



Learning to Juggle: Llama Nutritional Requirements and Feed

The stimulus for researching and writing this article came from a discussion on the topic of llama feed which first appeared on the BLS *Facebook* site in December 2016. I was struck by the vast difference of opinions and the sometimes conflicting advice offered, often with significant financial implications. How is someone meant to steer their way through all this in order to make an informed decision? This short article aims to equip the reader with some of the background information and rationale to do so.

Naturally, most contributors to the debate were inclined to describe what they did as ‘the’ way to do it but without explaining their rationale or thought processes that had led them to this practice. For all the reader knows, this could be based on little more evidence than the fact that their llamas were living ‘to tell the story’. However, as we all know, there is more to life than simply existing in the land of the living. How many of these animals might live longer, experience fewer ailments, have stronger bodies, better fleeces, healthier babies, require fewer human interventions, etc. if they have the correct diet, in the right sized balanced proportions at the right times in their lives? Contrary to all this, in light of the effective marketing and promotional material put out there by suppliers of various tonics and supplements I sometimes wonder how my animals ever made it through the embryonic stage of life, let alone grow into strong, healthy, breeding adults.

Where do we start?

As with pasture management, it may not be as simple or straight forward as you first thought and sweeping generalisations can be very dangerous. What is required by one llama may vary

from another depending on their gender, age, life style, habitat and surroundings (including climate/weather/temperature). To take an extreme example, an old male llama living in the mountainous region of Bolivia during winter, sharing its sparse habitat with various other creatures will have some same basic needs as that of a young domesticated female llama, in summer, living on the lush grass plains of Cheshire, but also some very different ones. As a result of my research on this topic, I have become aware of the dangers of classing llamas as ruminants or even as camelids in respect of nutritional needs. There are both subtle and significant differences. Llamas do not process food in exactly the same way as true ruminants and have some different requirements and habits to alpacas beyond those determined by differences in size alone.

How do they eat?

All living creatures ingest their food and drink, digest it by various means, absorb the majority and excrete the balance. In the words of LaRue Johnson (International Llama Association Educational Brochure #6), the llama is a modified ruminant herbivore that ingests plant material and digests it in a unique, three-compartment stomach. The llama's stomach is functionally similar but anatomically different from that of true ruminants (cattle, sheep and goats). The first compartment is essentially a huge fermentation vat which, through enzymatic and microbial processes, enables separation of plant material into readily digestible basic nutrients and semi-digestible cellulose.

A scholarly article published in [Vet Clin North Am Food Anim Pract.](https://www.ncbi.nlm.nih.gov/pubmed/7953953) (1994 Jul;10(2):187-201) (<https://www.ncbi.nlm.nih.gov/pubmed/7953953>) claimed that an understanding and appreciation of the 'New World llamas' unique gastric anatomy and physiology, including rapid motility, prolonged digesta retention, rapid liquid passage rate, low protein maintenance requirements, low metabolized energy requirements, and low basal metabolism was imperative before being able to make informed decisions on feed and nutrition. Whilst I would not doubt this is true for a second, it is not possible here to explore the necessary detail although from time to time reference will be made to research about llama metabolism as a background to nutritional and feeding considerations including during different stages of development and in accordance with different environments and lifestyles.

What do they need and why?

In common with all living matter, llamas require water for the operation of most of the physiological systems and processes.

In common with most mammals, llamas also require:

1. Proteins – to build new cells and tissue such as the muscular skeletal, circulatory and reproductive systems.
2. Carbohydrates –to generate energy for organ function and locomotion, to keep warm, etc.

3. Fats and Oils – largely for maintenance purposes and keeping the skin and fleece in good order, etc.



4. Vitamins, Macro minerals and Trace Elements -.

- a. Vitamins are compounds essential to growth, health and wellbeing that cannot be synthesised by the body. Vitamins A, D and E, especially have important roles in growth and development of young llamas and therefore critical in lactating mothers where they are passed on through colostrums and milk. A feature on Vitamin D deficiency and supplements appeared in the Winter 2014/15 edition of *Llama Link* and one in the Autumn 2016 edition discussed its relationship with phosphorous and calcium so discussion of vitamins, despite their vital importance, is not replicated here.
- b. Macro minerals such as calcium, phosphorous, sodium, chlorine, potassium and sulphur are required for bone structure, fluid balance regulation, nerve control and acid-base balance among others things.
- c. Trace minerals such as cobalt, copper, iodine, iron, manganese, selenium and zinc are associated with a range of metabolic processes. Deficiency diseases affect almost every physiological function and include immune dysfunction (copper, zinc, selenium), development abnormalities (copper, manganese, iodine), abortion (copper, iodine, selenium), retained placenta (copper, selenium, iodine) and metabolic disturbances (cobalt, iron, zinc, iodine). Zinc has been found to be influential in improving the quality of a llama's fleece.

