



# Using By-Product Feeds

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## Introduction

Feeding by-product feeds to cattle is not a new concept. Feed companies have used by-product feeds in commercial concentrates as a source of nutrients for years. However, the use of by-product feeds in rations mixed on-farm may be new to many producers. By-product feeds come from a variety of sources including grain processing, production of human foods and beverages, and manufacturing of fiber products. Although many of these feeds have been used for years, others are relatively new. Research has been conducted on most by-product feeds and the guidelines for their use are well documented; however, limited information is available on the feeding value or guidelines for using some by-product feeds. This publication will discuss factors that should be considered when feeding by-product feeds.

The primary reason producers should consider by-product feeds is to reduce feed cost. Feed is the primary cost associated with growing replacement heifers and producing milk, so cheaper feeds that offer the potential to lower feed cost and improve the bottom line are worth considering. Some by-product feeds provide nutrients in a specific form, such as rumen undegradable protein (RUP) or highly digestible fiber, that are desirable for improving ruminal fermentation and animal health. When forage supplies are limited during a drought or when animal numbers are increased without increased forage production, other high-fiber by-product feeds may be used to extend forage supplies.

Producers should consider disadvantages of by-product feeds as well. Additional time for purchasing and arranging delivery, and for formulating and mixing rations will be required. Specialized storage and feeding facilities needed for certain by-product feeds may require construction of additional buildings or equipment purchases, both of which will require additional investments. If a by-product feed is only available seasonally or in insufficient amounts, it is questionable whether changing the current feeding program would be justifiable. These factors must be taken into consideration before using by-product feeds.

## Economics

The main factor producers should consider when using by-product feeds is economics. Producers should check with several brokers to determine the market price and nutrient profile of each by-product feed considered. Prices vary throughout the year, so a few phone calls can save several hundred dollars over the course of the year. Once a delivery price has been established, the next step is to calculate the true cost for using the by-product feed. A sample worksheet for computing the total cost of a by-product feed is presented in Table 1 (p.2). For example, a producer is considering a by-product feed that can be purchased for \$125 per ton delivered to the farm. If 23 tons are delivered, then the initial cost is \$2,875. Interest costs equal \$71.88 assuming an interest rate of 10 percent and that the

Table 1. Calculating the true cost of a by-product feed.

|                              |                           |         |
|------------------------------|---------------------------|---------|
| Price delivered to the farm  | _____ tons @ \$_____ /ton | \$_____ |
| Interest                     | _____ % for _____ months  | _____   |
| Shrinkage and storage losses | _____ %                   | _____   |
| Extra handling cost          | _____ Hr @ \$_____ /Hr    | _____   |
| Total cost                   |                           | _____   |
| Divide total cost by         | tons                      |         |
| Total cost per ton           |                           | \$_____ |

load will be fed in three months. Shrinkage losses vary, but range from 15 to 30 percent for wet by-product feeds, 4 to 10 percent for dry feeds stored in a commodity shed, and 2 to 6 percent for the dry feeds stored in bins. If shrinkage and storage losses are maintained at 7 percent, an additional \$201.25 is added to the cost. Extra time for handling the by-product feed can easily add another \$50 or more to the cost. The total cost of the by-product feed is actually \$139.05 per ton. Failure to include these costs does not provide the producer a true evaluation of the by-product feed's potential for reducing feed cost.

Once the true cost of the by-product feed has been established, the impact of using this feed on feed cost should be calculated. One of the simplest approaches is to calculate the value of the by-product feed based on the energy and protein content of the feed compared with corn and soybean meal. However, this method does not account for other nutrients provided or differences in the nutrient form (i.e., degradable versus undegradable protein). There are computer programs, such as FEEDVAL (University of Wisconsin), that will calculate the cost of the by-product compared with other feeds using more nutrient information. Another way of evaluating by-product feeds is to use a least cost ration formulation program to compare its value against feeds currently being fed. This approach provides an analysis of this particular by-product feed at the current price, but it doesn't provide any information on usage if the price of the by-product feed changes. To determine the price range that the by-product feed will be economical, additional rations must be formulated using a least cost ration formulation program. The cost of the by-

product feed in the first formulation is set at \$0/ton to determine the upper cost at which usage will be reduced. In the second formulation, the price of the by-product feed should be increased to the upper cost calculated in the first ration plus \$0.01/ton; then reformulate the ration. This process is continued until the by-product feed is no longer used in the ration. The information from these simulations will determine the price range that the by-product feed will be economical to use as well as the impact on the usage of the by-product feed and other ingredients. In some situations the by-product feed may be economical to include in the rations, but the amount used is reduced so it is not practical to feed.

