CONSIDERATIONS FOR USING BY-PRODUCT FEEDSTUFFS IN THE SOUTHEAST

Joe W. West
University of Georgia
Coastal Plain Experiment Station
Tifton, GA

Introduction

The term by-product feeds is often used interchangeably with commodities and alternative feeds. These feeds are usually the result of the processing of a variety of crops and can be a valuable source of nutrients for cattle. Because many of these by-products are very fibrous, their main use is in cattle rations. The use of by-product feedstuffs for feeding dairy cattle has grown tremendously as more has been learned about the nutrient value of such feeds, as the recognition of the value of such feeds has grown, and as the size of dairy farms has increased, allowing for the efficient use of such products. With the use of by-product feeds come several advantages, including cost benefits, complimentary nutrient profiles to enhance ration formulation opportunities, and bulk handling for large operations. However, along with the many benefits come pitfalls, which, if not recognized, can lead to difficulties in managing a feeding program which relies heavily on by-products.

Use of by-product feeds shifts many of the services and risks from the traditional feed dealer to the dairy producer. As detailed by Coppock (1992), important functions of the feed dealer which may be assumed by the dairy producer include 1) purchasing agent, 2) quality control specialist, 3) facilities requirements, including storage and handling, 4) processing and distribution equipment, 5) formulation knowledge and experience, and 6) risk assumption associated with ingredient quality and composition of the final mix. Because of the intricacies involved in a successful by-product utilization program, Coppock (1992) advocated an "Integrated Nutritional Management Systems (INMS)" approach, patterned after the Integrated Pest Management Systems (IPMS) used successfully by entomologists, and Integrated Environmental Management Systems (IEMS), proposed by Dr. David Beede. Such approaches integrate many aspects of management into a systems approach so that the potential for success is improved. Much has been written on the topic of by-product feedstuffs. My objective in this paper is to discuss several aspects of by-products which must be considered for the successful management of a by-products program.

Categories of By-Products

By-product feeds fall into one of several nutrient categories. Within each category are feeds with different properties which must be considered before using the feed, even if economics appear favorable. For example, while the use of a high protein feed with good rumen bypass characteristics is desirable for high production, using high bypass protein supplements exclusively will result in a shortage of degradable intake protein in the rumen, starving rumen microbes for nitrogen and reducing the efficiency of rumen fermentation.

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An excess of rumen fermentable carbohydrate (CHO) results in acidosis and all the problems associated with this condition. Use of high fiber by-products reduces the dietary starch content while maintaining the energy level of the diet. However, an excess of high fiber ingredients may provide insufficient fermentable CHO for the rumen microbes, again reducing rumen efficiency. One major consideration in building a by-product feeding program is that the feedstuff must complement your ration program. There are many ways to categorize ingredients. Because of the nature of many by-products, they may fall into more than one category and provide dual benefits to the dairy ration.

High Protein Oilmeals

Commonly used oilmeal protein by-products in the southeast include soybean meal, cottonseed meal, and peanut meal, of which soybean meal (44 or 48% crude protein) is the standard (Table 1). Soybean meal may be replaced by cottonseed meal or peanut meal when cost is favorable. Other meals which are available include linseed meal, sunflower meal, and canola meal. The crude protein content of sunflower meal varies (from about 28 to 40%) and depends on the method of oil extraction. Canola meal is an acceptable protein source, has about 37% crude protein, and is lower in energy than soybean meal because of its higher fiber content. Canola meal, sunflower meal, and peanut meal protein are highly degradable in the rumen and may need to be fed in combination with a less degradable protein source. Whole seed canola can be fed, much like whole cottonseed, soybeans, and sunflower seed. Some processing is necessary so that the seed coat is broken, improving utilization. Knowledge of the unique characteristics of each feed ingredient will aid in the decision making process.

Undegraded Intake Protein (UIP) Sources

Many high protein by-products are available which supply UIP. At this conference last year, Clark (1993) indicated that microbial protein normally contributes the largest amount of crude protein that passes to the small intestine. The dietary amino acids that escape ruminal fermentation should complement those provided by microbial protein. Thus, by-products chosen for their UIP value should be chosen for quality of amino acids as well as high rumen escape values. A review of feedstuffs providing undegraded intake proteins was presented previously at this conference (Van Horn and Harris, 1993). Undegradability of some selected ingredients is presented in Table 2.