5. Other Supplements and Tonics

Neutral buffering materials such as sodium bicarbonate will need to be fed in conjunction with cereal mixes because the conversion of starch (in the cereals) into lactic acid which can increase acidity and create unfavourable environment for fibre digesting bacteria. Cereals mixes generally do see Table 1. Not critical, but it is said their performance is enhanced with Prebiotics causing them to release nutrients for growth, breeding and performance.

Yeast cultures contain high levels of Vitamin D₃ which can significantly improve the digestibility of phosphorous from normal feed.

Oatolol is said to aid the absorption of vitamins and trace elements.

6. Fibre to ensure the digestive system of semi-ruminants can function effectively. As with conventional ruminants, llamas have an important need for adequate fibre in their diet, as

much as 25% or more. Lack of adequate fibre is said to reduce gastric performance and seems to have a correlation with gastric or duodenal ulcers.

Given these nutrients are necessary, where can domesticated llamas get it from?

Where do they get what they need from?

Water, I am assuming, needs little discussion in this respect. For most llama keepers in the UK this is not a problem. To prevent the spreading of bacteria and disease it is imperative that the water provided is fresh and clean. Good husbandry practices should be used to ensure this although even with direct supplies feeding fountains this can be difficult if birds or other vermin can access it

Forages in general are the principle source of fibre and good pasture with a mix of grasses and herbs (types and age), can normally meet most of llamas nutritional requirements in the growing season. However, there is no guarantee it will.

Unfortunately, like humans, llamas do not necessarily choose what is best for them where food is in abundance. Some of my llamas clearly have their favourite plants or at least some preferred over others. Where they have choice which plant and the part of it they consume will vary in its nutritional value and balance of ingredients. A previous article in Llama Link by John Main (Llama Link No. 200?) suggested that in their natural habitat llamas preferred long, dry, courser vegetation compared to alpacas which are less choosy and also prefer shorter, moist, softer vegetation. (This is not true of my llamas they definitely prefer young soft grass shoots over older and/or more 'stemmy' varieties'). Where llamas share grazing with other species or are overstocked their choices might be limited by what everyone else around them chooses. Sheep, for example, go for the shorter stuff and cattle the longer vegetation. The same applies to dry matter. My llamas would probably not touch hay if proprietary mix was available ad lib (at least not in the short-term for they do appear to appreciate variety). Some llamas I am told, can also be picky about what they choose to eat and leave within a preparatory mix.

Good looking pasture is certainly no guide to its nutritional value. Despite healthy looking, vigorous plants, glistening a nice shade of green, the pasture may have deficiencies and even excesses in respect of some properties at certain times. The soil might have all the right nutrients for plant growth but lack variety of species to provide a broad spectrum of nutrients and over a sustained period (some grasses prosper in early Spring, others later in the year).

Research indicates that in Britain, whilst typical pasture is comparatively lush to many parts of the world, it is sometimes lacking in selenium, copper and zinc. Since these are essential trace elements as we shall see later, it could be cost-effective in the long run to have an analysis of your soil and or forage, fresh and as hay to inform future decisions on additives to the soil, over seeding and/or choosing any supplementary feed. This is a proactive approach compared to waiting for an ailment to arise in the animals and find it is indicative of a nutritional issue. However, one must also remember that what may be good for the soil to support the growth of forage may occasionally be at odds with what you llamas need in their

diet. This can be the case on land previously used for the intensive growth of crops where fertilizers containing high levels of heavy metals have been used (to support or are a by-product of the crop) that in excess are a threat to your llamas' health. This is why farmers are not allowed to grow root crops such as potatoes on land previously used for maize and fed by slurry. Similarly, clay soils will often benefit from the application of Magnesium Sulphate to break it down and improve drainage, yet this is likely to reduce vital levels of selenium. As discussed in the article on paddock management, it is a fine balance and simply applying one mineral to bring it into balance can lock others from getting to the plants where they are needed. Vitamins and minerals are a topic to which we will return later.

Of course, grass and other plants do not grow all year round and so there can be a requirement for supplementary feeding during certain periods of the calendar. An obvious question here might be, if the paddock grazing meets all the llamas summer requirements, what elements of the fresh herbage are lost in its conversion to hay or haylage since for some of us, this is a relatively accessible, abundant, cheap form of winter feed. How and when the hay is made can be critical here.