## Storage and Handling

Storage facilities must not be overlooked. Certain by-product feeds such as dried distillers grains can be stored in grain bins; however, other by-product feeds require specialized storage facilities such as a commodity shed or a pit (for wet feeds). Some producers have modified existing facilities without problems, but an engineer should be consulted to avoid problems that can occur because of the density of the feeds placed into these structures. Without proper storage facilities, spoilage and shrinkage losses will be higher.

Equipment for handling by-product feeds must be considered. The size of equipment needed for unloading, reloading, mixing, and delivering the feed to the animals will vary depending on the number of animals fed and amount of feed mixed. Equipment used for handling by-product feeds

should be in good repair and kept clean. Clean equipment that has been in mud or manure before use to avoid spreading any pathogenic bacteria from sick animals to healthy animals. Since many by-product feeds are stored in a commodity shed or pit, the equipment will come in contact with the by-product feed. Hydraulic fluid, motor oil, or engine coolants are potentially toxic to animals and must be avoided.

Another factor to consider is the type of feeding system present on the farm. Many commodities are not suitable for use in feeding systems that include small augers. For example, wet feeds such as corn gluten feed or brewers grain, or bulky feeds such as cottonseed or cottonseed hulls, are not feasible in these systems. Ideally, a mixer with scales is available for weighing each feed used in the ration. Scales allow producers to mix rations containing the desired nutrient concentrations. Guessing the amount of a particular ingredient that is mixed into the ration results in rations that have nutrient imbalances and do not support the desired level of animal performance.

In most situations, producers must take a tractor trailer load of a by-product feed to realize the full economic savings. If the by-product feed is not used in a reasonable period of time, interest cost will be higher. Longer storage times can increase spoilage and shrinkage losses, which reduce savings in feed cost.

## **Nutrient Analysis and Variation**

The typical nutrient content of many by-product feeds is outlined in Table 2 (p. 4). Because of differences in raw materials and processing methods, the nutrient content can vary significantly from the values provided in Table 2. An example of the variation measured in four by-product feeds commonly used is presented in Table 3 (p.5). As an example, the average crude protein (CP) content of corn gluten feed in this study was 22.9 percent (DM basis) with a minimum of 19.4 percent and a maximum of 33.4 percent. Based on this data set, the CP content could vary 18.7 percent from one load to the next. Since brokers do not always ship by-product feeds from the same source each time, producers need to ask their broker for information about the

typical nutrient analysis and variation they should expect.

The variation associated with each nutrient differs among by-product feeds. In general, there is greater variation, as measured by the coefficient of variation (CV), in mineral concentrations because of the low concentration in each feed, but that is not always the case. For example, there is greater variation in the amount of unavailable CP in corn gluten feed and distillers dried grains than in any other nutrient. For these by-product feeds, this variation is related to differences in drying and reflects the amount of potentially heat damaged protein, which is an important consideration. Although the coefficient of variation for calcium in hominy feed is very high, the calcium concentration in hominy feed is very low, so this is not as much of a concern.

Each load of a by-product feed should be sampled for nutrient analyses. Submit samples to a certified laboratory for analysis using wet chemistry. The actual nutrient concentration should always be used to formulate rations rather than average book values because of the variation that naturally exist. Book values do not always reflect the actual nutrient content and may cause an excess or deficiency of a nutrient needed for supporting growth or milk yield. Maintain a record of the nutrient analysis to monitor the variation associated with each by-product feed. It is recommended that producers develop a set of nutrient specifications for purchasing each by-product feed that includes minimum or maximum concentrations of select nutrients to reduce the variation.

## **Environmental Considerations**

Some by-product feeds have higher phosphorus concentrations than traditional feeds. Feeding large quantities of these feeds increases the amount of phosphorus excreted by the animal. The results of feeding excess phosphorus means increased acreage needed for spreading waste to comply with nutrient management plans, potentially limit future expansion plans, or both. To minimize these potential problems, do not include supplemental phosphorus in the diet when by-product feeds provide adequate amounts to meet the National Research Council

Table 2. Average nutrient concentrations of by-product feeds.

