

ASC-12

## BALANCING RATIONS

ISSUED: 6-72

REVISED: 6-91

John T. Johns, Roy Burris, Nelson Gay and David Patterson

Because feed costs are the major cost of producing beef, making the most efficient use of feeds is of prime importance in determining profits. Rations must be properly balanced for cattle to use feeds most efficiently. Ration balancing is another management tool the efficient producer can use to maximize profits.

To begin ration balancing, some basic information about frequently used terms is needed. A **ration** is the amount of feed an animal receives in a 24-hour period. A **balanced ration** is the amount of feed that will supply the proper amount and proportions of nutrients needed for an animal to perform a specific purpose such as growth, maintenance, lactation or gestation.

**Nutrients** are any feed component or group of feed components that are similar in chemical composition and that aid in the support of animal life. Examples of nutrients are proteins, carbohydrates, fats, minerals and vitamins. **Nutrient requirements** are the amount of nutrients the animal needs for a specific purpose. They are influenced by many factors, such as weight of animal, sex, desired rate of growth, stage of lactation, environment and others. For beef cattle, nutrient requirements may be found in published tables, such as the "Nutrient Requirements of Beef Cattle" published by the National Research Council.

The **nutrient composition** of a feed is the amount of specific nutrients contained in the feed. They are expressed as a percentage of the dry matter and may also be found in published feed composition tables. *A word of caution:* feed composition tables contain only average values. Unless your feed is average, the data would not be accurate.

Feed composition tables should be used when you have no other information. A chemical analysis of the feed can be done for a limited cost, and it will give much more accurate information. Common information provided from an analysis or a composition table will include **dry matter, crude protein, energy** and **minerals**.

**Dry matter** is the portion of the feed left after all water has been removed. It contains the nutrients. Values for dry matter intake shown in nutrient requirement tables are not all an animal will consume, but represent an amount that can be consumed under normal circumstances.

Different feeds contain different levels of dry matter; therefore, it is desirable to balance the ration on a dry matter basis and then convert the various feeds back to an as-fed basis.

**Crude protein** may also be called total protein. It is determined by measuring the nitrogen content of feed and

multiplying by the value 6.25 because proteins typically contain 16% nitrogen. Not all nitrogen-containing compounds are true proteins. These are called nonprotein nitrogen (NPN) sources. Many of these NPN compounds can have their nitrogen converted to microbial protein in the rumen under proper conditions. Generally, NPN sources are not used well as protein when cattle are on high roughage rations or have high protein requirements, such as young cattle with high rates of growth. True protein sources should be used in these cases.

**Energy** is not actually a nutrient. It is contained in nutrients such as carbohydrates, fats, etc. For practical purposes energy will be considered a nutrient. There are several methods of measuring feed energy values. Some of these are digestible energy, net energy for maintenance and gain and total digestible nutrients. Total digestible nutrients (TDN) is the value most commonly used in simple ration balancing.

**Minerals** are compounds needed to regulate many metabolic functions in the body. They may be classed as macro or trace minerals depending on the amounts needed. Examples of macro minerals are calcium and phosphorus. Iron, zinc and copper are examples of trace minerals.

Other important nutrients are vitamins and water. Rations are not normally balanced for these nutrients, but adequate amounts must be provided for desired rates of growth. Water is particularly important because feed intake decreases when water intake is not adequate.

**Roughages** are feeds that are relatively high in fiber and low in energy. Hay, straw, cobs, cottonseed hulls and corn stalks are examples of roughages.

**Concentrates** are feeds or mixtures of feeds that are relatively low in fiber and provide energy as the primary nutrient.

### Formulating Rations

A systematic approach will help in ration balancing. First, determine the nutrient requirements of the animal being fed. This means determining the sex, size and production level of the animal. With this information, nutrient requirements are available from a table.

The next step is to determine the feeds available for use. List their composition on a dry matter basis from a composition table or a chemical analysis. Now the amounts of the feeds necessary to balance the ration can be determined.

The following example will help in understanding the first method used. The method illustrated is called a Pearson Square. A ration will be balanced for a 500-pound medium-frame steer calf with a desired gain of two pounds per day. The requirements are shown in Table 1.