Late harvesting and/or certain types of plant can induce the loss of leaves, which implies the loss of proteins and a decrease in digestible dry matter. Rainfall on cut forage induces leaching of highly digestible nutrients, particularly the leaves of clover and other legumes. The exposure of bales to air and sunlight it is said induces a 30 to 40 % decrease in digestible nutrients (dry matter), and up to 10 % in covered storage. A moisture level above 15 % inside the hay due to lack of drying increases the risk of potentially harmful yeast and mould growth as well as reducing palatability. This is more frequently encountered with large round bales. The difference between good and poor quality hay cannot be over emphasised and is well expressed in a nice article penned by Karen Nicholson (formerly available at: <http://vermontllamaalpacaassociation.blogspot.co.uk/2014/04/all-hay-is-not-created-equal.html>). In it she explains the differences in content between different cuts of hay and what to look for when choosing hay to buy. A similar article can be found at: <https://www.progressiveforage.com/forage-production/management/all-hay-is-not-created-equal>.

According to Gina Bromage, the amount of protein in pasture can range from 30 to as little as 10%. A young, clover rich ley in early spring contains far more protein than poor ley at the end of Autumn. Gomez suggests a range of 19 down to 8 and provides a useful chart to show the crude protein and other nutrient content at different stages of the plant's life cycle (see: http://trace.tennessee.edu/cgi/viewcontent.cgi?article=1025&context=utk_largpubs). She also provides a table to show the typical respective values in different grasses (in the USA) and a diagram to illustrate the different values of proteins and carbohydrates in different parts (stem, leaf, shoots, etc.) of the plant, in this case alfalfa. There are of course other alternatives to hay such as haylage *Reidgrass* and Alfalfa each with their own pros and cons. Haylage when made from the right ley (best slightly different to hay) and fresh is generally liked by llamas, is less dusty and has more protein and carbohydrate because of how it is made and stored (less leaf damage, fermentation). If bought in, it usually comes in big bales, is difficult to move without machinery and a bale too large to be eaten before it starts to go off.

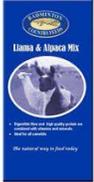
Readigrass and alfalfa is not always locally available and if it is, is expensive although it can generally be guaranteed to contain the necessary nutrition.

Essential vitamins A and E are generally readily available to the llama grazing on good pasture. However, when feeding llamas largely on hay, vitamins A and E may be insufficient and require supplementary feed. In contrast, Vitamin E is low in fresh pasture but higher in hay and so a required supplement in Summer (if hay not made available) but not winter. The following paragraphs discuss some of the ways in which we can supplement their forage.

Specialist, preparatory hard feeds

The discussion on Facebook suggested that many llama keepers feed non-specialist or specialist mixes for other animals such as goats, sheep and even cows to their llamas. This can be by choice or influenced by availability and price. Indeed it was the question of why llama/camelid mixes are so comparatively expensive that stimulated the discussion in the first place. Surprisingly, given the relatively small number of llamas in the UK, there are quite a few producers of specialist preparatory mixes. Market leaders, available nationwide, appear to be: *Badminton Llama and Alpaca Mix*, *Cambrilibra*, *Camelid Complete* and *Carrs Billington Camelid Mix*. Others include: *Argo*, *GLW* and *Mole Valley Camelid Mix*. Not all are readily available nationwide but via a tabular analysis I have attempted to summarise the main constituents of these 8 brands. (*Heyland* were contacted but did not respond).

Table 1-Comparative analysis of brand leaders

	<i>Badminton</i> 	<i>Camelibra</i> 	<i>Camelid Complete</i> 	<i>Carrs Billington</i> 	<i>Argo</i> 	<i>Mole Valley Alpaca Winter Pellets</i> 	<i>GLW Aztec Silver Camelid Feed</i>	<i>GLW Alpaca Course Mix</i>	<i>Averages</i>
Food Types									
Protein	16%	15%	15%	14.8%	15%	18%	16%	16%	15.725
Carbohydrates –Starch	Yes but Not Stated (NS) as a %	13.5%	12.71%	Yes, but NS	Yes, but N.S.	Yes, N.S.	N.S.	N.S.	13.1
Carbohydrates – Sugars	Yes	NS	7.27%	NS	N.S.	Yes	N.S.	N.S.	
Oils and Fats	3.1%	6%	3.7%	2.5%	3.0%	2.8%	5%	3.5%	3.7
Fibre	10.5%	15%	9% ?	9.0%	9.0%	10.2%	9%	9%	10%
Mix Composition									
Wheat	NS	NS	Yes	Yes	Yes wheat feed	Yes	Yes wheat feed	Yes wheat feed	
Oats	Rolled Oats	Black Oats	NS	Rolled Oats	Y	No		Yes	
Bio-moss	NS	NS	Yes	NS	NS	NS	NS	NS	
Hemp Seed Meal Micronized	No	Yes	NS	NS	NS	NS	NS	NS	