|                                   | DM       | CP   | RUP <sup>1</sup> | EE   | NDF  | ADF  | NE <sub>1</sub> | Ash  | NFC  |
|-----------------------------------|----------|------|------------------|------|------|------|-----------------|------|------|
|                                   | %        | %    | %CP              | %    | %    | %    | Mcal/lb         | %    | %    |
|                                   | DM Basis |      |                  |      |      |      |                 |      |      |
| <b>Oilseed</b>                    |          |      |                  |      |      |      |                 |      |      |
| Cottonseed, fuzzy                 | 90.1     | 23.5 | 22.9             | 19.3 | 50.4 | 40.1 | 0.88            | 4.2  | 2.7  |
| Soybeans, raw                     | 90.0     | 39.2 | 30.4             | 19.2 | 19.5 | 13.1 | 1.25            | 5.9  | 16.2 |
| Soybeans, roasted                 | 91.0     | 43.0 | 39.4             | 19.0 | 22.1 | 14.7 | 1.23            | 5.0  | 10.9 |
| <b>Energy Supplements</b>         |          |      |                  |      |      |      |                 |      |      |
| Bakery waste                      | 84.7     | 12.5 | 23.7             | 9.5  | 13.9 | 6.5  | 1.53            | 3.8  | 60.3 |
| Beet pulp                         | 88.3     | 10.0 | 76.3             | 1.1  | 45.8 | 23.1 | 1.07            | 7.3  | 35.8 |
| Citrus pulp                       | 85.8     | 6.9  | 31.7             | 4.9  | 24.2 | 22.2 | 0.80            | 7.2  | 56.8 |
| Hominy feed                       | 88.5     | 11.9 | 31.2             | 4.2  | 21.1 | 6.2  | 0.85            | 2.7  | 60.1 |
| Molasses, sugar cane              | 74.3     | 5.8  | 18.1             | 0.2  | 0.4  | 0.2  | 0.80            | 13.3 | 80.3 |
| Rice bran                         | 90.6     | 15.5 | 47.7             | 15.2 | 26.1 | 13.1 | 0.93            | 10.4 | 32.8 |
| Soybean hulls                     | 90.0     | 13.9 | 44.6             | 2.7  | 60.3 | 44.6 | 0.66            | 4.8  | 18.3 |
| Tallow                            | 99.8     | 0.0  | —                | 99.8 | —    | —    | 2.06            | 0.0  | —    |
| Wheat bran                        | 89.1     | 17.3 | 20.7             | 4.3  | 42.5 | 15.5 | 0.73            | 6.3  | 29.6 |
| Wheat middlings                   | 89.5     | 18.5 | 23.7             | 4.5  | 36.7 | 12.1 | 0.76            | 5.0  | 35.3 |
| <b>Medium Protein Supplements</b> |          |      |                  |      |      |      |                 |      |      |
| Brewers grains, wet               | 21.8     | 28.4 | 35.4             | 4.5  | 36.7 | 12.1 | 0.76            | 5.0  | 35.3 |
| Corn gluten feed                  | 89.4     | 23.8 | 30.0             | 3.5  | 35.5 | 12.1 | 0.79            | 6.8  | 30.4 |
| Distillers grains with solubles   | 90.2     | 29.7 | 50.8             | 10.0 | 38.8 | 19.7 | 0.89            | 5.2  | 16.3 |
| <b>High Protein Supplements</b>   |          |      |                  |      |      |      |                 |      |      |
| Blood meal                        | 90.2     | 95.5 | 77.5             | 1.2  | —    | —    | 1.06            | 2.5  | —    |
| Corn gluten meal                  | 86.4     | 65.0 | 74.6             | 2.5  | 11.1 | 8.2  | 1.08            | 3.3  | 18.1 |
| Cottonseed meal                   | 90.5     | 44.5 | 47.9             | 1.9  | 30.5 | 19.9 | 0.78            | 6.7  | 16.4 |
| Feather meal                      | 93.3     | 92.0 | 65.4             | 4.6  | —    | —    | 0.98            | 3.5  | —    |
| Fish meal, menhaden               | 91.2     | 68.5 | 65.8             | 10.4 | —    | —    | 1.06            | 19.7 | —    |
| Peanut meal                       | 92.3     | 51.8 | 13.2             | 1.4  | 21.4 | 13.5 | 0.91            | 5.8  | 19.6 |
| Soybean meal, 48%                 | 89.5     | 53.8 | 42.6             | 1.1  | 9.8  | 6.2  | 1.00            | 6.4  | 28.9 |
| <b>Forage Extenders</b>           |          |      |                  |      |      |      |                 |      |      |
| Cottonseed hulls                  | 89.0     | 6.2  | 55.7             | 2.5  | 85.0 | 64.9 | 0.48            | 2.8  | 3.5  |
| Peanut hulls                      | 91.0     | 7.8  | —                | 2.0  | 65.0 | 74.0 | 0.19            | 4.2  | 12.0 |
| Rice hulls                        | 92.0     | 3.3  | —                | 0.8  | 82.0 | 72.0 | 0.08            | 20.6 | 0.0  |

Source: National Research Council, 2001.

<sup>1</sup>Rumen undegradable protein with DMI of 4% of body weight.