**TABLE 1. -- Daily Nutrient Requirements (lbs.) For a 500-lb. Medium-Frame Steer, ADG=2.0<sup>1</sup>**

Dry Matter		Protein		TDN		Calcium	Phosphorus
lbs.	lb.	%	lb.	%	lb.	lb.	lb.
13.1	1.49	11.4	8.85	67.5	.061		.031

<sup>1</sup>1984 Nutrient Requirements of Beef Cattle

**TABLE 2. -- Nutrient Composition Of Various Feedstuffs, Dry Matter Basis<sup>1</sup>**

Feed	% Dry Matter	% TDN	% Protein	% Ca	% P
Fescue Hay	92	48	9.5	.3	.26
Shelled Corn	88	90	10.1	.02	.35
Soybean Meal	89	84	49.9	.33	.71

<sup>1</sup>1984 Nutrient Requirements of Beef Cattle

Feeds available and their composition are shown in Table 2. Energy or TDN will be the first nutrient balanced for, as the greatest amount of feed goes to satisfy energy needs.

The animal requires a 67.5% TDN ration. To use the Pearson Square method, place the value 67.5 in the center of the square. Place the TDN values of fescue and shelled corn on the left diagonals of the square and subtract across the diagonal, *smallest number from largest*. Now, add the two numbers on the right hand side of the square. These numbers mean that 22.5 parts of fescue and 19.5 parts of corn will give a 67.5% TDN mixture.

### Figure 1

There are 42 total parts in the ration. Divide the two numbers on the right side of the square by the total to determine the preliminary percentage of fescue and corn in the ration.

**Fescue**  $22.5 \div 42 = .54$  (54%)

**Corn**  $19.5 \div 42 = .46$  (46%)

The next step is to calculate the percentage of crude protein in the fescue-shelled corn mixture and compare with the animal's requirement. If the requirement is met or exceeded, the ration is balanced. If the requirement is not met, protein supplementation and additional balancing are needed.

Determine the percentage of crude protein in the fescue-shelled corn mixture by multiplying the percentage of each ingredient in the mix by its percentage of crude protein. Add the two resulting values for the percentage of crude protein in the total mixture. For example, fescue is 54% of the mix and contains 9.5% crude protein. Shelled corn is 46% of the mix and contains 10.1% crude protein.

**Fescue**  $.54 \times 9.5 = 5.1\%$

**Corn**  $.46 \times 10.1 = 4.6\%$

**9.7%**

The crude protein content of the total mix is 9.7% ( $5.1 + 4.6 = 9.7\%$ ). The animal requires 11.4% crude protein in the ration; thus a deficiency of 1.7% ( $11.4 - 9.7 = 1.7\%$ ) exists, and protein supplementation is needed.

Use the square method now to balance the fescue-shelled corn mix and soybean meal for an 11.4% crude protein mixture. Place 11.4 in the center and 9.7 and 49.9 on the left diagonals and subtract as before. Add the two figures on the left side of the square ( $38.5 + 1.7$ ) to determine the total parts of the ration (40.2). Divide each number on the right diagonal (38.5 and 1.7) by the total parts in the ration (40.2) to determine the percentage of the mixture composed of fescue and shelled corn (95.8%) and soybean meal (4.2%).

Fescue / shelled corn mix

## [Figure 2](#)

Now, determine the pounds of dry matter each feed ingredient contributes to the total. This is done by multiplying the pounds of daily dry matter consumed (13.1) by the percentage each ingredient contributes to the total. The protein supplement, in this case soybean meal, must be calculated first.

### **Daily**

dry matter	% Soybean	Soybean meal	
intake	x meal	=	dry matter
13.1 pounds	x .042	=	.55 pounds

Now, determine the pounds of daily dry matter available for fescue and shelled corn by subtracting the pounds of protein supplement dry matter from the daily dry matter.

<b>Daily</b>		<b>Pounds of</b>
<b>dry matter</b>	<b>Soybean meal</b>	<b>fescue-corn</b>
<b>intake</b>	<b>- dry matter</b>	<b>= dry matter</b>
13.1 pounds	- .55 pounds	= 12.55 pounds

There are 12.55 pounds of dry matter composed of the fescue-shelled corn mixture.

