Ration Balancing on the Ranch

Guide B-125
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INTRODUCTION

On most ranches there are times when cattle are fed commodities such as hay or grains. However, delivering these commodities in the appropriate proportion and quantity to meet nutrient requirements and production goals can be challenging. The ability to balance a ration can be beneficial to producers by helping them cost effectively achieve production goals.

To balance a ration, producers need to know the nutrient requirements of the cattle, nutrient content of feedstuffs being considered for the ration, and the mathematical calculations necessary to determine the amount of each feedstuff needed to meet the requirement. This guide will discuss ration balancing principles and describe the Pearson Square technique for ration balancing on the ranch.

NUTRIENT REQUIREMENTS

Nutrient requirements change depending on class of cattle (i.e., steer vs. heifer vs. cow vs. bull) and physiological state (i.e., gestating vs. lactating). For example, requirements for steers are generally less than for heifers at the same rate of gain, and a cow has higher requirements during lactation compared to gestation. Lactation requirements rise with increasing milk production. Compared to the middle third of gestation, requirements increase approximately 15 percent during the last third of gestation. Depending on level of milk production, the requirements can increase by 30 percent. Nutrient requirements for cattle of varying class and level of production can be obtained from the NRC (2000) or from your local Extension agent. Table 1 lists requirements of cows at different weights and physiological states; table 2 includes the requirements of steers and heifers at different weights and rates of gain.

NUTRIENT SUPPLY

The quality of a feedstuff is a function of its nutrient content and digestibility. These factors influence intake and animal performance. No single analysis fully measures feed quality. Instead, feedstuff quality is usually evaluated by measuring energy, fiber, protein and mineral components.

Table 1. Cow requirements for energy (TDN), protein (CP), calcium (Ca), and phosphorus (P)

Physiological State	TDN lb/day	CP lb/day	Ca g/day	P g/day
1,000-lb cow				
Lactation (10 lb peak)	12.0 lb	1.80 lb	22 g	16 g
Lactation (20 lb peak)	13.9 lb	2.38 lb	30 g	20 g
Mid-gestation	9.6 lb	1.30 lb	14 g	11 g
Late gestation	11.0 lb	1.64 lb	23 g	14 g
1,100-lb cow				
Lactation (10 lb peak)	12.7 lb	1.90 lb	24 g	17 g
Lactation (20 lb peak)	14.7 lb	2.47 lb	32 g	21 g
Mid-gestation	10.4 lb	1.40 lb	15 g	12 g
Late gestation	11.9 lb	1.77 lb	25 g	16 g
1,200-lb cow				
Lactation (10 lb peak)	13.5 lb	2.00 lb	25 g	18 g
Lactation (20 lb peak)	15.4 lb	2.56 lb	33 g	22 g
Mid-gestation	11.0 lb	1.50 lb	16 g	13 g
Late gestation	12.7 lb	1.90 lb	28 g	18 g

Source: NRC, 2000

Energy

The two most commonly used methods of measuring or expressing the energetic value of a feedstuff are total digestible nutrients and net energy.

- **Total Digestible Nutrients (TDN)** is a laboratory measure of the digestibility of a feed, which is related to its energetic value. For example, a cow consuming dormant native range forage with a TDN value of 57 percent would be expected to digest about 57 percent of the forage she consumes.
- **Net Energy (NE)** System is a more specific measure of a feed's energy value. The energetic value of a feed differs depending on the function the energy is used to power. Thus, the NE system identifies the energetic value of a feed to support maintenance (NEm), growth (NEg) and lactation (NEl).

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Table 2. Steer and heifer requirements for energy (TDN), protein (CP), calcium (Ca), and phosphorus (P).

Gender	Weight	Dry Matter Intake, lb/day	ADG	TDN, lb/day	CP, lb/day	Ca, g/day	P, g/day
Steer	500	12.8	1.5	8.0 lb	1.33 lb	23 g	13 g
Steer	500	13.0	2.5	9.6 lb	1.63 lb	33 g	16 g
Steer	500	13.6	3.5	10.7 lb	2.00 lb	45 g	20 g
Steer	700	16.5	1.5	10.4 lb	1.50 lb	23 g	15 g
Steer	700	16.7	2.5	12.3 lb	1.75 lb	30 g	17 g
Steer	700	17.5	3.5	13.7 lb	2.10 lb	41 g	21 g
Steer	900	19.9	1.5	12.5 lb	1.66 lb	23 g	17 g
Steer	900	20.2	2.5	14.8 lb	1.87 lb	28 g	18 g
Steer	900	21.1	3.5	16.6 lb	2.19 lb	38 g	22 g
Heifer	500	12.1	1.5	8.3 lb	1.25 lb	21 g	12 g
Heifer	500	12.8	2.5	10.0 lb	1.57 lb	31 g	15 g
Heifer	500	13.3	3.5	11.0 lb	1.94 lb	42 g	19 g
Heifer	700	15.5	1.5	10.6 lb	1.39 lb	20 g	14 g
Heifer	700	16.4	2.5	12.6 lb	1.68 lb	28 g	16 g
Heifer	700	17.1	3.5	14.1 lb	2.04 lb	38 g	20 g
Heifer	900	18.8	1.5	12.9 lb	1.53 lb	19 g	16 g
Heifer	900	19.8	2.5	15.2 lb	1.78 lb	26 g	18 g
Heifer	900	20.6	3.5	17.0 lb	2.12 lb	36 g	21 g