Table 3. Variation in the nutrient content of select by-product feeds.

|                        |                  | CP <sup>1</sup> | UCP  | ADF  | NDF  | EE   | Ca    | P     | Mg    | K     |
|------------------------|------------------|-----------------|------|------|------|------|-------|-------|-------|-------|
| <b>WBG<sup>2</sup></b> | Avg <sup>3</sup> | 27.0            | 2.7  | 18.0 | 37.3 | 6.3  | 0.24  | 0.65  | 0.27  | 0.26  |
|                        | Min              | 24.2            | 1.6  | 15.8 | 33.0 | 5.7  | 0.19  | 0.59  | 0.25  | 0.19  |
|                        | Max              | 30.6            | 3.6  | 20.5 | 43.6 | 6.9  | 0.28  | 0.76  | 0.32  | 0.34  |
|                        | CV               | 8.3             | 24.4 | 10.6 | 9.2  | 6.5  | 11.03 | 8.69  | 8.11  | 20.02 |
| <b>CGF</b>             | Avg              | 22.9            | 0.8  | 12.5 | 38.8 | 3.4  | 0.03  | 0.84  | 0.36  | 1.24  |
|                        | Min              | 19.4            | 0.4  | 10.7 | 31.5 | 2.9  | 0.02  | 0.63  | 0.28  | 0.95  |
|                        | Max              | 33.4            | 1.9  | 13.9 | 44.4 | 4.4  | 0.03  | 1.04  | 0.46  | 1.66  |
|                        | CV               | 18.7            | 57.4 | 8.0  | 9.9  | 13.0 | 19.86 | 13.93 | 14.95 | 16.17 |
| <b>DDG</b>             | Avg              | 31.2            | 9.4  | 20.3 | 35.6 | 13.0 | 0.07  | 0.80  | 0.02  | 1.01  |
|                        | Min              | 30.4            | 5.7  | 11.3 | 26.5 | 11.7 | 0.06  | 0.77  | 0.33  | 0.93  |
|                        | Max              | 32.3            | 12.8 | 25.1 | 45.1 | 15.7 | 0.07  | 0.85  | 0.39  | 1.10  |
|                        | CV               | 2.0             | 32.4 | 29.1 | 23.0 | 10.2 | 7.21  | 3.57  | 5.36  | 5.31  |
| <b>H</b>               | Avg              | 11.0            | 0.9  | 6.9  | 19.8 | 6.5  | 0.02  | 0.61  | 0.24  | 0.72  |
|                        | Min              | 10.1            | 0.5  | 4.8  | 15.8 | 5.6  | 0.01  | 0.46  | 0.19  | 0.55  |
|                        | Max              | 11.7            | 1.3  | 9.9  | 24.8 | 8.1  | 0.06  | 0.71  | 0.27  | 0.84  |
|                        | CV               | 5.8             | 28.2 | 22.1 | 15.3 | 12.3 | 63.56 | 13.02 | 11.58 | 13.99 |
| <b>SH</b>              | Avg              | 11.8            | 1.3  | 46.6 | 64.4 | 2.5  | 0.60  | 0.13  | 0.25  | 1.32  |
|                        | Min              | 10.8            | 1.0  | 40.4 | 57.3 | 1.2  | 0.18  | 0.04  | 0.07  | 0.35  |
|                        | Max              | 14.2            | 1.6  | 49.9 | 71.6 | 3.7  | 0.73  | 0.19  | 0.29  | 1.60  |
|                        | CV               | 9.8             | 12.7 | 6.2  | 5.9  | 35.7 | 25.60 | 29.99 | 26.06 | 26.62 |

<sup>1</sup>CP = crude protein; UCP = unavailable crude protein; ADF = acid detergent fiber; NDF = neutral detergent fiber; EE = ether extract; Ca = calcium; P = phosphorus; Mg = magnesium; and K = potassium.

<sup>2</sup>WBG = wet brewers grain; CGF = corn gluten feed; DDG = distillers dried grains; H = hominy; and SH = soybean hulls.

<sup>3</sup>Avg = average; Min = minimum; Max = maximum; and CV = coefficient of variation.

Source: DePeters et al. 2000. *Prof. Anim Sci.* 16:69-99.

recommendations. Numerous research trials have demonstrated that feeding excess phosphorus does not improve reproduction efficiency or health of dairy cows. When phosphorus is fed in excess of NRC recommendations, additional calcium may be required to maintain normal calcium--phosphorus ratios in the diet. Producers and their nutritionists may need to consider limiting the amount of by-product feeds included in the diet to maintain phosphorus balance and comply with nutrient management plans. Researchers are working on

technology to reduce the amount of phosphorus in by-product feeds and lessen these concerns.

Wet by-product feeds, such as wet brewers grains, wet corn gluten feed, and vegetable byproducts, must be stored in structures that minimize the runoff of nutrients that leach out during storage. Nutrients in runoff can potentially have a negative impact on ground or surface water supplies if not contained. These wet by-product feeds should be stored in facilities that will contain the runoff, such as pits or plastic bags.