Palm Kernel	Yes	No	Yes	No	NS	NS	Yes	NS	
Sunflower Seed	Yes	No	No	No	NS	Yes	NS	NS	
Barley	Yes	No	No	No	NS	Yes	NS	NS	
Beans	Yes	No	No	Yes	Yes	NS	NS	Yes	
Beet Pulp Cane	No	Yes	Yes	Yes	NS	Yes	Yes	NS	
Peas	Yes	No	No	Yes	Yes	NS	NS	Yes	
Molasses	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
Calcium Carbonate	Yes Limestone Flour	Yes	Yes	NS	NS	Yes	NS	NS	
Salt	Yes	No	Yes	No	NS	Yes	NS	NS	
Rapeseed	Yes	No	Yes	No	NS	NS	NS	NS	
Dried Grass	NS	NS	NS	NS	Yes	NS	NS	NS	
Maize	Yes	No	No	No	NS	NS	NS	NS	
Sugar Syrup	Yes	No	Yes	No	NS	NS	NS	NS	
Dicalcium phosphate	No	Yes	Yes	NS	NS	NS	NS	NS	
Vegetable oil and fat	Yes, Soya	Oatinol	NS	Yes	NS	NS	Yes	NS	
Seaweed Meal	No	Yes	No	No	NS	NS	NS	NS	
Omega 3 Fats	No	4000mg/kg	No	No	NS	NS	NS	NS	
Linseed Expeller	Yes	Yes	NS	NS	Yes	NS	NS	NS	
Soya Sunflower Seed	Yes	No	No	No	Yes	NS	Yes	NS	
Oligosaccharides	No	Yes	NS	NS	NS	NS	NS	NS	
Magnesium Oxide	No	Yes	NS	806mg/kg	NS	NS	NS	NS	

Yeast Cell Wall	No	Yes	NS	NS	NS	NS	Distillers' Grains	Alfalfa	
Vitamins									
Vitamin A	84000iu/kg	70,000iu/kg	33,000 iu/kg	40000iu/kg	NS	10000iu/Kg	30000iu/Kg	30000iu/Kg	370000iu/Kg
Vitamin D3	1,680iu/kg	15000 iu/kg	12.100 iu/kg	16000iu/kg	NS	2000iu/Kg	6000iu/Kg	6000iu/Kg	
Vitamin E (alpha tocopherol)	25iu/kg	Yes	235 iu/kg	NS	NS	280mg	250iu/Kg	250iu/Kg	
Vitamin B1	NS	25mg/kg thiamine mononitrate	Yes	80mg/kg	NS	NS	NS	NS	
Vitamin B3	NS	Nicotonic Acid	NS	NS	NS	NS	NS	NS	
Vitamin B5	NS	Pantothenic Acid			NS	NS	NS	NS	
Vitamin B6	NS	25mg/kg Pyrioxine hydrochloride	Yes	NS	NS	NS	NS	NS	
Vitamin B12	NS	Yes cyanocobalamin	Yes	NS	NS	NS	75/K	NS	
Vitamin B12	NS	6mg/kg riboflavin	Yes	NS	NS	NS	NS	NS	
Vitamin H	NS	Yes Biotin	NS	NS	NS	NS	NS	NS	
Vitamin K	NS	20mg/kg	NS	NS	NS	NS	NS	NS	
Elements									
Calcium	Yes, Limestone flour	3.5%	2.2%	NS	N.S	Calcium Iodate Hexahydra	NS	NS	

