What's For Dinner? Part 3

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This is the third in a series of three articles on formulating basic rations for livestock. Part 1 provided general background on nutrition, feeding and ration formulation. Part 2 explained how to formulate a ration for a horse. For latecomers, these articles can be found in the Nov.-Dec. 2001 and Jan.-Feb. 2002 issues of the Mid-Columbia Small Farms and Acreages Newsletter, respectively. Part 3 will focus on calculating a ration for a lactating ruminant. It will also introduce readers to two common methods of ration formulation: the Pearson Square method and the Simple Substitution method. It should be noted that computer software programs are available to help create balanced, least-cost rations for animals; nutrition professionals and many commercial livestock managers use such software.

Lactation places the greatest nutritional demands on an animal. In the case of a heifer that has just had a calf, she has several nutritional requirements:

- Maintenance (increases with cold weather, amount of work needed to obtain food, parasites, illness, etc.)
- Growth (until mature size is reached)
- Lactation (for about 6 months for beef cattle, 10 months for dairy cattle and 3-10 for dairy goats)
- Gestation (increasing demands throughout pregnancy, especially the last trimester; cattle are re-bred 2 months after calving, sheep and goats after 2-7 months, and horses after 9-30 days).

A lactating goat has incredible nutritional requirements; these requirements depend in part on the amount of milk produced as well as its fat content. Let's get started with an example. We will formulate a ration for a 60kg. (130 lb.) adult goat producing 4 kg (about 9 pints) of milk per day with 3.5% fat. This goat is grazing and browsing a bit, so her maintenance requirements reflect this activity level. Referring to The National Academy of Science's 1981 publication titled "Nutrient Requirements of Goats: Angora, Dairy and Meat Goats in Temperate and Tropical Countries

Here are this goat's requirements for major nutrients:

Dry Matter (DM)	Total protein (TP)	Digestible Energy (DE)	Calcium (ca)	Phosphorus (P)	Crude Fiber (CF)**
2.7 kg*	0.377 kg	9.39 mcal	12 g.	8.4 g.	0.46 kg (min.)

*using DM requirement of 4.5% of body weight

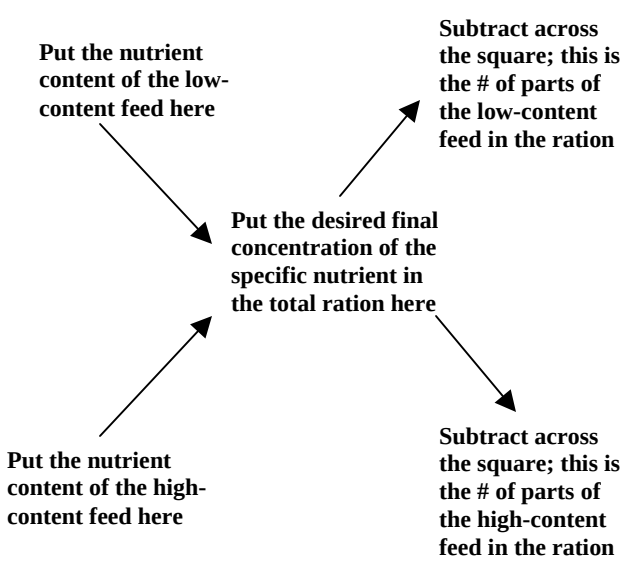
**Crude fiber (CF) isn't a major nutrient, but lactating ruminants need at least 17% crude fiber in their diet to ensure proper rumen function and high butterfat content in milk.

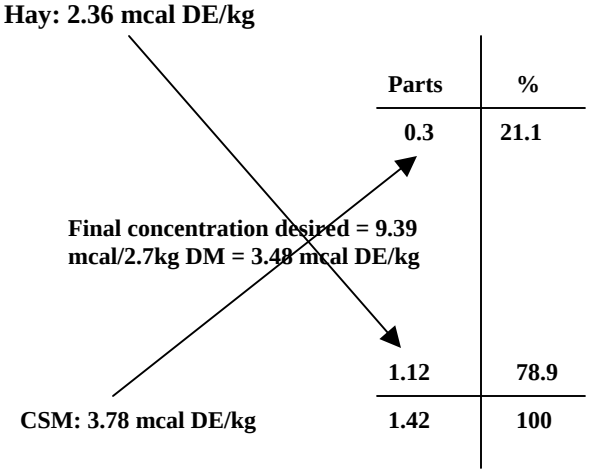
The major forage on hand is alfalfa hay. Based on analysis at a commercial lab, it has 91.4% DM, 30.6% CF, 17% TP, 2.36 mcal DE/kg, 1.41% Ca and 0.24% P. It is usually most cost effective to use a forage to meet as much of the nutritional requirements as possible, so here goes:

