UMC

Science and Technology

GUIDE

Published by the University of Missouri - Columbia Extension Division

APR 08 1980

R

Calculating Rations for Dairy Cattle, Part 1

(You also need tables in Part 2, Guide 3105)

Rex Ricketts and Steve Behan, Dairy Husbandry Department, College of Agriculture

Note: Tables 1 and 2 referred to in this guide are in Guide 3105, *Calculating Rations for Dairy Cattle, Part 2*.

A ration for dairy cattle should supply the nutrients necessary for 1) maintenance, 2) growth, 3) milk production, and 4) reproduction.

The maintenance requirements are those nutrients which must be supplied to the animal just to maintain it at its present state so it won't lose or gain weight. This does not include nutrients needed for growth, milk production, or reproduction. Maintenance requirements are proportional to body weight.

To find these requirements for a mature lactating 1,400-lb. cow, look in Part 2 at Table 1, Section C under 1,400 lbs. You will find she requires 1.12 lbs. crude protein (CP), 10.12 therms* net energy (NE), .048 lbs. calcium (Ca), and .039 lbs. phosphorus (P).

If a lactating animal is not mature, additional nutrients for growth must be supplied. The maintenance requirements for all nutrients, except Vitamin A, should be increased by 20% during first lactation and 10% during second lactation. (When calculating with a percent figure, such as 20%, merely move the decimal point two places to the left. Thus 20% becomes .20 in an equation; 1% becomes .01.) For example, a first calf heifer weighing 1,200 lbs. should receive (Table 1, Section C) 1.01 lbs. x .20 = .202 lbs. *additional* crude protein. Thus, the heifer should receive 1.01 + .202 = 1.212 lbs. crude protein per day.

Nutritional requirements for the dry pregnant cow are in Table 1, Section D. These include requirements for both maintenance and reproduction during the last two months of pregnancy.

Growth and maintenance requirements of heifers are in Table 1, Sections A or B. Section A is for large breed heifers like Holstein while section B is for small breed heifers like Jersey. These sections are categorized by body weight, age, and daily gain. If your heifers don't neatly fall into the large or small breed categories, use the weight, age, and daily gain (if known) combination which most nearly matches that of your heifers. Overestimating the daily gains a little bit is better than underestimating them.

*1 therm = 1 megacalorie

Calculating a Dairy Ration

Six steps to a ration:

1) Daily requirements of nutrients for the dairy animal (Table 1).
2) Nutrients supplied by the forages (Table 2).
3) Nutrients needed to be supplied by the ration (concentrates).
4) Pounds of ration required.
5) Percent protein needed in the ration.
6) Percent calcium and phosphorus needed in the ration.

Guide 3108 is a convenient work sheet to follow while calculating a milking ration, and reading 3108 along with this guide will help you understand explanations in this guide.

A milking ration should be formulated for the *higher producing cows* (top ⅓ to ¼) of the herd. Then lesser amounts of this ration can be fed to the lower producers.

1) *Daily requirement*. Obtain this from Table 1 under the appropriate section. Example: a mature lactating 1,400-lb. cow (Section C) needs 1.12 lbs. crude protein (CP) for maintenance and, if producing 65 lbs. of milk with 3.5% fat, needs an additional 5.33 lbs. CP (Section E, 65 x .082), which would give a total of 6.45 lbs. CP (1.12 + 5.33) per day. Follow the same procedure for net energy, calcium, and phosphorus.

2) *Nutrients from the forages*. In calculating the nutrient content of the forages, you can use either the average composition of the forage (Table 2) or better yet, forage analysis.

To calculate the amount of nutrients supplied by each forage, multiply the pounds of the forage fed by the percent or therms/lb. of each nutrient in the forage. Example: 5 lbs. of alfalfa hay 1/10 bloom would contain 5 x .167 = .84 lbs. crude protein,** and 5 x .55 = 2.75 therms net energy (NE). NE and estimated net energy (ENE) are interchangeable. The pounds or therms of each nutrient of the various forages are then added together to get a total of each nutrient supplied by the forages.

A cow eats from 1½% to 2% of her body weight in forage on a dry matter basis per day. This means that a 1,400-lb. cow would eat from (1,400 x .015) 21 lbs. to (1,400 x .02) 28 lbs. of forage on a dry matter basis per day. Forage intake of high producing cows may have to be limited to obtain high enough

**Numbers have frequently been rounded; this should account for any discrepancies in calculations.

Composition of Grain-Supplement Mix

AS FED

Ingredient	As fed % in Ration	Crude Protein (%)	Crude Protein (lbs./cwt.)	Net Energy (Therms /lb.)	Net Energy (Therms (cwt.)	Dry Matter (%)	Dry Matter (%)
Corn	45	8.9	4.0	.82	36.9	89	40.1
Milo	42.5	9.6	4.1	.73	31.1	88	37.4
SBOM 44%	12.5	44.1	5.5	.75	9.4	89	11.1
Total	100.0		13.6		77.4		88.6