						te			
Phosphorus	NS	12%	1.1%	NS	N.S.	NS	NS	NS	
Sodium	NS	0.3%	0.4%	65mg/kg	N.S.	NS	NS	NS	
Magnesium	Yes, Calcined Magnesite	0.5	0.3%	806mg	N.S.	NS	NS	NS	
Ash	6.6%	12%	10.2%	14%	7%	8%	9%	9%	9.4%
Trace Elements									
Iron	280mg/kg Ferrous Sulphate monohydrate	600mg/kg Ferrous sulphate monohydrate	NS	NS	NS	NS	NS	NS	
Iodine	6.5mg/kg calcium iodate anhydrous	5mg/kg calcium iodate anhydrous	20.09mg/kg	39mg/kg (calcium iodate anhydrous)	NS	10mg/Kg	NS	NS	
Cobalt	1.8mg Cobalt Carbonate Monohydrate	Yes	8.2 mg/kg	160mg/kg (carbonate monohydrate)	NS	0.4mg/Kg	NS	NS	
Copper	No	40mg/kg Cupric sulphate & dicopperchloride trihydroxide	40 Mg/kg	65mg/kg Cupric Sulphate Pentahydrate	NS	160mg/Kg	55mg/Kg	55mg/Kg	
Manganese	67mg/kg Managanus oxide	250mg/kg Managanus oxide & glycine chelate	160.76mg/kg	806mg/kg	NS	129mg/Kg	NS	NS	
Zinc	116mg Zinc Oxide	240mg/kg zinc oxide & Chloride monohydrate	750mg/kg	1389mg/kg	NS	1389mg/Kg	6000mg/Kg	6000mg/Kg	
Selenium	0.75mg Sodium	2.5mg/kg selenized yeast	2.9mg/kg	4.45mg/kg (sodium	NS	4.8mg/Kg	2.7mg/Kg	2.7mg/Kg	

	Selenite			selenite)					
Molybdenum	4.2mg sodium Molybdate	NS	0.02mg/kg	NS	NS	NS	NS	NS	
Tonics/Conditioners									
Acid Buffers	NS	0.5%	NS	NS	NS	NS	NS	NS	
Gut flora stabiliser	NS	Yes	NS		NS	NS	NS	NS	
Texture	Course mix	Pelletized	Pelletized	Course mix	NS	Pelletized	NS	NS	
Genetically Modified?	No	No	No	Yes	NS	NS	NS	NS	
How much to feed?	500mg/day No animal weight stated	600mg/day based on 60Kg dead weight	200-400g/day per adult	250g/day based on 60-65Kg dead weight	NS	60% of dry matter	NS	NS	
Availability?	Nationwide	Nationwide	Nationwide	Nationwide	NS	Nationwide	NS	NS	
Available in bulk?	No	Yes	Yes	Yes	NS	25kg bags	NS	NS	
Price per 20Kg	£10.60	£29.83	£12	£12 & VAT					

Direct comparisons were difficult because different feed stuffs are sometimes used by different companies to provide the same types of food (eg. carbohydrates can be in the form of sugars and starches and different cereals used as a source of starch) or minerals. I do not have space here to go into the relative merits of these different sources of carbohydrates, minerals and vitamins but it is important to be aware that, for example, dried peas have far more protein than cereal grains, cereal grains more carbohydrate in the form of starch and sugars when molassed in mixes. In fact, very rarely do manufactures mention calorific content which is especially significant in relation to obesity as we will see later. Unfortunately, the law only demands that producers provide values of crude protein, fibre and fat content. Guidance on how much to feed also needs to be considered in relation to the size of animal, price in relation to quantities purchased (some, but not all of the above offer discount on bulk order). As you will observe, the comparisons are not straight forward and only a guide. Given that many llama keepers claim to feed other animal mixes (due to preference/accessibility/price/palatability) in my research I did make comparisons with leading brands of goat and sheep feed. Interestingly, I found most variances within the camelid mixes included above, than between these and goat/sheep mixes although they averaged out very similar. Average, protein variance of 0.5% , oil/fats 0.7% . The main difference was in the greater percentage of crude fibre, a variance of 4.21% to the positive in the camelid products. I did not note any of the feed products (peas, oats, etc.) to be animal specific, nor the main and trace element levels much different either but this would demand some effort to work out factually. As something of an aside, but relevant to the *Facebook* discussion, the reason the other animal products are generally cheaper to buy (this study showed on average 25%) according to the manufacturers, relates to volume produced and the need to clean out the production line after producing their core products.

Mineral Licks



Of course, one does not necessarily have to buy preparatory mixes containing carbohydrates, etc. and there is no point if they are not needed or at worse still, potentially dangerous. Recognizing the shortage of key minerals on many pastures and especially during the winter months, animal feed companies have developed mineral powder supplements and licks both for different purposes and different species. Although I am yet to hear of a purpose made llama lick in the UK , I have only recently learned that J. G Animal Health do a camelid lick. Manufacturer Tiethbarn's nutritionist did make a recommendation of one of their horse products to address a potential shortage of Vitamin D and selenium in my llamas a few years ago. This was during the dark winter months when the llamas had less opportunity of

synthesising their own from sunlight. However, I also made it available to them in the summer a fly repellent since it contained garlic. If anyone out there had a specific problem then it is highly likely that amongst the vast range of purpose made licks there will be one to serve the specific purpose/shortage.