Ration balancing attempt #1: 100% alfalfa hay

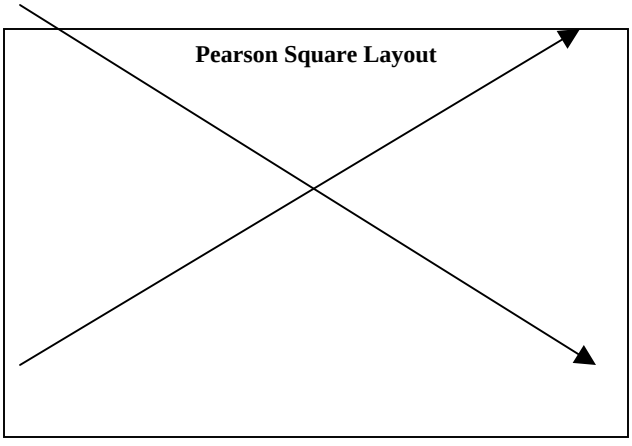
	DM	TP	DE	Ca	P	CF
Alfalfa hay	2.7 kg	0.459 kg	6.372 mcal	38 g	6.5 g	0.826 kg

As you can see, protein requirements are met but we lack about 3 mcal of digestible energy and 2 grams of phosphorus. We'll use the Pearson Square method to substitute a high-energy feed such as cottonseed meal (CSM) for some of the low-energy roughage. Here is the rundown on CSM's nutritional value: 86% DM, 21.4% CF, 24% TP, 3.78 mcal DE/kg, 0.16% Ca and 0.76%P.





After subtracting across the square, you will have the number of parts of each feed needed in the ration to achieve the proper concentration of the desired nutrient. Add these two numbers of parts together to get the total number of parts in the ration, then divide the total into each part to get the percent of each feed in the diet (this is a more useful number that is the number of parts). In the example above, we subtracted 2.36 from 3.48 to get 1.12 parts of CSM in the ration, and subtracted 3.48 from 3.78 to get 0.3 parts of hay in the ration. 0.3 + 1.12 parts = 1.42 total parts in the ration. Hay is 0.3/1.42 or 21.1% of the ration and CSM is 1.12/1.42 or 78.9% of the ration. Let's see if this new ration meets the goat's requirements.



Ration balancing attempt #2: 21.1% alfalfa hay and 78.9% CSM.

	DM	TP	DE	Ca	P	CF
Alfalfa hay	0.57 kg	0.097 kg	1.35 mcal	8 g	1.4 g	0.174 kg
CSM	2.13 kg	0.511 kg	8.05 mcal	3.4 g	16.2 g	0.456 kg
Total	2.7 kg	0.608 kg	9.4 mcal	11.4 g	17.6 g	0.630 kg
Requirements	2.7 kg	0.377 kg	9.39 mcal	12 g	8.4 g	0.459 kg

Now you can see that we have met the energy and protein requirements, but we are low in calcium and high in phosphorus. Balancing calcium and phosphorus is very important, especially in lactating and growing animals. Let's use the Simple Substitution method to substitute some dolomite limestone (DL) for some CSM. DL is 22.3% calcium and 99% DM.

The difference in calcium content between CSM and DL is 221.4 g (223 g Ca/kg DL - .16 g Ca/kg CSM); this difference is the substitution value of DL for CSM. The calcium deficiency of ration #2 is 0.6 grams. Divide the deficiency by DL's substitution value: 0.6/ 221.4 = 0.0027, which is the percent of CSM to substitute with DL (0.27%), leaving our final ration with 78.63% CSM:

Ration balancing attempt #3: 21.1% alfalfa hay, 78.63% cottonseed meal, 0.27% dolomite limestone.