DRY MATTER

Ingredient	As fed % in Ration	Crude Protein (%)	Crude Protein (lbs./cwt.)	Net Energy (Therms /lb.)	Net Energy (Therms /cwt.)	Dry Matter (%)	Dry Matter (%)
Corn	45	10	4.5	.921	41.4	100	45
Milo	42.5	10.9	4.6	.833	35.4	100	42.5
SBOM 44%	12.5	49.6	6.2	.844	10.5	100	12.5
Total	100.0		15.3		87.3		100.0

	Crude Protein (%)	Net Energy (Therms/cwt.)
As Fed	13.6	77.4
Dry Matter	15.3	87.3

intake of the milking ration to meet their needs. When forages are limited to less than 1% of body weight, butterfat may be depressed.

High moisture forages (silage, green chop, and pasture) can be converted to dry matter equivalents by a simple calculation. Multiply the pounds of high moisture forage on an as fed basis by the percent dry matter of that forage to get the pounds of high moisture forage fed on a dry matter basis. Example: 50 lbs. of corn silage, which is 35% DM, would be equivalent to (50 x .35) 17.5 lbs. of corn silage on a dry matter basis.

To estimate the consumption of a high moisture forage when the amount of hay consumed is known, work from a dry matter basis and convert to as fed. First calculate the pounds of hay consumed on a dry matter basis by multiplying the pounds of hay fed on an as fed basis by the percent dry matter of the hay. For example, 5 lbs. alfalfa hay as fed with 90% DM gives 4.5 lbs. (5 x .90) hay on a dry matter basis. Then subtract the amount of hay consumed on a dry matter basis from the total estimated forage intake of the cow on a dry matter basis (1.5% body weight). For example, a 1,470-lb. cow x .015 = 22 lbs. estimated forage intake on a dry matter basis. Thus, 22-4.5 = 17.5 lbs. of high moisture forage that should be fed on a dry matter basis.

The pounds of high moisture forage to be fed on a dry matter basis is then divided by the percent dry matter of the high moisture forage (corn silage was 35% DM), which gives you the pounds of high moisture forage to be fed on an as fed basis (17.5 ÷ .35 = 50 lbs. of high moisture forage on an as fed basis).

3) *Nutrients needed in the ration*. The ration furnishes the nutrients needed by the animal that are not supplied by the forages. You can figure the nutrients needed to be supplied by the ration by subtracting the nutrients supplied by the forages (Step 2) from the daily requirements of the animal (Step 1). Example: Our cow in step 1 requires 6.45 lbs. CP; 5 lbs. alfalfa hay + 50 lbs. corn silage will give her 2.24 lbs. CP, [Table 2: (5 x .167) + (50 x .028)]. So the ration should supply 4.21 lbs. CP (6.45 - 2.24 = 4.21).

4) *Amount of ration required*. After determining the nutrients needed to be supplied by the ration (Step 3), take the therms of NE (or pounds of total digestible nutrients needed) and divide this by the estimated therms/lb. (or TDN/lb.) of the ration, to get the pounds of ration to be fed. The energy content of a grain-supplement mix can be calculated as shown in the table above. A good quality ration should contain .76 therms/lb. of NE on an as fed basis, but this may range from .70 to .78 therms/lb. Example: Our ration needs to supply 14.9 therms of NE, (see Guide 3108, Step 3) so we would need to feed 14.9 therms ÷ .76 therms/lb. = 19.6 lbs. of ration.

5) *Percent protein*. To obtain the percent protein needed in the ration, divide the amount of protein needed to be supplied (Step 3) by the pounds of ration to be fed (Step 4), then multiply by 100. In our example we need 4.21 lbs. CP in the ration, which we are going to feed 19.6 lbs. of, so it needs to be (4.21 ÷ 19.6) x 100 = 21.5% protein.

The *Pearson square method* is an easy way to determine the amount of protein supplement needed to be added to the grain to obtain the desired percent protein in the ration. To set up the square the desired percent protein of the ration should be placed in the center of the square. The percent protein of the grain and supplement are placed in the left corners of the square (see below). The difference, obtained diagonally, between the percent protein desired in the ration from the percent protein in the grain or the supplement, would give you the pounds of the other needed to be used in the mix.