There is an American company advertising a general lick suitable for sheep, llamas and alpacas. Its contents are listed in the table below:

Table 2 - Mineral lick contents

Crude Protein, Min.	16.00%
NPN Max (AS)	
Crude Fat, Min.	5.00%
Crude Fiber, Max.	5.50%
ADF Fiber, Max	9.00%
Calcium (Ca), Min.	1.30%
Calcium (Ca), Max.	1.50%
Phosphorus (P), Min.	1.25%
Salt (NaCl), Min.	13.00%
Salt (NaCl), Max.	15.00%
Magnesium (Mg), Min.	2.50%
Potassium (K), Min.	1.10%
Sulfur (S), Min.	0.50%
Fluorine, Max	
Copper (Cu), Min.	25 ppm
Selenium (Se), Min.	5 ppm
Zinc (Zn), Min	1,000 ppm
Iron (Fe), Min.	400 ppm
Manganese (Mn), Min.	750 ppm
Iodine (I), Min.	8 ppm
Cobalt (Co), Min.	4 ppm
Biotin, Min	
Omega 3 fatty acid, Min.	
Vitamin A, Min	100,000 IU/lb
Vitamin D, Min	20,000 IU/lb
Vitamin E, Min	80 IU/lb

Finally, there are oral and injectable ways of getting the vital vitamins into your animal should there be a dire need. At least two companies produce vitamins A, D & E pastes for camelids, and several powder and injectable vitamin E/Selenium supplements, non of which are camelid specific. A recent report of the House of Commons select Committee on Agriculture suggested that it was better to achieve the right level of vitamins, minerals and trace elements in the soil (and by implication in the herbage) since mineral licks, injections and boluses 'are less desirable, less effective and more expensive'. This is because not all animals

make use of licks and are not capable of making use of all the nutrients in a single shot/dose. Herbage provides a steady flow. Other issues apply to hard feed, unless each and every llama is fed separately. Some just never get near to the feed bucket(s). Finally, the lucrative equine market is renowned for being exploited by companies marketing supplements and tonics not necessary or even advantageous in 'normal' circumstances. It would do the llama owner no harm to have their soil and forage tested and if the results show serious deficiencies llamas' blood checked before investing in some of these products.



Before leaving the matter of supplementary feed, it is important not to forget the matter of palatability. Some contributors to the *Facebook* discussion claimed their llamas liked one product and not the other. Based on my own experiences, I am sceptical that any llamas would reject outright one brand of mix, but I am sure that some prefer different textures. Mine appear to prefer the courser Carrs Billington mix to Camelibra pelletized food. However, if left with only one type, they would come round to eating their less favoured mix after only a matter of minutes. Gomez (op cit) does suggest that whilst pellet forms of feed can prevent selective intake by discerning llamas, they are also more likely to end up finely ground decreasing the fibre potential, possibly leading to acidosis although I note that in the examples above, anti-acid buffers are also included in the *Camelbra* mix to help compensate this.

How much should they have?

Given we now have an idea on where they can get their nourishment, how much should they have?



Again, it is a matter of age, size, gender and lifestyle.

In respect of water, many commentators on nutrition forget to mention that water represents 10-80% of the composition of foods. It is claimed by some authorities that daily, llamas will, on average, require 5-8% of their body weight. For an adult male this would amount to over a gallon (which weighs 6.5lbs), only some of which can be made up through food sources. I have to admit that if my llamas consume much of this as water they are secretive/night drinkers but because it is 'on tap' I never know. On the other hand, I sometime see lactating mothers at the height of summer regularly at the water fountain. What I find a frustration is birds regularly bathing in their water fountain and potentially passing on numerous bacteria and parasites. I once asked, via the BLS Forum if any llama owners had experience of on-demand drinkers without any form of reservoir and someone replied that their llama had got it tongue caught in it!

Regular body condition scoring can provide an indication of how well your llamas are thriving on their current rations. A nicely illustrated guide at <http://extension.psu.edu/animals/camelids/nutrition/body-condition-scoring-of-llamas-and-alpacas> describes the process and what to look for. A less practical means is blood metabolite testing. McNeil (see above) discusses the phosphate levels you would hope to see in a llama's blood (or more accurately serum) - 2.0mmol/L which he suggests is also a useful (and cheaper) guide to checking adequate Vitamin D levels (since the two are generally related).

