

## **Feeding Goats: Introduction to Ration Formulation**

### Objectives

1. Discuss principles of ration formulation for meeting specific nutrient requirements of goats.
2. Understand how nutrient needs of the goat change with physiological state and relate this to practical goat feeding strategies.
3. Become familiar with arithmetical techniques used in balancing rations.
4. Gain an appreciation of goat feeding systems and nutrient requirements. I.

### **INTRODUCTION TO RATION FORMULATION**

#### A. General Aspects

The major goal of animal nutritionists is to provide the animal with its required nutrients in a palatable, acceptable ration at minimum cost. To do this, we first need to know:

1. Animal requirements for specific nutrients.
2. Nutrient composition of feeds which may be used to formulate the ration.

This information can be found in NRC publications on nutrient requirements of goats and other animal species. The basic steps in ration formulation are outlined here and will be covered in more detail in lecture.

1. Identify the class(es) of animal to be fed (i.e. species, age, weight, productive capacity).
2. Identify the animal's specific nutrient requirements. In most cases we are mainly concerned with **energy, protein and macromineral** (Ca and P) requirements, expressed on a daily basis.

You will find a confusing array of terms for expression of energy requirements (TON, DE, ME, NE etc.). DO NOT DESPAIR - THESE WILL BE EXPLAINED!

3. - Select the feed ingredients to meet the nutrient requirements you have identified in the previous step. Remember, animal feeding and ration formulation is not an exact science. You must take into account not only the specific nutrient composition of the ration, but factors such as palatability, bulk (can the animal eat this much?) and special requirements of some species (e.g. fiber requirement of ruminants). In the real world, you must also consider factors such as availability and cost of your chosen ingredients.

4. Calculate the amount of each individual ingredient in the ration. This is generally a problem of simple arithmetic. We will demonstrate several techniques commonly used in ration formulation. These are also explained, with examples, in the following guidelines. You may use any of the method(s) you feel comfortable with.

B. Guidelines to Ration Formulation Techniques

1. Remember-

- a. Animals have a **daily requirement** (quantity/day) for energy and nutrients.
- b. Animals can eat only a limited quantity per day. NRC recommendations are determined from feed intakes of animals of certain weights at various physiological states i.e. maintenance, growth, gestation or lactation. Therefore, if animals are consuming 5 kg/day all of their energy, protein and mineral requirements must be packaged in this quantity. For example, a 50 kg growing goat is expected to eat 2.6 kg/day and this quantity must provide her with 352 g protein. Thus, each kg of diet must provide:

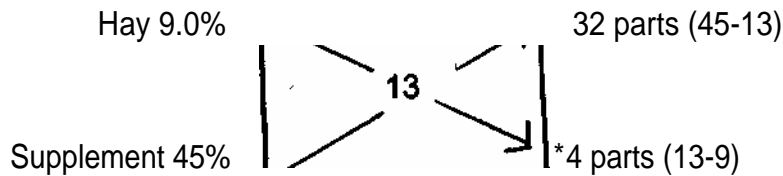
$$352 \text{ g protein}/2.6 \text{ kg diet} = 135 \text{ g protein/kg diet}$$

2. **Priority for balancing:**

- a. **Energy**
- b. **Protein**
- c. **Minerals (Ca & P)**

How do we go about balancing a diet? Let us use a simple example to illustrate the thought process as well as the arithmetic. We want to formulate a 13% crude protein diet for lactating does (30 kg) using a late-cut orchard grass hay and a protein/mineral/vitamin supplement. The hay contains 9% crude protein and the commercial supplement contains 45% crude protein. We want to make 100 kg of this diet and we assume the protein/mineral/ vitamin will meet all other nutrient requirements for the does if mixed with the hay to make a 13% crude protein diet.

One very basic technique for ration balancing, that some of you may be familiar with is the Pearson square. While the method has technical limitations as to the complexity of the diets you can formulate with it, it does provide a basic framework to understand the techniques used for more complex diets. We set up the square as follows, subtracting on the diagonal.



$$32 \text{ parts} + 4 \text{ parts} = 36 \text{ parts}$$

$$32/36 \times 100 = 88.9\% \text{ or } 88.9 \text{ kg hay}$$

and

$$4/36 \times 100 = 11.1\% \text{ or } 11.1 \text{ kg supplement}$$

We check this by:

$$(88.9 \text{ kg hay} \times 0.09) + (11.1 \text{ kg supplement} \times 0.45) = 13 \text{ kg protein in } 100 \text{ kg of diet}$$

Thus, from the Pearson square we can see two relationships developing.