8.9% protein in grain		22.5 lb. grain
	21.5% protein needed in the ration	
44% protein in supplement		12.6 lbs. supplement

Composition of Mineral Supplements

as fed value / dry matter value	Dry Matter (%)	Ca (%)	P (%)	Ca:P ratio
Ground Limestone	100	36.0	0.0	
Defluorinated Rock Phosphate	100	31.7	13.7	2.3:1
Steamed Bonemeal*	95	29.0	13.6	2.2:1
	100	30.5	14.3	
Dicalcium Phosphate	96	22.8	18.1	1.3:1
	100	23.7	18.8	
Sodium Phosphate	87		22.5	
	100		25.8	
Sodium Tripoly Phosphate	96		24.9	
	100		26.0	

*Also contains 12.7% CP, .12 therms/lb. ENE, 2% crude fiber, and 16% TDN on a dry matter basis.

22.5 + 12.6 = 35.1 total lbs.
(22.5 ÷ 35.1) x 100 = 64% grain
(12.6 ÷ 35.1) x 100 = 36% protein supplement

In our example 12.6 lbs. supplement (21.5 - 8.9) is to be mixed with 22.5 lbs. grain (44 - 21.5) to obtain the desired 21.5% protein in the ration.

An easy way to determine the pounds of each to be used in the ration is by percentage. Mixing 22.5 lbs. of grain with 12.6 lbs. of supplement gives 35.1 lbs. total. The percentage of grain in the mix is (22.5 lbs. ÷ 35.1 lbs.) x 100 = 64%. The percentage of supplement in the mix is (12.6 ÷ 35.1) x 100 = 36%. A ton mix would contain 1,280 lbs. of grain (2000 x .64) and 720 lbs. of supplement (2000 x .36).

There are adjustments which can be made in the Pearson square to allow a percentage of the ration to be saved for addition of minerals, vitamins, additives, or salt. If you did not allow for these energy or protein deficient materials to be added, they would dilute the percent protein or ENE content of the ration. To save 2% of the ration, multiply the percent protein of both the grain and supplement by 98%. Use these products as the percent protein of the grain and supplement in the Pearson square. Proceed then as usual in the use of the Pearson square. When you get the percentage of grain and supplement in the ration, multiply each of these percentages by 98% to get the percentage of each in 98% of the ration. You then have 2% of the ration saved for addition of minerals or whatever, without diluting the percent protein or ENE content of the ration.

Example: 8.9 x .98 = 8.7%
44 x .98 = 43.1%

8.7% protein in grain — 21.5% — 21.6 lbs. grain

43.1% protein in supplement — 21.5% — 12.8 lbs. supplement

21.6 + 12.8 = 34.4 total lbs.
(21.6 ÷ 34.4) x 100 = 62.8
x .98 = 61.5% grain
(12.8 ÷ 34.4) x 100 = 37.2
x .98 = 36.5% protein supplement
61.5 + 36.5 = 98.0% of total ration

High producing cows may milk relatively well on an energy deficient ration since they have body reserves of energy, in the form of fat. However, these same cows have very limited reserves of protein. So if protein is deficient in the ration, milk production declines or stays at a low level.

6) *Percent Calcium and Phosphorus.* To obtain the percent calcium or phosphorus needed in the ration, divide the amount of each needed to be supplied (Step 3) by the pounds of ration to be fed (Step 4), then multiply by 100. Example: In our ration we need to supply .09 lbs. Ca and .11 lbs. P (Guide 3108, Step 3). We will be feeding 19.6 lbs. of ration, so it needs to contain (.09 lbs. ÷ 19.6 lbs.) x 100 = .46% Ca and (.11 lbs. ÷ 19.6 lbs.) x 100 = .56% P.

Calcium or phosphorus not supplied by the forages and grain ration can be furnished by adding one or more of the mineral supplements found in the table on the left. The mineral supplements added should satisfy the total mineral needs of the animal and also provide a Ca:P ratio of 1.3:1 to 2:1 in the total ration.

While formulating your ration, first meet the phosphorus requirement with the lowest cost phosphorus source, and then fulfill the calcium requirement with a single source of calcium, such as limestone.

Vitamin A

Stabilized Vitamin A can be added to the ration at a very low cost to insure adequate Vitamin A intake. A rule of thumb of 2,000 international units (IU) Vitamin A per pound (4 million IU per ton) is a good guide to follow.

Water

Since milk is 88% water, a high producing cow cannot produce at her fullest potential without adequate water. Water should be provided free choice at all times at a convenient location.

Dry Cows

The requirements found in Table 1, Section D are for maintenance and reproduction (pregnancy) in the dry cow. These do not include nutrients needed for conditioning. Because of this, the dry cow, which is not in good condition, should be fed a little bit more than the calculated requirements suggest. Three reasons for feeding during the dry period are:

- to build up body reserves, to be used during peak production,
- to have the cow adjusted to higher grain intake, and
- to get sufficient phosphorus while maintaining low calcium which results in an active parathyroid gland and prevents milk fever.

The amount of feed needed to supply the energy requirements of a high producing cow in early lactation will probably exceed her ability to eat. At this time she must depend on body stores, primarily of fat, which were put on during late lactation and the dry period to give her the extra nutrients needed during her peak production.

