - has resulted in an animal that is extremely efficient. As an adaptive response, the animal builds body reserves - reserves of fat that are not needed in our environment (Johnson, 1991). Now change scenarios - bring that same camelid to the United States - now it becomes the beloved "pet" or object of extreme adoration. Part of the "American Phenomena" is to feed anything (or anyone) that we love with the best food that we can in as massive amounts as we can. This "need" to nurture with food those living beings we love has lead to an epidemic of obesity among humans, companion animals, and those species kept as "backyard livestock." Now I may be embellishing slightly, but ...I'm not far off. As an added note, once a camelid becomes overweight the best plan to reduce that weight is to increase

exercise. Merely decreasing the amount of feed is not as effective and could be dangerous in pregnant females or growing animals.

One way to monitor and prevent llamas from becoming too fat, is to condition score the animals. This system is similar to those developed for horses, sheep, hogs, beef and dairy cows. Using this system, body condition of the animal can be watched at all times. The llama condition score system is based on a scoring system of 1 to 10, a score of 1 being very thin and 10 being obese. A condition score of 5-6 would be perfect. Ideal body weights for llamas are 250-275 pounds for a small frame size; 275-300 pounds for a medium frame size; 300-350 pounds for a large frame size and 350-400 pounds for an extra large frame. Remember, frame size is dependent on bone structure as well as stature (Johnson, 1991). It is of importance to note that there is some natural weight cycling in llamas and alpacas - a natural gain in spring and early summer, and a loss in late summer, fall and winter (Pugh, 1996a). By using the body condition score and keeping records of them, you will be able to "spot" anything out of order very quickly!

Behavior "How does behavior of an animal affect what and how you feed and manage it?"

Llamas are browsers by nature and if allowed, that is their preferred eating style. In most captive situations in the US, llamas have little choice but to be grazers. Alpacas tend to be more opportunistic than llamas, and in their native land showed selection of a wider variety of forage types (San Martin and Bryant, 1989). Overall in comparative studies, llamas and alpacas will consume more coarse forage (stems) than will domestic sheep - perhaps indicative of the dry season in their home country. During times of drought, camelids are able to adapt to their environment by reducing intake and decrease transit time of digesta (you do not see this type adaptation in domestic ruminants). Work by Pfister et al. (1989) indicates that llamas are better adapted to coarse forages than alpacas, because when given a choice, llamas will select tall, coarse bunchgrass while alpacas prefer plants of moist bottomlands.

Though the llama and alpaca do not have a prehensile tongue as seen in cattle, they are able to utilize salt blocks to some extent (Hoffman and Fowler, 1995; Johnson, 1989; San Martin and Bryant, 1989), often by chewing the block rather than licking it (Fowler, 1989). It is suggested to feed loose, iodized salt in mineral feeders that can protect the salt from the environment.

Camelids are notorious for their dung piles. Obviously because they do use dung piles, clean up is much easier! In their native environment it is thought that dung piles were used to mark an animal's home territory.

Physiological Status "What is the physiological status of the animal and how does that affect what it is fed?"

Physiological status is defined as the state or level of physiological function that the animal is in; for example the most common physiological states are maintenance, growth, gestation, lactation, working and geriatric. Each physiological status has different nutrient requirements to meet the functions of the body. Those states that have the highest nutrient requirements are late gestation, early lactation and growth. It should be emphasized again here that camelids are extremely efficient. Also, you will see animal variation - some are "easy keepers" and look at

food and become obese. Other animals are "poor keepers" and will need dietary supplementation merely to maintain weight.

Maintenance

Maintenance is defined as where an animal's weight is maintained - the animal is neither gaining nor losing weight. We often see this with studs outside of the breeding season, geldings that are not working or mature non-pregnant females. Since these animals are so energy efficient, just keeping them in a grazing situation with mineral supplementation is more than adequate - no grain is needed (Hoffman and Fowler, 1995). If the pasture is lush and has a lot of plant growth, the animals may still become fat, thus limited grazing or feeding a forage at 1% of body weight is advised. Forage is the key to camelid management, and in fact, if the diet does not contain at least 25% crude fiber, animals will develop gastric ulcers (Johnson, 1989). Forage usually has less energy than grain, and an animal will not be as hungry on a forage diet. Grain supplementation is rarely needed in a maintenance scenario. Monitoring body condition score is essential to prevent "fat" animals. As an added note, geldings have a lower energy requirement than intact males and females.