Source: NRC, 1984

Fiber
Two fiber measurements are commonly performed to evaluate feed samples. These are neutral detergent fiber and acid detergent fiber.

- **Neutral Detergent Fiber (NDF)** is a measure of the major cell wall components (hemicellulose, cellulose and lignin) of a feedstuff. Feeds with a high NDF content are considered to be lower quality than feeds with lower NDF concentrations. The NDF content of a feed can be used as a predictor of intake. For example, if all other nutrients are held constant (like percent crude protein), we would expect a cow to consume a greater amount of forage containing 55 percent NDF than forage that is 70 percent NDF. A common equation used to predict intake from percent NDF is:
  Intake (% body weight) = (120 ÷ % NDF)

- **Acid Detergent Fiber (ADF)** is a measure of the less digestible portion of the plant cell wall material (cellulose and lignin). The ADF content of a feed can be used as a predictor of digestibility and thus energy. If a feed has a high ADF value and all other nutrients are similar, it will likely be less digestible than a feed with a lower ADF value. TDN can be estimated using the ADF concentration measured in a feedstuff by the following equation: **TDN (%) = 88.9 – (.779 × % ADF)**

Protein
Protein in a feed is most often expressed as crude protein (CP). The crude protein content is calculated by first determining the amount of nitrogen in the feed, then multiplying by a factor of 6.25. This factor is used because the average nitrogen content of protein is 16% (100 ÷ 16 = 6.25).

Minerals
Minerals are inorganic components of the animal's diet and cannot be decomposed or synthesized by chemical reactions. Dietary minerals are classified by the amount present in an animal's body. Macrominerals are found in the body at a concentration greater than 100 parts per million (ppm), and trace minerals are found in the body at a concentration less than 100 ppm. On a forage analysis, macrominerals are listed as a percent and trace minerals are listed as ppm (or mg/kg). Table 3 lists some common macrominerals and trace minerals.

DETERMINING NUTRIENT COMPOSITION OF FEEDSTUFFS

To calculate how much of a feedstuff or commercial feed is needed, the nutrient composition must be determined. The nutrient composition of commercial feeds can be obtained from feed dealers or commodity brokers. However, the most accurate alternative is to have the feed analyzed at a commercial laboratory. Table 4 is an example forage analysis from a New Mexico dormant range forage sample. Tabular feed values are also published but are not as accurate as a feed nutrient analysis. Tabular values for some feedstuffs commonly used in New Mexico are listed in Table 5. To obtain a more extensive list of feedstuff values, contact your local Extension agent or search the Web.

RATION BALANCING

A balanced ration supplies the proper amount and proportions of nutrients to meet a particular animal's needs. Supply is evaluated by the total quantity of feeds available and their

Table 3. Common macrominerals and trace minerals found on forage analyses.

Macrominerals	Trace Minerals
Calcium	Aluminum
Chlorine	Cobalt
Magnesium	Copper
Phosphorus	Iodine[a]
Potassium	Iron
Sodium	Manganese
Sulfur	Molybdenum
	Seleniuma
	Zinc

[a]Iodine and selenium are not always included in a standard mineral analysis but usually can be included at an additional cost.

nutrient analyses, while demand is evaluated by the nutrient requirements of the animal.

Computer programs are often used to balance rations. These programs increase the speed of calculations, but producer input still must be correct for a ration to be balanced properly. Oklahoma State University has several ration balancing programs that can be downloaded for free at www.ansi.okstate.edu/software. The use of computer spreadsheets and other balancing programs has made hand calculations less common; however, it is beneficial for producers to know how to balance a simple ration by hand.