## Risk and Additional Responsibilities

Several risks and additional responsibilities are associated with using by-product feeds. As discussed previously, additional time is required for checking prices, managing inventories, and feeding (if the current feeding system is not set up for using by-product feeds). If a producer does not have sufficient time to devote to these tasks, then it may not be desirable to add by-product feeds into feeding programs. Large amounts of money can be invested in inventory that may reduce cash flow. The extent of investment depends on the number of by-product feeds, amounts fed, and the producer's current cash flow position.

The producer assumes complete responsibility for balancing rations to support desired growth or milk production levels and animal health with by-product feeds. Also, the producer assumes the responsibility for quality control including screening for any contaminants or poor quality feeds that feed companies normally provide. By-product feeds can be contaminated by a number of products, especially those that do not come from the food processing industry. For example, aflatoxin and other mycotoxins are potential risks in certain by-product feeds such as peanut meal, cottonseed, and grain screenings. Cotton products may contain gossypol that can be toxic when fed to certain monogastric or young ruminants or if too much is fed to mature ruminants. Residues from herbicides, pesticides, etc., must be avoided because of potential animal health problems and the risk of contaminating the resulting milk and meat. Most by-product feeds from the production of human foods have already been checked for these residues, but that may not be the case for by-product feeds from other sources.

## Limits on Amounts Fed

Producers frequently ask how much of a by-product feed can be included in a ration. Table 4 (p.7) outlines some suggested limits for common by-product feeds in dairy rations. There are several reasons for limiting the amount of a particular by-product feed in rations including cost, palatability, moisture content of the total diet, protein balance, carbohydrate balance, fiber levels, and fat concentrations.

By-product feeds such as cottonseed meal and corn gluten meal are normally included in amounts needed to meet the protein requirements. Feeding more only increases feed cost. Excessive amounts of degradable protein in rations may not maintain production levels in high producing cows during early lactation. By-product feeds such as blood meal, feather meal, and fish should be restricted due to poor palatability.

Similarly, the need for a balance of carbohydrates may limit the amount of high-fiber feeds such as corn gluten feed, soybean hulls, or wheat middlings. Fiber levels normally determine the upper limit of high fiber feeds such as cottonseed hulls, peanut hulls, or rice hulls. Rice hulls also have high concentrations of silica, which will damage the digestive tract of the cow and should be limited if fed. By-product feeds such as bakery waste, distillers grains, and hominy feed have high concentrations of fat, which could interfere with normal fiber digestion if excessive amounts are included in the diet, especially if oilseeds are fed as well.

Moisture levels in the total diet should not exceed 50 percent under normal circumstances, which may limit the amount of wet by-product feeds such as brewers grain, corn gluten feed, and distillers grain. This is especially true when large amounts of silage are fed. However, research data has indicated that diets containing large amounts of wet by-product feeds can be fed in certain situations even when the moisture level exceeds 50 percent.

## Whole Oilseeds

Whole oilseeds such as cottonseed and soybeans are good sources of energy, protein, and fiber. They are typically included in the ration to increase the energy density of the diet while maintaining acceptable fiber levels. These feeds contain approximately 20 percent ether extract (EE) or fat and should be limited based on the fat content of the ration. These feeds can be used to provide an additional 2 to 3 percent fat above that provided by the basal ingredients in the ration with no more than 5 to 6 percent total fat in the DM. Amounts greater than this may interfere with fiber digestion and normal rumen function. If additional fat is needed, it should be provided by a ruminally inert or protected fat source.

Table 4. Suggested limits for by-product feeds in rations.