To determine the individual pounds of fescue and shelled corn, multiply the pounds of dry matter

composed of the fescue-shelled corn mixture by the percentage of fescue or shelled corn determined in the first square. Subtract this value from the total pounds of fescue-shelled corn dry matter to obtain the pounds of dry matter of the second ingredient. In this example, fescue dry matter would be 6.77 pounds ( $12.55 \text{ lbs.} \times .54 = 6.77 \text{ lbs.}$ ), and shelled corn dry matter would be 5.78 pounds ( $12.55 \text{ lbs.} - 6.77 = 5.78 \text{ lbs.}$ ).

**Pounds of fescue dry matter:**

$$12.55 \times .54 = 6.77 \text{ pounds of fescue dry matter}$$

**Pounds of shelled corn dry matter:**

$$12.55 - 6.77 = 5.78 \text{ pounds of shelled corn dry matter}$$

Now, each dry matter quantity must be converted to as-fed quantity so the farmer knows how much to actually feed. This is done by dividing the pounds of dry matter by the percent dry matter of the feed ingredient.

$$\text{Fescue} = 6.77 \div .92 = 7.35 \text{ pounds as fed}$$

$$\text{Shelled corn} = 5.78 \div .88 = 6.56 \text{ pounds as fed}$$

$$\text{Soybean Meal} = .55 \div .89 = .67 \text{ pounds as fed}$$

Thus, the daily ration for this steer becomes 7.35 pounds of fescue, 6.56 pounds of shelled corn and .67 pounds of soybean meal.

Determine the calcium and phosphorus supplied by each ingredient and compare to the daily requirements to decide if a mineral supplement is needed. This is done by multiplying the dry matter pounds of each feed in the ration by its calcium and phosphorus content and adding the results. The results are compared to the animal's needs; then an excess or deficiency can be determined.

**Pounds of**

**feed dry matter x % Ca = lbs. Ca**

$$\text{Fescue } 6.77 \quad \times .003 \quad = .020$$

$$\text{Shelled Corn } 5.78 \quad \times .0002 \quad = .001$$

$$\text{Soybean meal } .55 \quad \times .0033 \quad = \underline{.0018}$$

$$\text{Total} \quad .0228$$

**Pounds of**

**feed dry matter x % P = lbs. P**

$$\text{Fescue } 6.77 \quad \times .0026 \quad = .017$$

$$\text{Shelled Corn } 5.78 \quad \times .0035 \quad = .020$$

$$\text{Soybean Meal } .55 \quad \times .0071 \quad = \underline{.0039}$$

$$\text{Total} \quad .040$$

**Calcium need - intake = excess or deficiency**

$$.061 \quad - .0228 \quad = .0382 \text{ deficiency}$$

**Phosphorus need - intake = excess or deficiency**

$$.031 \quad - .040 \quad = .009 \text{ excess}$$

Phosphorus level of the ration is adequate, but a deficiency of calcium exists. Minerals are generally supplied by free-choice supplementation with commercial mineral supplements or home mixtures.

A second method of ration balancing may simply be termed trial-and-error formulation. In this method, a ration is estimated, and the nutrient content calculated. These results are then compared to the nutrient needs of the animal for which the ration is being balanced. Deficiencies are corrected by changing proportions of feeds in the rations or by substituting or adding ingredients.

The following example will help in understanding. The same systematic approach is necessary. Knowledge of animal nutrient requirements, feeds available and their nutrient composition are still necessary. For this example, a 1000-pound cow in the last one-third of gestation will be used. Her nutrient requirements are shown in Table 3. The same feeds as in the previous example will be used. Their nutrient composition is shown in Table 2.

**TABLE 3. -- Nutrient Requirements (lbs.) for a 1000-lb. Mature Cow, Final Trimester Of Gestation<sup>1</sup>**

Dry Matter		Protein		TDN		Calcium		Phosphorus	
lbs.		lbs.	%	lbs.	%	lbs.	%	lbs.	%
19.6		1.6	8.2	10.5	53.6	.050	.26	.039	.20

<sup>1</sup>1984 Nutrient Requirements of Beef Cattle

As hay is the primary source of nutrients for most cows, this example will begin by assuming that all of the dry matter being consumed is coming from fescue hay. This means the cow is eating 21 pounds of actual fescue hay daily (lbs. of dry matter 19.6 divided by the percentage of dry matter .92 equals 21 pounds).