Pearson Square

The Pearson Square is a relatively simple ration balancing technique. This method can be used to balance for only one nutrient, but any nutrient can be used. Only two ingredients can be used, but those can be mixtures of feedstuffs. Thus, many feeds can be included in the final ration. There are four steps to the Pearson Square method: 1) balance for energy first (TDN), which is the nutrient required in the greatest amount; 2) determine if this ration will also meet the animal's crude protein requirements; 3) if protein requirements are not met by the ration, determine the amount of additional protein needed; 4) convert individual feedstuff amounts from dry matter to as-fed basis.

An example will be provided to illustrate the use of Pearson Square to balance a ration. Feedstuffs used in this example are listed in Table 5.

Example 1. Balancing a ration for weaned calves in a drylot using hay and grain

In this example, a ration will be balanced using wheat hay, whole corn and cottonseed meal (feed values are listed in table 5) for a 700-lb heifer calf with a desired gain of 2.5 lb/day. Her daily requirements are (table 2):

- 16.4 lb dry matter intake
- 76.8% TDN (12.6 lb TDN ÷ 16.4 lb dry matter intake)
- 10.2% CP (1.68 lb CP ÷ 16.4 lb dry matter intake)

To balance this ration:

1. Balance for TDN.
   a. Draw a square and write 76.8 (the desired TDN concentration) in the middle of the square (fig. 1).

Table 4. Example native range forage sample collected in late November 2003 at the Corona Range and Livestock Research Center, Corona, N.M.

	Dry Basis	As Received	Unit
Moisture		28.14	%
Dry Matter (DM)		71.86	%
Crude Protein (CP)	6.87	4.94	%
Neutral Detergent Fiber (NDF)	63.14	45.37	%
Acid Detergent Fiber (ADF)	42.92	30.84	%
Net Energy – Lactation (NEl)	0.48	0.35	Mcal/lb
Net Energy – Gain (NEg)	0.18	0.13	Mcal/lb
Net Energy – Maintenance (NEm)	0.50	0.36	Mcal/lb
Total Digestible Nutrients (TDN)	48.26	34.68	%
Calcium	0.58	0.42	%
Phosphorus	0.09	0.06	%
Potassium	0.64	0.46	%
Magnesium	0.09	0.06	%
Sodium	0.02	0.01	%
Sulfur	0.14	0.10	%
Aluminum	1,130.00	812.02	ppm
Cobalt	0.70	0.50	ppm
Copper	18.30	13.15	ppm
Iron	901.00	647.46	ppm
Manganese	72.80	52.31	ppm
Molybdenum	1.88	1.35	ppm
Selenium	0.16	0.11	ppm
Zinc	19.30	13.87	ppm

   b. At the upper left corner of the square, write "wheat hay = 53". At the lower left corner, write "corn = 88". These numbers represent the TDN percentage in each feedstuff. **Note:** The nutrient requirement in the middle of the square <u>must</u> be between the nutrient concentrations of the two ingredients.
   c. Subtract diagonally across the square, converting negative answers to positive, and write the numbers on the right side of the square (top value = 11.2, bottom value = 23.8).
   d. Sum the numbers on the right side of the square (11.2 + 23.8 = 35). These numbers indicate that a ration of 11.2 parts wheat hay and 23.8 parts corn (a total of 35 parts) will result in a ration with 76.8 percent TDN.
   e. Divide the wheat hay and corn "parts" by 35 to get the percentages of wheat hay (11.2 ÷ 35 = 32%) and corn (23.8 ÷ 35 = 68%).

2. Determine if crude protein is adequate.
   a. Multiply the percent of each feedstuff in the mix by its crude protein content. Wheat hay is 32 percent of the mix and contains 9.1 percent crude protein. Corn is 68 percent of the mix and contains 9.8 percent crude protein. Therefore, the crude protein concentration in the mix is:

Table 5. List of common New Mexico feedstuffs.

Feedstuff	% DM	% TDN	% CP	% Ca	% P
	---------------% of Dry Matter---------------				
Alfalfa, mid-bloom	91	60	17.0	1.39	0.24
Alfalfa, late bloom	91	53	12.0	1.19	0.24
Alfalfa, mature	91	50	14.0	1.18	0.21
Brome hay	88	56	14.4	0.29	0.28
Corn gluten feed	90	80	23.8	0.07	0.95
Corn, rolled	88	90	9.8	0.03	0.32
Corn, whole	88	88	9.8	0.03	0.31
Cotton gin trash	90	45	7.4	0.65	0.12
Cottonseed hulls	91	45	4.1	0.15	0.09
Cottonseed meal	92	75	46.1	0.20	1.16
Cottonseed, whole	92	95	23.0	0.16	0.62
Forage sorghum hay	91	56	11.3	0.51	0.31
Prairie hay	91	48	5.3	0.35	0.14
Sorghum grain, rolled	90	82	12.6	0.04	0.34
Soybean hulls	91	80	12.2	0.53	0.18
Soybean meal	89	84	49.9	0.40	0.71
Soybean, whole	90	94	40.3	0.27	0.65
Sunflower meal	90	65	25.9	0.45	1.02
Wheat hay	84	53	9.1	0.16	0.24
Wheat middlings	89	83	18.4	0.15	1.00
Wheat straw	89	41	3.5	0.17	0.05

