Simple Ration Formulation: Pearson's Square

Pearson's Square is a simple, quick way to calculate the amounts of feed necessary to meet a nutrient requirement of livestock and other animals. This method is most effective when only two feeds are being used. For example, when two grains are mixed for part of a total mixed ration (TMR) or as a supplement to pasture feeding, Pearson's Square can be used to determine what quantity of each grain would be needed to achieve a specific nutrient level in the mixture.

The basic structure of a Pearson's Square can be seen in **Figure 1**. In this example, soybean meal and corn are being used to meet the crude protein (CP) requirement of a lactating dairy cow. The nutrient requirement, in this case CP, could also be energy, total digestible nutrients (TDN), fat, and so on, depending on the information needed by the user.

The number in the center of the square or box is the animal's nutrient requirement. This number is usually determined from the National Research Council publication for a specific livestock species or from producer experience. It is based on animal class and production stage and level. The two feeds being considered are listed at the top and bottom left-hand corners of the square. The nutrient concentration of each feed is listed as well.

To use Pearson's Square:

1. Subtract the nutrient requirement (middle of square) from the nutrient concentration (on left of square) in the feed across the diagonal (top left – middle = bottom right; bottom left – middle = top right). Repeat this for both feeds. Make any negative numbers on the right side of the square positive. The answers on the right side of the square are the parts of each feed to include in the ration.
2. After subtracting across the diagonal, sum the parts of the two feeds to get the total.
3. Then, divide each part by the sum of the parts to calculate the percent of each feed in the ration.

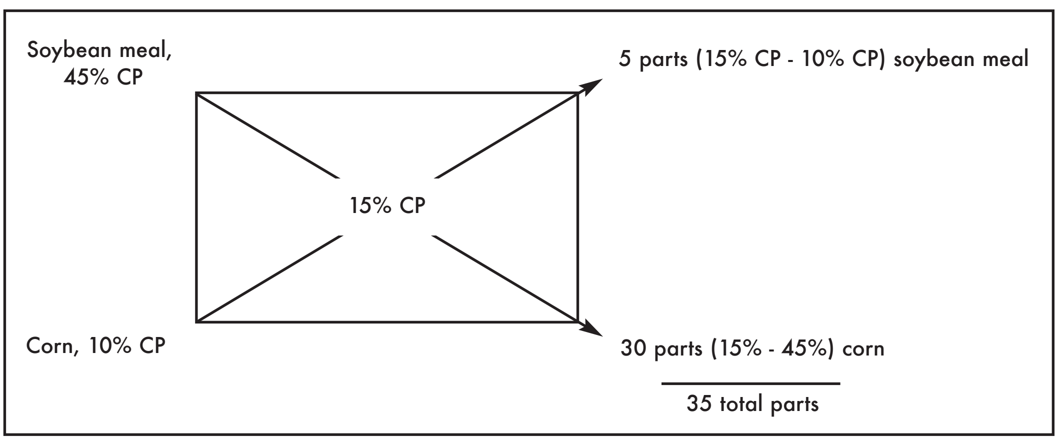

Figure 1. Using Pearson's Square to calculate amounts of corn and soybean meal needed to meet crude protein (CP) requirement.

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Pearson's Square calculations:

1. Subtract across the diagonal:
    a. 15% - 10% = 5 parts soybean meal
    b. 15% - 45% = 30 parts corn
2. Sum the parts:
    a. 5 parts soybean meal + 30 parts corn = 35 total parts
3. Divide each part by the total to calculate the percent of each feed to include:
    a. 5 parts soybean meal ÷ 35 total parts = 0.143 * 100 = 14.3% soybean meal
    b. 30 parts corn ÷ 35 total parts = 0.857 * 100 = 85.7% corn

So, in a half-ton (1,000-pound) batch of this corn and soybean meal mix, 143 pounds of soybean meal and 857 pounds of corn are needed to achieve 15% CP in the mix (calculations shown below).

Soybean meal: 1,000 lb * (14.3 ÷ 100) = 143 lb SBM
Corn: 1,000 lb * (85.7 ÷ 100) = 857 lb corn

There are a few important things to remember about using Pearson's Square for formulations:

1. This method is only efficient when no more than two ingredients are being used.
2. The animal requirement (number in center of the square) must fall between the nutrient concentrations in both feeds. For example, if the requirement is 60% TDN, then one feed must be greater than 60% TDN and one must be less than 60% TDN.
3. Disregard any negative numbers calculated on the right side of the square. Treat them as positive numbers.
4. Nutrient concentrations of the feeds and the requirement must be expressed on the same basis (for example, dry matter or "as-fed").
5. Always CHECK THE MATH for accuracy.