Next, calculate the nutrients supplied by fescue and compare them to the cow's need. The nutrients supplied are determined by multiplying the pounds of dry matter of the feed consumed by the feed's nutrient content on a dry matter basis. In this example, fescue supplies 9.4 pounds of TDN, 1.86 pounds of crude protein, .058 pounds of calcium and .05 pounds of phosphorus. A comparison with nutrient needs shown in Table 3 reveals an energy deficiency of 1.1 pounds of TDN.

An addition of corn grain is necessary for extra energy. We cannot simply add corn because the daily dry matter intake would be exceeded and cattle might not be able to consume this amount. Corn must be substituted for fescue. This means we will gain nutrients from corn, but we will also lose nutrients from the fescue. The net effect of substituting corn for fescue must be determined.

One pound of fescue dry matter contains .48 pounds of TDN while one pound of corn dry matter contains .90 pounds of TDN. The net effect of replacing one pound of fescue dry matter with one pound of corn dry matter is a gain of .42 pounds of TDN (.90 - .48 = .42).

A deficiency of 1.1 pounds of TDN exists. Dividing the pounds of nutrient deficiency by the pounds of nutrient net gain will tell us the pounds of dry matter to substitute. For example:

1.1 pounds TDN needed

= 2.6 pounds of corn dry matter substituted for 2.6 pounds of fescue dry matter

.42 pounds TDN net gain

Now the ration is 17 pounds of fescue dry matter and 2.6 pounds of shelled corn dry matter.

Calculate the nutrients supplied by the substituted ration and compare to the cow's nutrient need. The comparison is shown in Table 4. As can be seen, all nutrient needs are met or exceeded. The ration is balanced for the nutrients desired.

Now, convert pounds of dry matter to pounds as fed as done for the previous ration. Divide pounds of dry matter by percent dry matter. Thus the daily ration actually fed becomes 18.5 (17 ÷ .92) pounds of fescue and 2.95 (2.6 ÷ .88) pounds of shelled corn.

Animals will gain more efficiently and economically with a balanced ration. By using these guidelines, you should be able to balance rations that will meet the needs of most farm animals.

**TABLE 4. -- Nutrient Content of the Substituted Ration and Comparison with Requirements**

Feed	Dry Matter lbs.	TDN lbs.	Crude Protein lbs.	Calcium lbs.	Phosphorus lbs.
Fescue	17.0	8.16	1.61	.051	.044
Shelled corn	2.6	2.34	.26	--	.009
Totals	19.6	10.50	1.87	.051	.053
Animal Requirements	19.6	10.50	1.60	.050	.039

**TABLE 5. -- Nutrient Requirements of Selected Groups of Beef Cattle<sup>a,b</sup>**

Body wt., lb	Gain, lb	Dry Daily Intake, lb	Crude Protein Matter lb/day	TDN				
				D.M.	% of lb/day	D.M.	% of Ca, %	P, %
Heifer calves								
400	1.5	10.2	1.17	11.4	7.0	68.5	.45	.24
500	1.5	12.1	1.25	10.3	8.3	68.5	.38	.22
600	1.5	13.8	1.32	9.5	9.4	68.5	.32	.21
Pregnant yearling heifers - last third of pregnancy								
750	1.4	16.6	1.5	8.9	10.0	59.9	.32	.21
850	0.9	17.6	1.4	8.2	9.6	54.5	.26	.20
950	0.9	19.0	1.5	8.0	10.3	54.1	.27	.20
Dry pregnant mature cows - middle third of pregnancy								
1000	---	18.1	1.3	7.0	8.8	48.8	.18	.18
1100	---	19.5	1.4	7.0	9.5	48.8	.19	.19
1200	---	20.8	1.4	6.9	10.1	48.8	.19	.19
.Dry pregnant mature cows - last third of pregnancy								
1000	0.9	19.6	1.6	8.2	10.5	53.6	.26	.21
1100	0.9	21.0	1.6	7.8	11.2	53.2	.26	.21
1200	0.9	22.3	1.7	7.8	11.8	52.9	.26	.21
Two-year-old heifers nursing calves-first 3-4 months postpartum-10 lb milk/day								
800	0.5	17.6	1.9	10.8	11.2	63.8	.34	.24
900	0.5	19.2	2.0	10.4	12.0	62.7	.32	.23
1000	0.5	20.8	2.1	10.0	12.9	61.9	.31	.23
Cows nursing calves - first 3-4 months postpartum-average milking (10 lb/day)								
1000	---	20.2	2.0	9.6	11.5	56.6	.28	.22
1100	---	21.6	2.0	9.4	12.1	56.0	.27	.22
1200	---	23.0	2.1	9.3	12.8	55.5	.27	.22
Cows nursing calves - first 3-4 months postpartum-superior milking (20 lb/day)								
1000	---	20.6	2.5	12.3	13.8	67.0	.39	.27
1100	---	22.3	2.6	11.9	14.5	65.2	.38	.27