1. hay + supplement = 100 kg
2. 0.09 hay + 0.45 supplement = 13 kg in 100 kg of diet or 13%

Using these relationships we can set up two equations that can be solved simultaneously, facilitating our formulation of this diet and subsequently, more complex diets.

1. Define your unknowns. In our case we let  $x$  = hay and  $y$  = supplement
2. Develop first equation:  $x + y = 100\text{kg}$

Note that in this equation  $x$ ,  $y$  and 100 is the quantity in either kilograms or a percentage. If a set amount of the diet is used for vitamins, minerals or essential feedstuffs (often referred to as slack space), this amount is subtracted from 100.

3. Develop second equation:  $0.09x + 0.45y = 13$

4. Now solve the two equations for x and y.
  - a. rearrange simplest equation:  $x + y = 100$  or  $x = 100 - y$
  - b. Substitute equation 4. a. into second equation and solve.

$$\begin{aligned}0.09(100 - y) + 0.45y &= 13 \\9 - 0.09y + 0.45y &= 13 \\0.36y &= 4\end{aligned}$$

Note that the arithmetic looks very familiar to that associated with Pearson square but we have derived a formula that can consistently be used in ration balancing. This formula offers us greater flexibility in diets where we need to balance for more than one nutrient and are using more than one feedstuff.

- c. Solve for x.

$$\begin{aligned}x + y &= 100 \\x + 11.1 &= 100 \\x &= 88.9\end{aligned}$$

- d. Check your solution for x and y by plugging into second equation.

$$\begin{aligned}0.09 \times 88.9 \text{ kg hay} + 0.45 \times 11.1 \text{ kg supplement} \\= 13 \text{ kg protein in } 100 \text{ kg}\end{aligned}$$

Looks familiar, doesn't it?

That was a rather simple example to illustrate the relationships which are quantified through the use of simultaneous equations to balance our diet. Remember our priorities are **ENERGY, PROTEIN AND MINERALS**, in that order. Ruminants have other needs in addition to their energy, protein and mineral requirements. In particular, minimum levels of NDF and ADF are required to ensure proper rumen function. This creates a problem when using the simultaneous equation technique for balancing rations because the number of variables increases beyond what is reasonable to do by hand (hence the eventual use of computers). Another mathematical method for balancing rations with many variables is substitution. The use of the substitution method allows you to determine the deficiency or need of a specific nutrient in a ration mix and then utilize an ingredient with a known advantage to achieve a balance.

After we have determined the requirements of the animals in question and have decided on the feedstuffs we are going to use we go through the following steps:

1. Use simultaneous equations to balance the energy and fiber components to meet the animal's daily intake and energy requirements.
2. Calculate how much energy, protein, Ca and P this diet provides. It should be adequate for energy but may be deficient in protein, Ca and P.
3. Now choose a feedstuff that is similar in energy density to your original energy feedstuff but is higher in protein density (usually an oilseed meal or animal protein source). Determine the increase in protein content if we substitute 1 kg of our protein source for 1 kg of our energy source. For example if we need 500 g of additional protein in our diet and we are going to substitute soybean meal (44% CP) for hay (9% CP) our advantage in using soybean meal is 35% or 0.35. Thus we have:

$$\text{need/advantage or } 500 \text{ g}/0.35 = 1429 \text{ g of soybean meal}$$

This is substituted into our diet so that 1429 g of SBM now replaces 1429 g of hay.

4. Again recalculate the amount of energy, protein, Ca and P the diet provides. Have we met our first two priorities for energy and protein? Let's assume we have and now we are deficient only in Ca and P. Using an approach similar to step 3 above, we determine the extent of our deficiency or need and divide it by the concentration of Ca and/or P in the mineral supplements we choose to use. **Note that we do not calculate the advantage of using this mineral supplement over our other feedstuffs.** This is for two reasons: first, the quantity of mineral supplement added to a diet is so small that it really does not alter the proportions of the diet, and second, we usually reserve a set proportion of the diet for minerals and vitamins (usually 1-3% of the diet), called slack space.