Growth

Growth involves the young cria as it is growing. Growth involves the building of body structure and will require a higher protein requirement (12-14%) than what is needed for maintenance (8-10%). Initially the cria will acquire its nutrients from its dam's milk. As with other mammals, immediately after birth, a newborn cria must consume 10% of its body weight daily in colostrum (Johnson, 1991). If llama colostrum is not available, goat colostrum may be used. Within 7 to 10 days, the cria will begin to mimic its mother's example of grazing, though full rumination does not occur for several months. Creep feed is not usually necessary unless the dam has a limited milk supply. Regular weighing of the cria will enable you to monitor this. If milk does seem to be limiting, a leafy forage like alfalfa serves as a good creep feed; but if grain is used, crias need to be vaccinated for enterotoxemia (Johnson, 1991).

The cria is usually weaned at four to six months of age. Animals can be weaned as early as two months (Johnson, 1991), but a much higher plane of nutrition is needed (16-18% CP and 60% TDN). Irrespective of when the animals are weaned, it is a stressful time for the young animal, and a higher plane of nutrition is warranted during the transition.

Gestation

Gestation is the period when the female is bred, and the embryo begins to develop. The gestation period is roughly 350 days. Of those 350 days, the first two trimesters or early pregnancy is where females often become obese - often because of the "extra care" from their owners. I have had many arguments with individuals who say immediately after breeding, "Oh Oh, now she is eating for two!" which immediately involves a higher plane of feeding. Frankly in the first trimester or 3.5 months, the female can be maintained on a maintenance diet unless she is lactating. If she still is nursing, obviously additional nutrients are needed. When the cria is

weaned, a maintenance diet alone is sufficient. During the second trimester the female will gradually begin to increase her intake of forage, and seldom are supplemental grains necessary.

The last 3 or 3.5 months of gestation, the third trimester, is when 90% of fetal growth occurs. Now, a small amount of grain can slowly be added into the diet twice a day (for example one pound twice daily for female llama). This level of grain can also be continued for the first three months of lactation to meet the needs of milk production (Johnson, 1989). A word of caution again - each animal is different - some will need more and some will need less - use regular body condition scoring as a monitor. Most female llamas gain 45-60 pounds during gestation, while alpacas gain on average 20-30 (Pugh, 1996). As with all physiological stages, don't allow the animal to become fat, as the added fat can result in birth complications (Hoffman and Fowler, 1995).

Lactation

The dam usually reaches peak milk production three weeks after birth of the cria. Because of this, the female's nutrient requirements are higher at this time (Johnson, 1991). Again as indicated above, a small amount of grain should be fed until the third month of lactation. After that time, a gradual decrease in the amount of grain will allow for lower milk production and a gradual "natural" weaning process. It should be cautioned again that the females should not be allowed to become overweight. One of the first places fat is deposited is the mammary gland, and there is a potential for decreased milk production in the future (Hoffman and Fowler, 1995).

Work

Again, emphasizing that every animal is different and that their body condition score needs to be monitored, animals under intense work (packing) need more energy. A hard working pack animal may have twice the energy requirement that it would have for maintenance (Fowler, 1989). During these times grain should slowly be added into the diet - the amount of grain increased to provide 25-50% more energy (Pugh, 1996a). Caution should be taken if an animal is working under high heat and humid condition to prevent heat stress.