By-products of the alcohol industry (distillers dry grains and dry and wet brewers grains) are high in energy, low in starch, and have relatively high UIP values (Tables 1 and 2). By-products of the milling industries include corn gluten feed and corn gluten meal, of which corn gluten meal has the greater UIP value (Table 2). Meat meal, meat and bone meal, blood meal and fish meal are all high protein, high UIP feedstuffs, making them very desirable for rations for high producing dairy cows. The range of protein is wide in these ingredients (about 24% for corn gluten feed to greater than 80% for blood meal (Table 1), the UIP values vary by ingredient and processing method, and amino acid contents differ greatly.

Special considerations for this group of feedstuffs include availability of the protein (is there heat damage or is the protein availability poor?), does the amino acid profile complement your other ration ingredients, is the product stable over time, or should it be used rapidly to avoid spoilage or proliferation of potential disease causing organisms?

Medium Protein Feeds

Some of the feeds in this category tend to blur with the UIP category. Included are brewers grains (wet or dried), distillers grains, corn gluten feed, and wheat mids. These have moderate crude protein contents, some have good UIP levels, and have good energy levels with low starch contribution to the diet (Table 1).

Energy feeds and Milling By-Products

This category contains high energy feeds which have highly digestible fiber and contribute substantial energy to the diet. Included are hominy feed, soybean hulls, citrus pulp, beet pulp, and peanut skins, among others. These feeds are low in starch and have some fiber value, although caution should be used when formulating, because the fiber levels cannot be taken at face value. Even though they are low in starch content, many are high in nonstructural carbohydrate (NSC) content, meaning they are highly fermentable and can contribute to acidosis.

Fiber Suppliers

Fiber suppliers are by nature lower in energy content than other feedstuffs, but contribute significantly to the roughage content of the ration. These include cottonseed hulls, peanut hulls, rice hulls, sugarcane bagasse, soybean hulls, and citrus pulp also fall into this category, although the fiber digestibility of these ingredients is high and their roughage value is low. The digestibility and energy value of ingredients such as peanut hulls and rice hulls is extremely low (Table 1), and their place in rations for high producing dairy cows is questionable.

Multiple nutrient ingredients

This category includes those by-products which provide multiple nutrients. The prime example is whole cottonseed, which is an excellent source of protein, fiber, and fat for energy. Whole soybeans, though not a by-product, are similar. Peanut skins are high in fat, fiber, and protein, though they must be used in moderation for reasons to be discussed later. These ingredients often price into a ration at high values because of their multiple nutrient contribution.

Fats

This category includes tallows and greases, and also includes the oilseeds which have already been mentioned. These ingredients are very high in energy (from fat) and are critical for the feeding of high producing cows and for feeding during hot weather.

However, vegetable oils can be toxic to rumen microbes, and excessively high levels of fat can upset rumen digestion. Careful formulation to optimize energy use while avoiding negative ruminal effects is necessary.

Challenges When Using By-Products

Occasionally there are specific qualities or characteristics of by-products which affect their utilization. This includes potentially toxic components, antiquality factors, or simple nutrient variation. Knowledge of these factors may help the user avoid situations which impact the use of the product.

Nutritional Characteristics

A complete analysis of the by-product feed is an absolute necessity. For a commonly used feedstuff this allows accurate ration formulation and helps define the quality of the ingredient from that particular source. In some cases there may be compounds present in the feedstuff which place limitations on or prevent its use.

Gossypol in cottonseed products is an example of a potentially toxic agent. Although whole cottonseed are an excellent feedstuff for dairy cows, caution must be exercised when feeding large amounts of cottonseed products because of the presence of this polyphenolic pigment compound. Though normally detoxified in the rumen, excess gossypol in the diet can overload the capacity of the rumen for detoxification. High levels of cottonseed products depressed blood hemoglobin, caused erythrocyte fragility, and increased respiration rates during elevated ambient temperature (Lindsey et al., 1980). It is doubtful that within normal ranges of feeding (5 to 8 lbs. whole cottonseed) that gossypol toxicity will occur in a functional ruminant. However, feeding whole cottonseed in combination with cottonseed meal and (or) cottonseed hulls could result in a toxic level in the diet. Cottonseed are an excellent feedstuff for dairy cattle, but the temptation to feed too much of a good thing should be avoided.

Cocoa shell meal contains the alkaloids theobromine and caffeine. Theobromine has been suggested to have appetite stimulating effects. Chase (1989) reported that cocoa shell meal contained 17% crude protein, 48% ADF, and 1% theobromine, and saw no differences in milk yield or DMI when fed at 3, 6, or 9% of diet DM. However, Newton and McCormick (1981) reported that heifers had a staggering gait when fed diets containing 7.5% cocoa shell meal. Caution should be used, and some indicate that theobromine should be less than .1% of the diet. These contradictory results and the presence of unusual compounds such as theobromine suggest caution in evaluating and including new by-products in dairy rations.