1200	---	23.8	2.7	11.5	15.2	63.7	.36	.26
Bulls, maintenance and slow rate of growth (regain condition)								
1400	2.0	27.7	2.2	8.0	17.8	64.0	.25	.20
1600	1.0	29.7	2.2	7.3	16.6	55.8	.22	.19
1800	0.5	30.9	2.2	7.0	16.1	52.0	.20	.20

<sup>a</sup>Vitamin A for

(1) pregnant heifers and cows-1270 IU per lb dry feed

(2) lactating cows and breeding bulls-1770 IU per lb dry feed

<sup>b</sup> Nutrient Requirements of Beef Cattle, National Research Council, 1984.

**TABLE 6. -- Composition of Commonly Used Feeds (dry matter basis) NRC 1984.**

Feedstuff	Dry Matter, %	TDN, %	CP, %	Ca, %	P, %
Alfalfa hay, midbloom	90	58	17.0	1.41	.24
Alfalfa hay, late bloom	90	52	14.0	1.43	.25
Barley grain	88	84	13.5	.05	.38
Bluegrass hay	89	56	13.0	.33	.16
Crimson clover hay	87	57	18.4	1.40	.22
Ladino clover hay	90	60	22.0	1.35	.31
Red clover hay	89	55	16.0	1.53	.25
Corn, yellow	88	90	10.1	.02	.35
Corn, yellow, high-moisture	72	93	10.7	.02	.32
Corn stover	85	50	6.6	.57	.10
Ground ear corn	87	83	9.0	.07	.27
Corn silage (few ears)	29	62	8.4	.34	.19
Corn silage (well-earred)	33	70	8.1	.23	.22
Corn, distillers grain (dehydrated)	94	86	23.0	.11	.43
Fescue hay, early veg.	91	61	12.4	.51	.36
Fescue hay, early bloom	92	48	9.5	.30	.26
Lespedeza hay, midbloom	93	50	14.5	1.20	.25
Molasses (syrup)	78	79	8.5	.17	.03
Oats	89	77	13.3	.07	.38
Orchardgrass hay, early bloom	89	65	15.0	.27	.34
Orchardgrass hay, late bloom	91	54	8.4	.26	.30
Sorghum stover	88	54	5.2	.52	.13
Sorghum grain (milo), 8-10 CP	87	84	10.1	.04	.34
Sorghum silage	30	60	7.5	.35	.21
Sorghum sudangrass hay	91	56	8.0	.55	.30
Sorghum johnsongrass hay	89	53	9.5	.84	.28

Soybean meal (44%)	89	84	49.9	.33	.71
Timothy hay, midbloom	89	57	9.1	.48	.22
Urea (45% nitrogen)	99	0	281.0	0	0
Wheat	89	88	16.0	.04	.42
Wheat hay	88	58	8.5	.15	.20
Wheat silage, full bloom	25	59	8.1	.15	.20
Wheat straw	89	41	3.6	.18	.05
<b>Mineral Sources</b>					
Dicalcium phosphate	97	---	---	22.0	19.3
Ground limestone	100	---	---	39.4	---
Magnesium Oxide (56% Mg)	98	---	---	3.1	---
Steamed bone meal	97	8.4	15	31.5	14.2
Sodium tripolyphosphate	96	---	---	---	25.0