Geriatric

How animals adapt to their advanced years is as variable as people. In some, there is little change, while others age very quickly - again a good reason to regularly body condition score and weigh animals. Older camelids actually have a lower energy requirement (Fowler, 1993a) than younger animals. But by closely monitoring your animal, even subtle changes can be caught early. In general, with age we see compromised strength in an animal's muscles and bone structure (joints) and often arthritis attacks the joints (Fowler, 1993a; Hoffman and Asmus, 1989). The best thing to do for an older animal is to ensure that in the heat of the summer, shade or a cool place is provided. Older animals are more susceptible to heat stress as they have a lower sweat gland activity (Fowler, 1993a; Fowler, 1994). When temperatures are colder, a heated barn and warmed water provide comfort for the animal. Warmed water is particularly important, as with other species, cold and icy water can result in decreased water consumption. Decreased water consumption can result in decreased feed intake and resultant weight loss. Also, as part of the aging process, gut function and motility is slowed, the chance of colic or an

impaction occurring is higher. Monitor the animal to ensure that it visits the dung pile, or as an older animal it could be compromised very quickly. With age, we see a lowered immune function in all species. Thus alleviating stressful conditions can aid in immune function. If an animal's mouth (teeth) become compromised (Fowler, 1993a), a high fiber, pelleted complete diet could be fed.

Environment "What environmental issues do you have to be aware of for camelids and how does that change management?"

The llama and alpaca evolved in the cool mountainous areas of South America. Thus, it is common sense that if these animals are brought into a different environment, management will vary. Animals do adapt to the environment where they are born, but the effects of the centuries in South America still have an impact in the management of these animals. Likewise if an animal is born in Colorado and moved to Virginia, or an animal born in Virginia and moved to Canada - there will be stress involved, and intensive management is needed to prevent problems from occurring.

Heat Stress

Dromedary and Bactrian camels - "cousins" of the llama and alpaca - evolved in a much different environment than the South American camelids. Camels are adapted to a hot, arid climate and deal better with hyperthermia and dehydration. The llama and alpaca do not have this adaptation, evolving in a much cooler environment. Llamas and alpacas are primarily dependent on cooling their bodies by evaporative cooling via the thermal window (fiberless area on ventral abdomen), even though they do have sweat glands over the entire surface of the body. Heat stress can cause neurological damage, congenital damage or abortion in pregnant females, lower sperm count in intact males or even a case of colic (Fowler, 1994). To help minimize heat stress, fiber can be sheared, feed only needed protein (protein provides more energy than carbohydrates) and by feeding a highly digestible diet (to minimize the heat produced by microbial fermentation) (Pugh, 1996a). Animals should have a cool, shady place and water can be provided to drink, lay in, stand in or be sprayed with. (Baum, 1994). Monitoring and maintaining an optimal weight is critical in warmer and more humid environments, as heavier animals are more prone to problems of overheating.

An excellent tool that has been advantageous in a clinical setting is a rule of thumb provided by Baum (2000). This formula provides an owner the information that can alert them to potential heat stress.

"If the sum of environmental temperature (in °F) plus humidity is > than 150 - watch for heat stress.

If the value is 180 or more - then you are on "RED ALERT" and can expect heat stress." Based on research done on sheep, Baum (2000) also advises her clients to supplement thiamin (vitamin B0 at a rate of 1 mg/lb BW/day. Again, this is anecdotal information, but information that has been applied successfully in a clinical setting for several years.

As an added caution, just because you live in a cooler environment does not mean that your animals will not be prone to heat stress. Factors other than environment that lead to this concern include packing, racing, breeding, fighting, transportation, prolonged restraint, chased by dogs (or children) or having an intact male adjacent to other intact males (Fowler, 1994).

Cold Stress

Many individuals are under the assumption that cold is not a problem for the llama and alpaca, as they evolved in the mountainous regions of South America. The truth of the matter is that the temperature in the high elevations of North America (minus 40° F and wind chill) is much colder than the camelids home environment (Fowler, 1989). Under intense cold, animals should be supplied shelter and a source of ice-free water. If needed, grain can be added to their diet for extra energy - up to 1/5 of their diet dry matter (remember to add grain slowly to allow the microbes a chance to adjust)(Pugh, 1996a). In this case scenario, a pelleted, high fiber diet would allow for increased intake and thus more energy.

Feeding "Nutrient" Management "What are some specific "nutrient" requirements that need to be monitored for this species?"