A sudden change from low grain intake during the dry period to high grain intake at freshening may throw a cow off feed. This is because in the dry period, most of the microorganisms in the rumen are primarily types which digest forage. These should be gradually changed to those which digest more grain. Therefore, about two weeks before the cow is due to freshen, gradually increase the amount of grain being fed to .5 to 1% of her body weight.

The dry cow should be kept on the dry cow ration up to the time of calving. She should be fed 4 to 8 lbs. (depending on her body condition) of this ration per day throughout the dry period.

The dry cow should be fed grass hay or other non-legume forage to maintain a low calcium diet and also a grain ration low in calcium (.10 to .20%) and high in phosphorus (.5 to .8%) to prevent milk fever.

A low calcium-high phosphorus diet for dry cows keeps the parathyroid gland active. If this gland is active when a cow calves, the calcium can be mobilized from the bones and more can be absorbed from the digestive system to meet high calcium requirements of lactation.

Estimating the Value of Purchased Feeds

The Missouri Feed Law requires the manufacturer of mixed feeds to state on the tag the minimum percent crude protein and fat and maximum percent crude fiber in the feed. This law does not require them to state the TDN or ENE or calcium or phosphorus content of complete feeds.

The percent crude fiber can be used to make an estimate of the TDN content of the feed. A good quality feed should contain 6% or less crude fiber. The estimated TDN of a feed with 6% crude fiber is 75%.

As the fiber content increases the estimated TDN decreases. As a general guide, 1% increase in crude fiber above 6% reduces the TDN 1.5% below 75%. A decrease of 1% crude fiber below 6% will raise the TDN 1.5% above 75%. The following formula will help you in obtaining an estimate of the TDN content of purchased feeds: Estimated % TDN = 75 - [(crude fiber % - 6) x 1.5].

High Moisture Grains

Data indicates that high moisture grains are equal to dry grains in nutritive value on a dry matter basis.

Dry Matter Values

Table 2 is set up with both as fed and dry matter values. The as fed value is listed first; then directly beneath it is the corresponding dry matter value.

To convert a dry matter value to the corresponding as fed value, multiply the dry matter value by the percent dry matter of the feed.

	DM	CP	ENE	Ca	P
Corn silage	35				
	100	8	.723	.27	.2

	DM value	% DM	As fed values
CP	8	x .35 =	2.8
ENE	.723	x .35 =	.253
Ca	.27	x .35 =	0.09
P	.20	x .35 =	0.07

The dry matter values give you a better way of comparing the relative worth of feeds by taking out the dilution factor of moisture. This will put all the feeds on the same level no matter what their percent moistures are. For example, even though on an as fed basis 1 lb. of alfalfa silage has only 40% the nutrient content of 1 lb. of alfalfa hay, on a dry matter basis 1 lb. of the silage and 1 lb. of the hay have very similar nutrient contents.

Calculating a Ration on Dry Matter Basis

Using dry matter values in calculating a ration is more accurate than using as fed values. In calculating on the dry matter basis, use dry matter values and pounds of forage fed on a dry matter basis. To calculate the pounds of ration needed to be fed (Step 4) on a dry matter basis, either calculate the ENE of the grain-supplement mix on a dry matter basis (Table 2) or use the average value of .84 therms/lb. (compared to .76 therms/lb. used in calculating on an as fed basis). After this step is done the percent protein, calcium, and phosphorus in the ration are then found as outlined in Steps 5 and 6.

An added step which must be done after calculating a ration on a dry matter basis is converting from dry matter percents of ingredients to as fed percents in the ration. To do this take the percent of each ingredient on a dry matter basis and divide this by the percent dry matter of that ingredient. Add these quotients together to get a total. Find the percent of each ingredient on an as fed basis by going back to these quotients individually and dividing them by the total; then multiply this by 100.

Example:

	% ingredient DM basis in ration		% DM		Quotient	% As Fed
Corn	62.78	÷	.89	=	70.54	62.89
SBOM	35.40	÷	.89	=	39.77	35.46
Dical	.83	÷	.96	=	.86	.77
Limestone	.44	÷	1.00	=	.44	.39
TM Salt	.55	÷	1.00	=	.55	.49
					112.16	100.00

An example is [(70.54 Quotient) ÷ (112.16 sum of quotients)] x 100 = 62.89% As Fed Basis for corn.

■ Issued in furtherance of Cooperative Extension Work Acts of May 8 and June 30, 1914 in cooperation with the United States Department of Agriculture. Leonard C. Douglas, Acting Director, Cooperative Extension Service, University of Missouri and Lincoln University, Columbia, Missouri 65211. ■ An equal opportunity institution.

3104 *Revised 2/80/10M*