Some points to remember:

- > THINK about the sense of what you are doing as you formulate rations. Can an animal eat that much feed? If a ruminant, is there enough fiber?
- > Animals eat pounds (kg), not percentages. Check that you have met absolute requirements by weight before expressing the final ration in fractional terms.
- > There is almost never a single, perfect answer to a ration balancing problem.

## DIET EVALUATION WORKSHEET

Student Name \_\_\_\_\_

Lab No. \_\_\_\_\_

.Problem No.\_

(species, age, other classification)

Expected

\_\_\_\_\_   
 Performance

Water? \_\_\_\_\_

Salt? \_\_\_\_\_

### Nutrient Requirements

	DM (kg)	Energy (Mcal)	Protein (g or kg)	Gate)	P(9)

### Feed Composition (DM basis)

Feed	Feed No.	DM%	Energy (Mcal)	Protein %	Ca%	P%
<b>1</b>						
<b>2</b>						
<b>3</b>						
<b>4</b>						
<b>5</b>						
<b>6</b>						
<b>7</b>						
<b>8</b>						
<b>9</b>						
<b>10</b>						

### Ration Make-Up and **Composition**

Ration	As fed (kg)	DM (kg)	Energy (Mcal )	Protein (g or kg)	Ca(g)	P(9)
1						
2						
3						
4						
5						

PROBLEM #1

These are short calculations that will help introduce you to arithmetic procedures in ration balancing.

\*\*Reminders:

1. Requirements are expressed in amounts/day.
2. We need to identify our animal, her requirements, and the feeds we have available

a. You have a 30 kg doe producing 1 kg of milk testing 4% fat and having minimal activity. What are her total requirements for energy (Mcal DE/day)? For total protein? (Assume that this animal will eat 0.96 kg/day)

b. You have the following feed available:

Clover Hay, 500 g/day available, 2.84 meal/kg DE, 152 g TP/kg.

What must the protein concentration of your supplement be? The energy concentration?

c. Your neighbor has a 70 kg doe producing 5 kg of milk. She requires a 13.9% protein diet. In what proportion must he mix your supplement with your hay to provide his goat with her requirements?

c. A 500 kg mix of your ration is still short 3.5 kg of Ca and 2.0 kg of P (Total). How much dicalcium phosphate (6-01-080) and limestone (6-02-632) would be needed to overcome the deficiency?

We have a herd of 20 kg wethers with a goal of gaining 150 g/month. All kids also received a top dressing of loose trace mineral salts containing Bovatec over their corn.

### Requirements

		TDN(g)	CP(g)	NE(Mcal)	Ca(g)	P(g)	
Maintenance plus low activity		334	46	.68	2	1.4	
150g gain daily		300	41	.6	2	1.4	
Total		634	87	1.28	4	2.8	
Feed	Ibs fed	g fed	TDN	CP(g)	NE(Mcal)	Ca(g)	P(g)
Whole Cora	.5	227	177	20	.42	.05	.61
Low Quality grass/legume pasture	2 Ibs DM	908	554	72	1.16	4.9	2.09
Total	2.75	1135	731	92	1.58	4.95	2.7

Are there deficiencies that you notice with this ration?

If we substitute a higher quality legume/grass pasture (64% TDN, 15% CP, 0.53% Ca, 0.23% P), can we correct these deficiencies?

What if these goats had a moderate level of activity rather a low activity?



You expect your does to have a BF test of 3.5%. Instead the BF test is coming in at about 3.2%. What could be the problem? (Hint: the NDF content of the corn is 10%, of the pellets is 10% and of the alfalfa is 35%. How could you fix this problem?)

154 lb multiparous doe milking 5 kg (-5 quarts ) daily

		TDN(g)	CP(g)	NE(Mcal)	Ca	P	
Maintenance plus low activity		560	77	1.14	3	2.1	
Lactation -5 kg of milk(3.5% fat)		1710	340	3.45	10	7	
Total		2562	458	5.18	15	10.5	
Feed	lbs fed	g fed	TON	CP(g)	NECMcal)	Ca(g)	P(g)
Com	4	1816	1416	157	3.32	.36	4.91
Bi-CU pellets	1	454	327	96	.77	6.58	2.86
Alfalfa hay	3	1362	763	222	1.71	13.62	4.63
Total	8	3632	2506	475	5.8	20.56	12.40