In answering this question, I will not cover all of the nutrients, this too can be found in various texts and publications. I would, however, like to emphasize a few nutrients of most importance.

Water

Llamas are well suited to dry, arid environments and can get by with drinking water only once a day; however, at that time, particularly if they are working, they must drink two to three gallons (5 to 8% of body weight) (Johnson, 1989). Irrespective of this, fresh clean water should be available at all times. Water is the cheapest nutrient to feed, but often the most neglected. One factor that I cannot stress enough is that producers, especially for those having wells or springs as their water source - TEST YOUR WATER! I have seen many cases involving high levels of trace minerals, bacteria or other contaminants that could affect animal health. Water tests are cheap - much cheaper that the price of an animal or a vet bill. Also, watch to see if your animals drink from the automatic waterers, as some animals are slow to adapt if they have been kept in a pasture with a stream or other natural water source (Fowler, 1989).

Carbohydrates - Forages and Grains

Llamas do very well on low-quality, cafeteria-type diets with minimal or no grain (Fowler, 1989; Johnson, 1989). They like variety. Grass hays are better than alfalfa because of potential hypercalcium when llamas are fed alfalfa. If given a choice, llamas usually select a more coarse, low-quality feed. In regards to pasture management, Hoffman and Fowler (1995) give an excellent overview, and Fowler (1993b) characterizes grasses of "camelid" quality. Fowler (1996) also wrote another article emphasizing "concerns" when feeding grasses to llamas and alpacas. There are also plants that could be potentially toxic to camelids, thus a producer should be familiar with them in order to protect their animals (Hoffman and Asmus,1989; Knight, 1996).

Supplementation of grain to the camelids is not advised except for those physiological states with higher nutrient requirements - late gestation, early lactation, weaning, work, extreme cold or for thin animals. If grain is supplemented to crias, they must be vaccinated against enterotoxemia. The nutritive value of grains is characterized for camelids in another article written by Fowler in 1989.

Protein

Protein or rather amino acids are essential for camelids - particularly during late gestation, early lactation and growth. For a llama or alpaca at maintenance, 8-10% crude protein (CP) is adequate, and a rate of 12-14% CP is suggested for late gestation, early lactation and growing. Young camelids are usually weaned at four to five months of age. They can be weaned earlier at two months; however they will have a higher CP requirement (16%). As a rule of thumb - good quality alfalfa hay may have 20% CP while a good grass hay may contain 12% CP. Camelids have a relatively low protein requirement as they are capable of recycling nitrogen like the ruminant.

Minerals

When discussing mineral supplementation for llamas and alpacas, one needs to consider the area of the country, and in some situations the area of the county or even the property. There are extremes of high and low mineral contents even in small areas. For example, one neighbor had a selenium (Se) deficient soil and needed to supplement Se, while the other neighbor had Se-sufficient land. If the individual with Se-sufficient soil supplements Se, they could create a Se-toxicity scenario. So why is the mineral content of the soil important? It is important because the mineral content of a forage or grain grown on the land will mimic the mineral content of the soil. If you purchasing your feeds, follow up and find out what kind of soil the crops were grown on - or test your feeds which is an even better ideal. Different forages need different mineral supplementation. For example, the calcium content in alfalfa hay is 4-6 times higher than most grass hays. A calcium:phosphorus ratio of 1.2 to 2:1 is adequate when feeding camelids. Again, check the mineral content of your water! Recommended levels of supplemental trace minerals are listed in Table 1.

It is a common practice to include trace minerals in a salt career - thus the animal's individual craving for salt controls trace mineral intake. In cases of growing, lactating or working animals, trace mineral deficiencies could occur as animals may not eat enough salt (Pugh, 1996b). In these physiological stages supplemental trace minerals need to be provided in a grain mix or some other form to ensure consumption.