Sources: NRC, 2000; Atlas of Nutritional Data on U.S. and Canadian Feeds, 1971

Wheat hay: 0.32 × 9.1 = 2.91%
Corn: 0.68 × 9.8 = 6.66%
2.91 + 6.66 = 9.57%→crude protein is not adequate (is < 10.2%)

b. The crude protein content of the diet needs to be increased by adding a protein supplement (cottonseed meal for this example). Another Pearson Square will be used to determine the correct amount of cottonseed meal.

3. Determine amount of protein supplement needed.
   a. Draw a square and write 10.2 (the desired CP concentration) in the middle of the square (fig. 2).
   b. At the upper left corner of the square, write "wheat hay:corn mix = 9.57". At the lower left corner, write "cottonseed meal = 46.1". These numbers represent the CP percentage in each feedstuff. Note: The nutrient requirement in the middle of the square must be between the nutrient concentrations of the two ingredients.
   c. Subtract diagonally across the square, converting negative answers to positive, and write the numbers on the right side of the square (top value = 35.9, bottom value = 0.63).
   d. Sum the numbers on the right side of the square (35.9 + 0.63 = 36.53). These numbers indicate that a ration of 35.9 parts wheat hay:corn mix and 0.63 parts cottonseed meal (a total of 36.53 parts) will result in a ration with 10.2 percent CP.

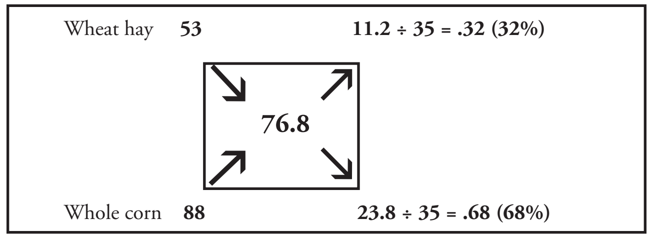

Figure 1. Balancing for TDN using the Pearson Square method.

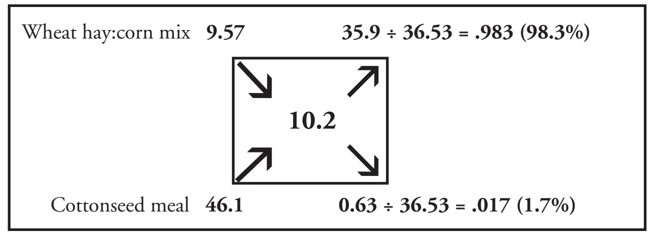

Figure 2. Balancing for CP using the Pearson Square method.

   e. Divide the wheat hay:corn mix and cottonseed meal "parts" by 36.53 to get the percentages of wheat hay: corn mix (35.9 ÷ 36.53 = 98.3%) and cottonseed meal (0.63 ÷ 36.53 = 1.7%).

4. Determine the pounds of dry matter that each feedstuff contributes to the total, and convert from dry matter to as-fed basis.
   a. Multiply the dry matter intake of the heifer (16.4 lb) by the percentage of cottonseed meal in the ration (16.4 × 0.017 = 0.28 lb cottonseed meal). Subtract this amount from total dry matter intake to determine how much of the dry matter intake remains for the wheat hay:corn mix (16.4 – 0.28 = 16.12). Then multiply 16.12 by the relative amounts of wheat hay and corn obtained from the first Pearson square (32 percent wheat hay and 68 percent corn).

      Wheat hay: 16.12 × 0.32 = 5.16 lb wheat hay, dry matter basis
      Corn: 16.12 × 0.68 = 10.96 lb corn, dry matter basis

   b. Convert the individual amounts from dry matter to as-fed basis. This step is required in order to know how much of each ingredient to feed to the heifer. The pounds of dry matter of each feed are divided by the percentage of dry matter in each feed.
      Cottonseed meal: 0.28 lb ÷ 0.92 = 0.30 lb CSM, as fed
      Wheat hay: 5.16 ÷ 0.84 = 6.14 lb alfalfa hay, as-fed
      Corn: 10.96 ÷ 0.88 = 12.45 lb whole corn, as-fed

Once the individual daily ration has been calculated, a producer can plan their feeding program. Multiply the individual daily ration amounts by the number of head to determine the total amounts to feed each day.

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