|                                   | Maximum<br>% of DM | Maximum<br>lb DM per day <sup>1</sup> |
|-----------------------------------|--------------------|---------------------------------------|
| <b>Oilseed</b>                    |                    |                                       |
| Cottonseed, fuzzy                 | 10 - 15            | 4.5 - 6.7                             |
| Cottonseed, delinted              | 10 - 15            | 4.5 - 6.7                             |
| Soybeans, raw                     | 10                 | 4.5                                   |
| Soybeans, roasted                 | 10 - 15            | 4.5 - 6.7                             |
| <b>Energy Supplements</b>         |                    |                                       |
| Bakery waste                      | 8 - 10             | 3.6 - 4.5                             |
| Beet pulp                         | 20 - 30            | 9 - 13.5                              |
| Citrus pulp                       | 20 - 40            | 9 - 18                                |
| Hominy feed                       | 20 - 35            | 9 - 15.7                              |
| Molasses                          | 3 - 5              | 1.3 - 2.2                             |
| Rice bran                         | 10 - 15            | 4.5 - 6.7                             |
| Soybean hulls                     | 15 - 25            | 6.7 - 11.2                            |
| Tallow                            | 2 - 3              | .9 - 1.3                              |
| Wheat bran                        | 15 - 25            | 6.7 - 11.2                            |
| Wheat middlings                   | 15 - 25            | 6.7 - 11.2                            |
| <b>Medium Protein Supplements</b> |                    |                                       |
| Brewers Grains                    | 15 - 25            | 6.7 - 11.2                            |
| Corn gluten feed                  | 20 - 40            | 9 - 18                                |
| Distillers grains                 | 15 - 40            | 6.7 - 18                              |
| <b>Protein Supplements</b>        |                    |                                       |
| Blood meal                        | 3 - 4              | 1.3 - 1.8                             |
| Corn gluten meal                  | No Limit           | No Limit                              |
| Cottonseed meal                   | No Limit           | No Limit                              |
| Feather meal                      | 3 - 4              | 1.3 - 1.8                             |
| Fish meal                         | 3 - 4              | 1.3 - 1.8                             |
| Linseed meal                      | No Limit           | No Limit                              |
| Meat and bone meal                | 3 - 8              | 1.3 - 3.6                             |
| Peanut meal                       | No Limit           | No Limit                              |
| Soybean meal                      | No Limit           | No Limit                              |
| <b>Forage Extenders</b>           |                    |                                       |
| Cottonseed hulls                  | 30 - 35            | 13.5 - 15.7                           |
| Peanut hulls                      | 12 - 15            | 5.4 - 6.7                             |
| Rice hulls                        | 10 - 15            | 4.5 - 6.7                             |

<sup>1</sup>Amounts are based on an intake of 45 lb dry matter per day and should be adjusted for actual dry matter content.

Whole cottonseed contain gossypol, which is toxic to monogastric and young ruminants. Although mature dairy cattle can detoxify gossypol, no more than 10 pounds of cottonseed products (cottonseed meal plus whole cottonseed) should be included in rations to prevent toxicity. Soybeans may be fed raw or roasted and can be cracked. Do not include raw soybeans in rations containing urea as they contain an enzyme, urease, which breaks urea into ammonia that will decrease the palatability of the ration. Roasting increases the amount of protein escaping rumen degradation. Roasted soybeans are especially effective when rations based on haylage are fed to high producing cows during early lactation. Do not grind oilseed since this releases the oil directly into the rumen and may interfere with digestion. Extruded oilseed are very digestible, but limit the amount fed to reduce the negative effect the free oil will have on fiber digestibility.

## Energy Supplements

Several by-product feeds are good sources of energy. Some of these feeds have high concentrations of digestible fiber that the rumen microbes use for energy rather than starch. Other by-product feeds contain high concentrations of sugars, processed carbohydrates, or fats. The amount included in the ration should be based on the form of carbohydrate and fat concentration provided as well as total dietary concentrations. Saturated fats are more suitable for cattle than unsaturated fats as they are less likely to interfere with fiber digestion when fed at recommended amounts.

One measure many nutritionists use to describe the form of carbohydrate in a diet is non-fibrous carbohydrate (NFC). The NFC fraction represents the starch, sugar, and other soluble carbohydrates present in the feed. Corn contains approximately 75 percent NFC, which is primarily starch. Typically rations should be formulated to contain 32 to 40 percent NFC since higher levels of rapidly fermentable carbohydrate decrease ruminal pH, causing metabolic problems such as subclinical acidosis and laminitis as well as milk fat depression. High-fiber, by-product feeds are useful for balancing carbohydrate types to dilute NFC.

Soybean hulls are generally restricted to less than 25 percent of the ration DM due to their rapid passage rate through the small intestine. Beet pulp and citrus pulp are restricted more commonly due to total fiber levels and the need for minimal levels of NFC. Hominy feed also contains high concentrations of fat, which limits its use in diets. Rice bran, wheat bran, and wheat middlings are normally limited to less than 25 percent of the rations due to poor palatability. Peanut skins contain tannins that may decrease protein digestibility.

Bakery waste is normally limited to a maximum of 10 to 15 percent of the ration DM because of the high fat concentrations that could alter normal ruminal fermentation. The amount of fat from these sources reduces the amount of oilseed that may be included in the ration to keep fat concentrations from exceeding 5 to 6 percent of the total ration DM. Molasses is generally restricted to no more than 5 percent of the ration DM due to the possibility of digestive upsets that can occur with excessive amounts.

Tallow is considered to be more ruminally inert and may be used as a source of fat when the proper handling facilities are available. Limit blends of animal and vegetable fat to no more than 2 to 3 percent of the total ration DM. Vegetable oils contain high concentrations of unsaturated fatty acids that reduce fiber digestion in the rumen.