Copper (Cu) is commonly added to feedstuffs, thus is considered safe, however molybdenum (Mo) is not - thus the balance between the two minerals is often neglected. In one study, Cu:Mo levels fed were 16.6:1 (36 mg Cu/kg and 2.2 mg Mo/kg), and four llamas died (Junge and Thomberg, 1989). When selecting a mineral supplement, the Cu:Mo should be 6-10:1 (Pugh, 1996b). This is particularly important in parts of Colorado or other parts of the country where there are drainage areas with extremely high Mo. If the Cu:Mo story is not enough to

cause "worries," now add the scenario of sulfur (Pugh, 1996b). If the sulfur level exceeds 2000 ppm (mg/kg), a Cu deficiency could be the result. Again, a reminder to test your water!

Zinc (Zn) is another "monitor" mineral, and producers should ensure that the zinc level is higher that the Cu level (Pugh, 1996b). High levels of Zn can suppress Cu absorption, thus Zn levels should be no higher than 100 ppm of the total diet.

Vitamins

Most of camelid vitamin A requirements are met by feeding a high quality forage containing 13carotene. This carotenoid is converted to vitamin A in the animal's liver or gut wall. Recommended levels of supplemental vitamin A and E are listed in Table 1. In regards to vitamin D, llamas and alpacas evolved in the high altitudes of South America. At these altitudes, even though the animals have thick fleeces blocking 13ultraviolet light, they still acquiring enough light to convert to vitamin D3. However, in the northern latitudes, lack of sufficient II-ultraviolet light could indeed be a problem. During the winter months because of the orientation of the sun, 13-ultraviolet light only reaches the earth during certain months. This could be a problem in the case of fall-born crias, because when they are born later in the later seasons, they may not be able to acquire sufficient vitamin D3 from the sun (13-ultraviolet light) for vitamin D production. Since milk is a very poor source of vitamin D, and if young animals are not provided supplemental vitamin D, they may develop rickets (Fowler, 1992; Hoffman and Fowler, 1995; Smith, 1996). Even if a summer is unusually cloudy, or in areas of thick fog where 13-ultraviolet rays are blocked, rickets in the camelid industry is a reality. Rickets can also occur with insufficient amounts of phosphorus, calcium, magnesium or even an inverse Ca:P.

Summary

In summary, more scientific research on the South American camelids is needed. Until more nutritional information is in place, we will continue to use the extrapolated nutrient requirements from domestic ruminants; the scientific camelid data available; and some anecdotal information - some wrong and some right - but the bottom line is that we are only beginning to learn how to feed these species. The mammalian body is phenomenal. The body can compromise and "rob Peter to pay Paul" for a long time, but ultimately the body can go no longer - and the animal dies. Yes, the camelids in the US may live longer than in their native habitat, but how much longer could they live with a better diet?

So what do you as a camelid owner do? My advice is to research as much as possible. Research by coming to conferences like this, read the literature, and "surf the net." My only caution regarding information from the Internet is "be careful." In my preparation for this talk, I did a lot of "surfing" and became very concerned about some of the information presented as gospel. I can think of several examples where if the "advice" were followed - it is my opinion as a nutritionist - your animals could be compromised and may even die. Many of the maladies seen in the camelid industry today can be traced back to nutrition. I obviously was not able to present everything on camelid nutrition, but it is a start. Nutrition is not a panacea to "all," but sound nutrition is an excellent place to start. Good luck!

Table 1. Estimated Nutrient Requirements of Llamas and Alpacas.

Nutrient	Level	Source
Crude Protein, %	8-14	Johnson, 1989
ME, Kcal BW'75	84.5	Carmean, 1992
Calcium, %	0.3-0.85	Van Saun, 1999
Phosphorus, %	0.16-0.40	Van Saun, 1999
Potassium,%	0.5-1.0	Van Saun, 1999
Magnesium,%	0.12-0.20	Van Saun, 1999
Copper, ppm	13-15	Van Saun, 1999
Iron, ppm	60-130	Van Saun, 1999
Manganese, ppm	45-55	Van Saun, 1999
Selenium, ppm	0.4-0.6	Van Saun, 1999
Zinc, ppm	40-50	Van Saun, 1999
Vitamin A, IU/kg	3000-3500	Van Saun, 1999
Vitamin D, IU/kg	3000	Extrapolated
Vitamin E, IU/kg	17-20	Van Saun, 1999

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