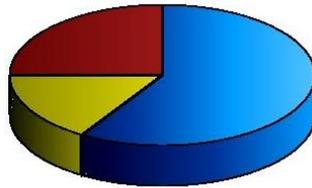
In any event of a problem, or just as part of proactive planning, you should consider consulting your vet who will be able to assess your llamas' condition and advice you accordingly.

Certainly, don't be fooled by how hungry your llamas appears for as most llama keepers know, a lot of them can be greedy and give the appearance they haven't eaten in years. They will almost certainly eat to excess if an abundance of food is presented to them. As with humans, the high intake of carbohydrates and or fats can lead to obesity caused by the laying down of excess food as fat. Although in their natural habitat it is known that llamas have a tendency to carry excess weight going into winter and periods of scarcity, in the domestic environment excess weight is generally unhealthy. It places undue stress on their delicate legs and pasterns, their heart and often manifests itself in their ability to fend for themselves within the herd. Overfeeding is easily done but often for the wrong reasons. It is owners not wanting to feel stingy but making their llamas feel cared for; wanting to treat or reward them for interacting, taking pity on them on cold frosty mornings thinking an extra helping of mix might cheer them up. Sadly, of the many llamas I have seen in the UK, a significant number would appear on general observation to be obese and very few owners weigh their llamas or see a suitable set of weighing scales a priority on their shopping list. It might just be that they could save you money in the long run!. An article on weight management in llamas appeared in the Winter 2011 edition of Llama Link and another in the Summer 2012 edition, discussed the merits of feeding barley straw to satisfy a llamas appetite and at the same time help reduce weight.

Finally, remember that unless your llamas are growing, in late gestation, early lactation, extremely athletic, or exposed to prolonged cold temperatures, they should not be allowed unlimited free choice access to quality forages or be supplemented with concentrates

In what proportions?

Like most herbivores, llamas are limited to an absolute maximum daily dry matter intake. This figure appears to be between 1.4 and 2.0% of their body weight. This needs to be borne in mind in relation to balance of feed. Given that grass might be at times as much as 80% water and the ‘average llama’ weighs say 80 Kg, its an awful lot of grass to bite, ingest and digest.



But, it’s not just a matter of what and how much they eat, but in what proportions. The feed comparison table above indicates the quantities of food type and ingredients per 20Kg unit of mix. From this, and with considerable effort, you could work out crude quantities of each constituent part but again without knowing the calorific value of each constituent it doesn’t provide all you need to know.

The recommendation of the US National Research Council for llamas by type of food are summarized in the following table:

Table 3-Llama daily requirements

	Daily requirements	Example: For a 150 lb animal (68 kg)
Dry matter intake	1 to 1.3 % of Body Weight (BW) (or 38 g/kg x BW 0.75)	68 kg x 0.01 = 680 g = 1.5 lb 68 kg x 0.013 = 884 g = 2 lb
Metabolizable energy	70 kcal/kg x BW 0.75 (range 60 - 85 kcal/kg BW 0.75)	70 x (68kg) 0.75 = ± 1,650 kcal
Protein For maintenance:	3.5 g CP x kg BW 0.75 (or 48 g of CP/1 Mcal)	3.5 x (68 kg) 0.75 = ± 80 g

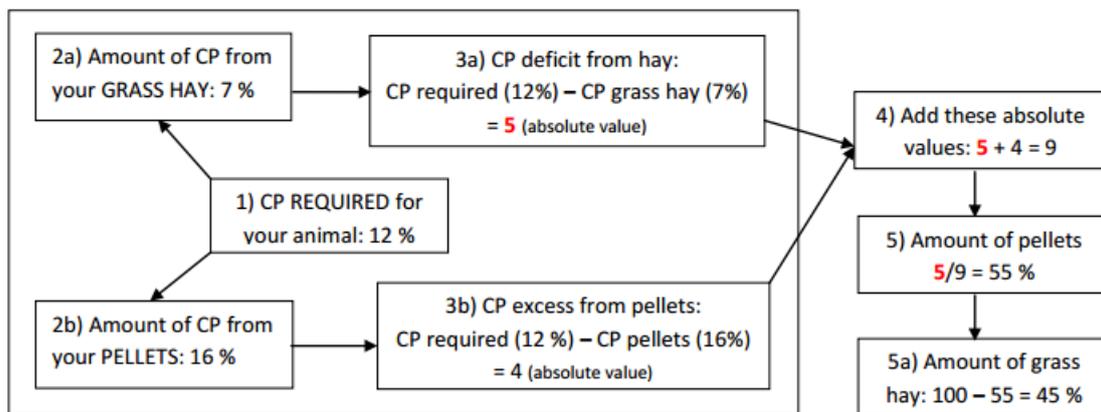
Note: 1 Mcal (megacalorie) = 1000 kcal (kilocalorie)