Math check for the example above:
143 lb soybean meal * 45% CP = 64.3 lb CP
857 lb corn * 10% CP = 85.7 lb CP
Cow's requirement = 1,000 lb * 15% CP = 150 lb CP
Check: 64.3 lb CP + 85.7 lb CP = 150 lb CP

Using Pearson's Square with Supplement Mixes

Though not always recommended, it is possible to use Pearson's Square to balance more than two ingredients. For example, with two separate grain mixes (A and B), each made up of two ingredients, for a total of four feedstuffs, Pearson's Square method can be used to calculate the amount of grain mixes A and B needed to meet the requirements. Energy (Mcal/d) is the required nutrient in the following example.

Grain mix A is 40% corn and 60% soybean hulls (SBH), whereas grain mix B is 50% dried distillers grains (DDG) and 50% cottonseed hulls (CSH). The energy requirement being balanced for is 1.44 Mcal/d. The energy contents of the feeds are listed in **Table 1**.

Table 1. Energy concentrations (mcal/kg) of various feedstuffs (NRC, 2001).

Feed	Energy (Mcal/kg)
Corn	2.01
Soybean hulls	1.37
Dried distillers grains	1.97
Cottonseed hulls	0.48

First, treat grain mixes A and B as the two feeds to use in the Pearson's Square. This means you must calculate the amount of energy (Mcal/kg) available in each mix. These are the steps:

1. Grain mix A
    a. 40% corn at 2.01 Mcal/kg, so 2.01 * (40 ÷ 100) = 0.80 Mcal/kg
    b. 60% SBH at 1.37 Mcal/kg, so 1.37 * (60 ÷ 100) = 0.82 Mcal/kg
    c. 0.80 + 0.82 = 1.62 Mcal/kg

2. Grain mix B
    a. 50% DDG at 1.97 Mcal/kg, so 1.97 * (50 ÷ 100) = 0.98
    b. 50% CSH at 0.48 Mcal/kg, so 0.48 * (50 ÷ 100) = 0.24
    c. 0.98 + 0.24 = 1.22 Mcal/kg

Second, make sure the energy requirement (1.44 Mcal/d) falls within the range of the energy content of each grain mix (1.22 to 1.62 Mcal/kg); otherwise, the Pearson's Square method will not work.

Third, set up the Pearson's Square as in **Figure 2**.

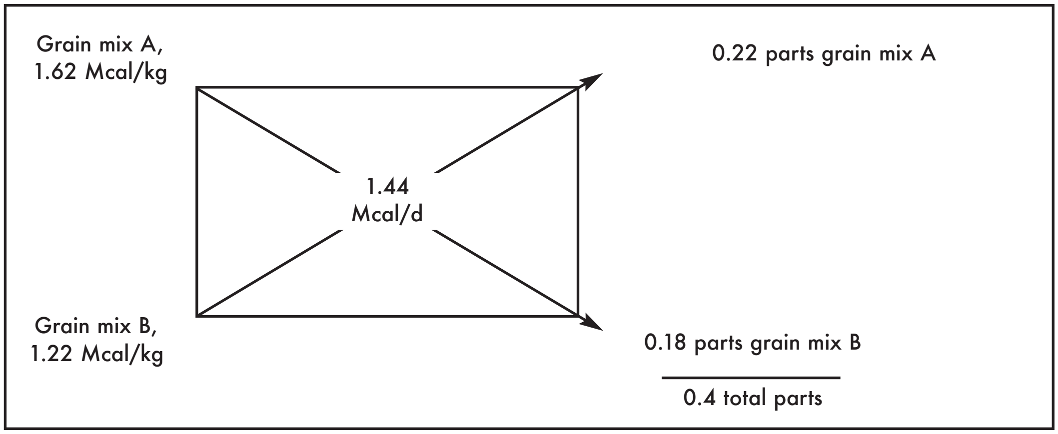

Figure 2. Using Pearson's Square to formulate rations with more than two ingredients.