## Medium Protein Supplements

The medium protein supplements contain moderate concentrations of protein and energy and normally include brewers grain, corn gluten feed, and distillers grains. These feeds are commonly available in wet or dry form. In some cases, dry matter intake and milk yield decrease when the total moisture content of the ration exceeds 50 percent, especially when large amounts of fermented feeds are used. However, recent research suggests that greater amounts of wet feeds, such as brewers grains, can be fed during the summer even though the moisture level of the diet may exceed 50 percent. Wet by-product feeds including brewers grains, corn gluten feed, and distillers grains should be used quickly and stored in a manner that reduces

spoilage, especially during the summer. These feeds can also be used to extend or replace a portion of the forage as long as fiber concentrations are maintained and the amount of undegradable protein and NFC in the diet is balanced.

## High Protein Supplements

The high protein by-product feeds contain greater amounts of protein and lesser amounts of energy. These protein supplements have higher concentrations of undegradable protein, which makes them useful for growing calves and high producing dairy cows. Blood meal, feather meal, fish meal, and porcine or poultry meat meals are not very palatable and must be limited to avoid depressed intake. Current FDA regulations prohibit feeding ruminant derived meat meal or meat and bone meal to ruminants to prevent bovine spongiform encephalopathy (BSE).

Other protein supplements are not limited in the ration except for meeting the protein requirements since any excess increases ration cost. The amount of cottonseed meal may be restricted to a greater degree or not even used for very young ruminants if it contains gossypol due to the potential for toxicity. Peanut meal should be checked for aflatoxin as well due to the potential for toxicity.

## Forage Extenders

Several by-product feeds can be used to provide bulk in the ration when forage is limited. These by-product feeds provide very limited amounts of protein and energy. Cottonseed hulls have been used most commonly and have worked very well in built-in-roughage type rations. Peanut hulls should be checked for aflatoxin prior to using them in rations. The use of rice hulls should be limited because of high concentrations of silica that is abrasive to the intestinal tract of the animal if used in moderate quantities.

## Other By-product Feeds

Several other “unusual” by-product feeds are occasionally used by cattle producers. Some examples include candy, cocoa by-product, fruit pomace, fresh vegetables or fruits, and vegetable residues. Before using these feeds, the producer (or nutritionist) must know the nutrient composition of these products to determine what limitations should be imposed. For example, most candies are predominately sugar and should be treated like molasses. Producers should also determine if the by-product feed contains any compound, either naturally occurring or added during processing, which may be toxic to animals. For example, cocoa by-product contains theobromine, which can stimulate appetite when fed at 1 percent of the diet but is toxic when fed at 3 percent of the ration DM.

Handling is one of the biggest challenges for using many of these unusual by-product feeds. Many times these by-product feeds are still in individual wrappers (candy), packaged (donuts) or canned (milk) when received. The wrapping must be removed before the product can be fed. Although there are specialized machines that can remove the wrapping, the cost of this equipment is prohibitive given the volume of product available. Some individuals have devised means of getting the product separated from the wrapper without great expense.

Another challenge with some of these odd products is that the producer has to take all of the by-product feed produced and move it out of the plant as contracted. This requires some advanced planning since the plant may have a continuous production schedule that may require picking up a load at odd times.

Many of these unusual by-product feeds are wet, which presents a challenge in storing to prevent spoilage. Also, many of these by-product feeds may be available for short periods of time, such as cannery waste. Once the handling and storage issues have been addressed, the same guidelines for determining the nutrient content and the use apply. The nutrient composition of several unusual by-product feeds is presented in Table 5 (p. 10).

Table 5. Chemical analysis of unusual by-product feeds (DM basis).