	DM	As Fed	TP	DE	Ca	P	Crude Fiber
Alfalfa hay	0.57 kg (1.25 lb)	0.62 kg (1.36 lb)	0.097 kg	1.35 mcal	8 g	1.4 g	0.174 kg
CSM	2.12 kg (4.66 lb)	2.47 kg (5.43 lb)	0.509 kg	8.01 mcal	3.4 g	16.1 g	0.454 kg
DL	0.01 kg (0.022 lb)	0.01 kg (0.022 lb)	-	-	2.2 g	-	-
Total	2.7 kg (5.94 lb)	3.10 kg (6.82 lb)	0.606 kg	9.36 mcal	13.6 g	17.5 g	0.628 kg
Requirements	2.7 kg		0.377 kg	9.39 mcal	12 g	8.4 g	0.459 kg
Difference	-		+.229 kg	-0.03 mcal	+1.6 g	+9.1 g	+0.169 kg

Whew--this ration is almost balanced! We are feeding more than the required amount of protein; the only concern here is the financial impact of this excess protein. The energy level is acceptable. The real concern is the calcium-to-phosphorus ratio, which we would like to be between 1.5 or 2 parts of calcium to one part of phosphorus to maintain bone health and avoid important metabolic diseases such as milk fever. We are currently feeding 10 grams of DL; increasing this by a factor of eight will not add significant dry matter to the diet and will result in a much healthier total of 29 grams of calcium to 17.5 grams of phosphorus (ratio of 1.6 to 1). This fine tuning is another example of the "art" vs. the science of ration formulation. With free choice water and trace-mineralized salt crumbles, this ration should meet this goat's nutritional needs. As mentioned in Part 1 of this series, we would monitor the effectiveness of this ration by the animal's performance and general health. If the goal is to maximize production, this goat could probably be "pushed" to consume more than 4.5% of her body weight in dry matter, thereby providing her with more nutrients, but not all animals can consume more. Lactating cattle are hard pressed to consume 2.5-3.0% of their body weight daily.

A few final thoughts:

- I initially tried to balance this ration using corn, but there was not enough fiber in the diet to make it a safe ration. I changed to CSM due to its high concentration of protein, energy and fiber.

- If you feed an animal more than its nutritional requirements, it will save the excess energy as fat and eliminate excess protein in the urine. Pushing an animal nutritionally will achieve some degree of added performance (more milk, faster rates of gain), but eventually performance will peak and the animal will just get fat. This is not good for the animal or your wallet.

- Feeding below required levels will adversely affect performance and the animal will not perform up to its genetically-determined potential. Underfed animals will lose body condition and eventually show signs of malnourishment.

- It is OK and even expected that lactating animals will lose some body condition during lactation. A heavily-lactating animal does not have the physical capacity to take in as much feed as it needs to keep up with its nutritional demands, so it calls on its energy reserves –the body fat that was laid down during pregnancy. Large swings in body condition are neither healthy nor desirable, though.

- The goat in the example above will consume some additional roughage and energy while browsing. With a heavily-lactating animal, a manager should use the philosophy of "If you have finished your dinner, you can go out and play"; heavily-lactating animals really need to consume all the nutrients you have provided in the balanced ration; you don't want this animal going out to browse and filling up on low-energy but fun-to-chew fiber.

- In order for the Pearson Square to work, the nutrient content of one feed must be above the final nutrient content needed and the other must be below it. For example, you can't have 25% protein in a final ration if the protein content of the feeds used are 10%, 17% and 5%.

- In high-producing animals that are being fed a high percentage of grain, some bicarbonate or other buffer may need to be added to the ration because concentrates (such as grains) are very acidic. If the pH in the rumen drops too low, vital digestive bacteria and protozoa in the rumen die and the animal will be unable to digest the feed well; serious other problems can also occur.

- Additional examples of the Pearson Square and Simple Substitution methods can be found in any textbook on livestock feeds and feeding.

- Remember to convert the final ration to an "as fed" basis because in reality, feeds contain water. Our final ration above is 2.7 kg of DM, but this is 3.07 kg as fed. Information on how to convert from a dry matter basis to as fed basis was covered in a previous part of this series.

Ration formulation is a great way for youths to see math in action and a good excuse for us old-timers to blow the dust off some brain cells! I hope this series of articles has provided you with information you can use as you develop your ration formulation skills.