Peanut skins appear to be an excellent feed product for dairy cows. As illustrated in Table 3, peanut skins have an excellent protein, fiber, and fat content, with an analysis similar to whole cottonseed. However, peanut skins have a significant tannin content (Table 3), which forms insoluble protein-tannin complexes and renders protein indigestible. Heifers and steers fed feedlot diets near NRC requirements for crude protein and containing 10 or

20% peanut skins had sharply lower average daily gains than controls. However, heifers grazing rye pasture and supplemented with corn plus peanut skins had superior gains to those supplemented with corn alone (McBrayer et al., 1983). The excess of protein supplied by rye grazing apparently overcame the protein binding effects of the tannins. Addition of urea to diets containing peanut skins helped to overcome negative effects of tannins (Hill et al., 1987). Dairy cows fed diets above NRC minimums for crude protein and containing 0, 8, 16, or 24% peanut skins (dry basis) had a quadratic increase in milk yield up to 16% peanut skins in the diet, declining at 24%, and a linear decline for crude protein digestibility occurred as peanut skins increased in diet DM.(West et al., 1993). These levels of peanut skins are similar to those used successfully in beef cattle diets and suggest a safe level of inclusion at 10 to 15% of diet dry matter. Thus with careful nutritional management an ingredient containing an undesirable compound can be used successfully.

Feedstuffs with a high moisture content such as wet brewers grains add a significant amount of water to the diet. When used in rations containing a high proportion of wet ingredients, limitations due to rumen fill may occur. This has been called the "watermelon syndrome" (Loper, unpublished communication), suggesting that in the long term excess water in the diet, and thus greater fill, will limit intake. Lahr et al. (1983) reported improved DMI when alfalfa hay was substituted for alfalfa silage, and greater DMI as DM content of the diet increased incrementally from 40 to 78%. However, Robinson et al. (1990) found that diets containing 35, 45, and 65% DM, achieved by soaking grains in water, did not affect feed intake by mid to late lactation cows. Robinson et al. (1990) observed that at least three potential factors could cause reduced DMI with increasing ration moisture content: 1)increasing concentrations of fermentation end products which restrict intake, 2) increased bulk of feedstuffs caused by intracellular water, causing greater rumen fill, and 3) increased intake of water which exceeds the capacity to transport water from the rumen, again restricting intake due to fill. The work by Robinson et al. (1990) showed that water intake did not limit feed DM intake. West et al. (1993) fed diets containing 0, 15, and 30% wet brewers grains to lactating Jersey cows during hot weather. Percentages of DM for diets containing 0, 15, and 30% wet brewers grains were 54.6, 43.3, and 35.5%, respectively. Jersey cows consumed an average of 19 and 38 pounds of wet brewers grains daily for 15 and 30% wet brewers grains diets. This high level of inclusion did not depress DMI or milk yield, suggesting that diets with high moisture contents can be fed successfully during hot weather, possibly because DMI is somewhat depressed due to the environmental conditions, reducing space limitations in the rumen. Research results with high moisture diets on intake have been variable, but moisture content should be considered when evaluating high moisture by-products. This is especially true if the feeding program contains a large quantity of fermented feeds or green chop.

Nutrient variation across sources of by-products, and even within a given by-product source are an accepted fact when using by-products. Belyea et al. (1989) compared the variation in composition of corn gluten feed, distillers dried grains, rice bran, soybean hulls, and whole cottonseed and found coefficients of variation for NDF, ADF, cellulose, and crude protein ranging from 1 to 10%. Chandler (1987) reported values for wet brewers grains which differed from NRC book values, and coefficients of variation for crude protein, ADF, and fat in the 6 to 8% range and for minerals in the 6 to 23% range. Chemical analyses of feedstuffs is essential for accurate ration formulation and is critical in a by-product feeding program where nutrient variation is an inherent characteristic of the feed.