| Item                   | DM (%) | TDN (%) | NE <sub>1</sub> (Mcal/lb) | NE <sub>m</sub> (Mcal/lb) | NE <sub>g</sub> (Mcal/lb) | CP (%) | EE (%) | ADF (%) | Ash (%) | Ca (%) | P (%) | K (%) | Mg (%) |
|------------------------|--------|---------|---------------------------|---------------------------|---------------------------|--------|--------|---------|---------|--------|-------|-------|--------|
| Apple pulp             | 21.4   | 74.0    | 0.77                      | 0.78                      | 0.47                      | 7.8    | 6.3    | 26      | 4.9     | 0.10   | 0.10  | —     | —      |
| Bakery waste           | 92.0   | 89.0    | 0.94                      | 1.00                      | 0.69                      | 10.7   | 12.7   | 13      | 4.4     | 0.14   | 0.26  | 0.53  | 0.26   |
| Beans, cannery residue | 9.4    | 72.5    | 0.75                      | 0.76                      | 0.45                      | 23.5   | 3.0    | 17      | —       | —      | —     | —     | —      |
| Beans, green           | 89.0   | 63.0    | 0.65                      | 0.63                      | 0.35                      | 16.9   | 3.8    | 32      | 9.0     | —      | —     | —     | —      |
| Bread, waste           | 68.3   | 89.3    | 0.95                      | 1.00                      | 0.69                      | 15.0   | 2.2    | 3       | 2.8     | 0.14   | 0.20  | 0.23  | 0.05   |
| Cabbage                | 9.5    | 85.3    | 0.89                      | 0.93                      | 0.63                      | 25.3   | 4.2    | 20      | 14.7    | 0.64   | 0.35  | 2.53  | 0.21   |
| Cantaloupe             | 10.0   | 66.0    | 0.68                      | 0.68                      | 0.37                      | 20.4   | 8.3    | 26      | —       | —      | —     | —     | —      |
| Carrots                | 12.0   | 84.0    | 0.88                      | 0.64                      | 0.64                      | 9.9    | 1.4    | 11      | 8.2     | 0.40   | 0.35  | 2.80  | 0.20   |
| Cereal byproduct       | 88.5   | 87.6    | 0.90                      | 0.96                      | 0.66                      | 9.1    | 3.5    | 4       | 3.2     | 0.17   | 0.29  | 0.33  | 0.10   |
| Chocolate byproduct    | 95.2   | 102.7   | 1.16                      | 1.16                      | 0.82                      | 11.9   | 20.5   | 16      | 2.1     | 0.22   | 0.30  | 1.18  | 0.22   |
| Cookie byproduct       | 90.1   | 95.0    | 1.02                      | 1.06                      | 0.74                      | 9.7    | 10.6   | 7       | 3.0     | 0.23   | 0.29  | 0.46  | 0.13   |
| Corn, cannery waste    | 23.0   | 70.0    | 0.72                      | 0.73                      | 0.42                      | 8.8    | 2.7    | 29      | 5.9     | 3.40   | 0.63  | —     | —      |
| Cotton gin trash       | 90.0   | 44.0    | 0.43                      | 0.39                      | 0.03                      | 7.4    | 1.7    | 46      | 5.9     | 0.65   | 0.12  | —     | —      |
| Lettuce                | 5.0    | 51.0    | 0.51                      | 0.47                      | 0.15                      | 22.0   | 4.1    | 14      | 15.9    | 0.86   | 0.46  | 4.52  | —      |
| Melons                 | 4.1    | 70.7    | 0.73                      | 0.74                      | 0.43                      | 11.5   | 3.3    | 29      | 6.6     | —      | —     | —     | —      |
| Onions, dried          | 91.4   | 57.6    | 0.59                      | 0.57                      | 0.25                      | 12.6   | 2.0    | 28      | 8.0     | 1.80   | 0.21  | 1.76  | 0.16   |
| Peaches                | 10.0   | 80.0    | 0.83                      | 0.86                      | 0.55                      | 8.9    | 3.7    | 13      | —       | —      | —     | —     | —      |
| Peanut skins           | 94.0   | 65.0    | 0.67                      | 0.65                      | 0.37                      | 17.4   | 25.5   | 16      | 3.0     | 0.19   | 0.20  | —     | —      |
| Potatoes, fresh        | 23.0   | 81.0    | 0.85                      | 0.90                      | 0.60                      | 9.5    | 0.4    | 3       | 4.8     | 0.04   | 0.24  | 2.17  | 0.14   |
| Tomatoes               | 6.0    | 69.0    | 0.71                      | 0.70                      | 0.43                      | 16.4   | 5.0    | 11      | —       | 0.16   | 0.49  | 4.21  | —      |
| Turnips, fresh         | 9.0    | 85.0    | 0.89                      | 0.95                      | 0.65                      | 11.8   | 1.9    | 34      | 8.9     | 0.59   | 0.26  | 2.99  | 0.22   |

Source: Waller. 2004.

## Summary

By-product feeds can be used to provide economical sources of nutrients for cattle. These feeds should be sampled and analyzed frequently to determine their nutrient content, and rations should be balanced using the actual nutrient concentrations rather than table values to assure that desired nutrient concentrations are provided. The amount of a by-product feed included in a ration should not exceed the recommended guidelines under most conditions. If the limits are exceeded, the producer must examine the nutrient profile of the ration carefully to insure that desired production levels can be achieved and animal health will be maintained. The moisture level of wet by-product feeds and the total ration should be monitored to insure that proper amounts of the by-product feed are added to the ration and that intake is maintained. Producers should store by-product feeds properly to reduce shrinkage and prevent molding and spoilage. Additional time and management are required if commodities are to be used; however, the benefits are generally considered worthwhile to most producers.

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**B1320**

**December 2006**

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Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, The University of Georgia College of Agricultural and Environmental Sciences and the U.S. Department of Agriculture cooperating.

J. Scott Angle, Dean and Director