Pearson's Square calculations:

1. Subtract across the diagonal:
   a. 1.44 – 1.22 = 0.22 parts grain mix A
   b. 1.44 - 1.62 = 0.18 parts grain mix B
2. Sum the parts:
   a. 0.22 parts grain mix A + 0.18 parts grain mix B = 0.40 total parts
3. Divide each part by the total to calculate the percent of each feed to include. This step varies from the first example, because more than two ingredients are being used. Before dividing, multiply the parts of each grain mix by the proportions of each ingredient in the mix (this should sum to the total parts). The total ration will be 55% grain mix A (40% corn and 60% SBH) and 45% grain mix B (50% DDG and 50% CSH).:
   a. 0.22 * (40 ÷ 100) = 0.09 parts corn
   b. 0.22 * (60 ÷ 100) = 0.13 parts SBH
   c. 0.18 * (50 ÷ 100) = 0.09 parts DDG
   d. 0.18 * (50 ÷ 100) = 0.09 parts CSH

For grain mix A:
0.09 parts corn ÷ 0.4 total parts = 0.225
0.13 parts SBH ÷ 0.4 total parts = 0.325

For grain mix B:
0.09 parts DDG ÷ 0.4 total parts = 0.225
0.09 parts CSH ÷ 0.4 total parts = 0.225

Finally, go back and check the math as follows:
0.225% corn * 2.01 Mcal/kg = 0.45 Mcal/d
0.325% SBH * 1.37 Mcal/kg = 0.44 Mcal/d
0.225% DDG * 1.97 Mcal/kg = 0.44 Mcal/d
0.225% CSH * 0.48 Mcal/kg = 0.11 Mcal/d
0.45 + 0.44 + 0.44 + 0.11 = 1.44 Mcal/d = Orig. req.

Now, calculate how much of each feed ingredient to use in a 1,000-pound batch. Because the energy concentration is in Mcal/kg, first convert 1,000 pounds to kilograms (see conversion section below for directions).

So, 1,000 lb = 454 kg
454 kg * 0.225% corn = 102.2 kg corn
454 kg * 0.325% SBH = 147.6 kg SBH
454 kg * 0.225% DDG = 102.2 kg DDG
454kg * 0.225% CSH = 102.2 kg CSH
102.2 + 147.6 + 102.2 + 102.2 = 454.2 kg (1,000 lb of mix)

Converting Units for Ration Balancing

When balancing rations, the most important thing to remember is ALWAYS to make sure the units match. Feed amounts can be reported in either kilograms or pounds. The conversion factors for pounds and kilograms are below:

1. To convert lb to kg:
   a. 1 lb = 0.454 kg
   b. 10 lb * 0.454 = 4.54 kg
2. To convert kg to lb:
   a. 1 kg = 2.2 lbs
   b. 10 kg * 2.2 = 22 lbs

Converting As-Fed to Dry Matter

Feeds can be reported on a dry matter (DM) or wet/as-fed basis. Almost always, nutrient concentrations will be reported as a percent of dry matter. However, be sure to check this.

If the nutrient concentrations are reported as percent of dry matter and feed ingredient amounts are as-fed, the math will not add up and nutrient content will be overestimated.

Example:

Corn at 85% dry matter and 8% CP (DM basis)
10 lb of as-fed corn * (8 ÷ 100) = 0.8 lb of CP

This is not correct, because 10 pounds of as-fed corn at 85% dry matter will yield 8.5 pounds of corn and 1.5 pounds of water, and that water does not have any protein. So, to find out how much CP is in 10 pounds of as-fed corn, first calculate the pounds of dry matter corn. Then multiply the result by the %CP (shown below):

1. Convert as-fed to dry (to match nutrient units):
   a. 10 lb corn * (85 ÷ 100) = 8.5 lb DM corn
2. Multiply lbs DM corn by the CP concentration:
   a. 8.5 lb DM * (8 ÷ 100) = 0.68 lb CP (DM basis)

References

National Research Council. 2001. Nutrient Requirements for Dairy Cattle. 7th rev edition. National Academy Press, Washington, DC.

Parts of this publication were adapted from:

Wagner, J. and T. L. Stanton. 2006. Formulating Rations with the Pearson Square. No. -1.618. Colorado State University Extension. www.ext.colostate.edu.

The information in this publication is intended to aid producers in simple ration balancing problems or formulation of simple grain mixes. For information about more intensive ration balancing, contact your county Extension office, a feed supplier, or a consulting nutritionist.

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