How much protein they require appears from research findings to be relatively little for an animal of their size. This is said to be because llamas have an exceptional ability to recycle and utilize urea (the major by-product of normal protein breakdown in the body). This is also suggested to be the consequence of evolution where the llama has had to get the most

nutriment from the relatively poor forage in their natural environments high up in to the Bolivian, Chile and Peruvian mountains. Gina Bromage shows a range of protein requirements in a llamas diet from 10.5 for a young adult to 13 for a lactating female.

Gomez provides a chart to illustrate how at a particular point in time this (12% requirement) might be made up and the protein diet balanced. One should be cautious here, however, that the pellets may cause a carbohydrate imbalance at the same time so there are wider considerations.

Table 4 Balancing Crude Protein from herbage and supplementary feeds



It is also important to realise that whilst excesses of some food types (carbohydrates) can lead to obesity, some vital minerals, trace elements and vitamins in excess can also be damaging and cause physical problems, this is why most manufacturers of preparatory mixes include the concentrations of elements on their packaging and I have embraced them in the tabular analysis above. A series of articles at <http://extension.psu.edu/animals/camelids/nutrition> discuss the consequences of under and over supply of certain trace elements. In respect of copper, it suggests that llamas are prone to copper toxicity when fed diets with greater than 20mg/kg and a higher than 16:1 ratio of copper to molybdenum. Molybdenum is a trace element that plays a role in dietary copper availability. If feeding appropriately for copper, one should first evaluate forage copper content then match preparatory mix/mineral lick accordingly. If your hay has a copper content greater than 15ppm then you may need to choose a preparatory mix with a low copper content.

Too much selenium in the diet can cause alkali disease and "blind staggers", while too little can cause white muscle disease or interference with growth, reproduction and lactation. This makes me question the merits of my leaving the selenium rich garlic lick out in the summer! The only way to find out would be to have an analysis made of my paddock herbage.

Some elements and vitamins have a vital relationship either working in unison to aid and abet a process or counteract one another. For anyone interested in more detailed discussion of the complex relationship between phosphorous, Calcium and Vitamin D, again I refer you to the McNeil article mentioned above.

Conclusions

As with paddock management, health, nutrition and feed is a delicate balance; it is not straight forward. There is no simple, universally applicable model. The llama keeper needs to learn how to juggle all these considerations simultaneously.

There is a consensus that all llamas to be in good shape have some basic, common, minimum needs but these will vary in type, quantity and proportion with different genders, ages, roles in life and time of year. A single llama has a limited the amount of dry matter it can consume and it is no good if that which it ingests has only limited nutritional value. Likewise, it is no good if the llama consumes its full capacity with highly nutritious food.

How the llamas' diet is provided for domestic animals in the UK will usually be a mix of foraging and human intervention. The combination will vary at different times of the year and also depend on the surroundings and local environment. Regular assessment of llama condition, the quality of the forage (fresh and dried), the nutritional requirements of the animal at that stage in its life and the lifestyle it is leading is the best way of helping your llamas to achieve their potential and lead full, long lives. In the growing season, adjustments to the mineral properties of the soil may suffice or need to be compensated for through the provision of supplements of one form or another. Outside the growing season and in adverse weather conditions this may well include the use of proprietary feed mixes, mineral powders, pastes or injections. However, you simply cannot manage the nutrition of your llamas adequately unless you condition score and weight them regularly.

When making dietary adjustments, it is important to ensure changes in the type and quantity of feed are introduced gradually so that the animal's palate and metabolism can make the necessary adaptations.

Finally, as I mentioned via the BLS *Facebook* discussion on nutrition and feed, I would be interested to learn of different owners' feeding strategies since catering separately for different llamas can logistically be very difficult. Even amongst two llamas with the same dietary requirements sharing a paddock at feed time it can be difficult to make sure they both obtain equal amounts and proportions. I have a 3 acre paddock housing 5 adult male llamas with 6 feeding points yet one or two frequently lose out having to settle for whatever the 'greedy beggars' leave them! And, as mentioned earlier, impossible to prevent a single llama being choosy about what it picks out from a mix it has access to. I guess no one as yet is using an automated feeder or lick activated by a microchip to dispense/allow only the necessary amount!