Management Concerns When Using By-Product Feeds

As mentioned previously, the producer assumes many of the functions of the feed dealer when he purchases commodities (Coppock, 1992). Management of commodities becomes an important role in a successful feeding program. In determining the value of a product, one must consider not only nutrient value but transportation costs, shrink and other storage losses, and if wet products are used, what the nutrient value is on a DM or air dry basis. Dry matter content, especially for wet feeds, is extremely important to both nutrient formulation and feed value. If shrink in storage is due primarily to moisture, it can be adjusted for during formulation. Losses to birds and rodents are common and are more difficult to account for. Some animal products and high fat products have limited storage time, especially during hot weather. Some products change in nutrient composition over time. Mehrez et al. (1980) reported that the single most important factor affecting degradability of fish meal was storage prior to processing, which increased degradability by 14 percentage units. While this effect occurs before the product reaches the user, other changes which occur on farm dramatically affect the usefulness of the product.

Storage to accommodate truck load lots allows the user to capitalize on volume benefits. However, improper storage can increase costs. Poor storage facilities which encourage mold growth create an aflatoxin hazard (in stored whole cottonseed, for example). Forced air through a stack of cottonseed minimizes effects of moisture and prevents mold growth. Wet ingredients such as wet brewers grains spoil rapidly, and incomplete clean-out before delivery of fresh grains accelerates spoilage. Containment in a three sided bunker with a polyethylene cover enhances storage life. Work by Ely and West (unpublished data) indicates that treatment of wet brewers grains with propionic acid, salt, or enclosing in a sealed bag significantly lengthens storage time, improving the potential for smaller dairy farms to use truckload quantities of wet brewers grains.

Linear programming provides a means for rapid comparison of a large number of ingredients, arriving at a minimum cost solution. However, unrealistic values can be placed on a feed if it happens to contain a nutrient that is limiting in the ration. For example, a ration that is limiting in potassium supplements may express brewers grains as an almost worthless supplement, because of its low potassium content, or may place an unrealistically high value on alfalfa hay because of its high potassium content. Provision of an economical source of all mineral elements and avoiding of nutrient deficiencies will allow feedstuffs to be evaluated correctly. Feedstuffs containing fat will often be priced well above simple nutrient value because of the critical need for energy in high producing cows. Constraints on the use of certain feedstuffs must be observed on certain feedstuffs if they are to be used successfully. Table 4 contains guidelines for selected ingredients. Like book values, these guidelines vary with the situation, but are useful starting points. Constraints on total inclusion of groups of ingredients should also be considered, such as cottonseed products for gossypol limits, or wheat products for starch degradability.

Conclusions

The availability of many by-product feeds make for a tempting source of nutrients for dairy cows. However, there is rarely a free ride, and purchase of commodities and by-products for on farm mixing and use shifts many of the services and risks formerly assumed by the feed manufacturer to the dairy producer. Larger herds can cut feed costs by purchasing feeds in bulk, and can use by-products successfully as an economical nutrient source. However, purchasing, storage, inventory control, knowledge of the nutritional qualities of each feed ingredient, and expert ration formulation are necessary for a successful commodity and by-product feeding program. The cheapest ingredient may not be the most economical ingredient for a feeding program. Careful evaluation of ingredients prior to purchase, and correct implementation into a feeding program are necessary for optimum benefits from by-product feeds.

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Table 1. Chemical composition of selected by-product feeds (dry basis).[1]

	DM	CP	UIP[2]	TDN	NEL	EE	ADF	NDF	Ca	P	Mg	K	Na
	-------- % --------			%	Mcal/lb	------------------------------------ % ------------------------------------							
Bakery product, dried	92	10.7	.20[3]	89	.93	12.7	13	18	.14	.26	.26	.53	1.24
Blood meal	92	87.2	.82	66	.68	1.4	---	---	.32	.26	.24	.10	.35
Brewers grains, dried	92	25.4	.49	66	.68	6.5	24	46	.33	.55	.16	.09	.23
Brewers grains, wet	21	25.4	.49	66	.68	6.5	23	42	.33	.55	.16	.09	.23
Canola meal	94	37.4	.28	74	.77	7.4	16	34	.76	1.15	.59	---	---
Citrus pulp	91	6.7	.30[3]	77	.80	3.7	22	23	1.84	.12	.17	.79	.09
Corn gluten feed	90	25.6	.25	83	.87	2.4	12	45	.36	.82	.36	.64	.15
Corn gluten meal	91	46.8	.55	86	.90	2.4	9	37	.16	.50	.06	.03	.10
Corrugated boxes, ground[3]	92	---	---	70	.72	---	65[4]	---	---	---	---	---	---
Cottonseed, whole	92	23.0	.40[3]	96	1.01	20.0	34	44	.21	.64	.46	1.00	.01
Cottonseed hulls	91	4.1	.50[3]	45	.44	1.7	73	90	.15	.09	.14	.87	.02
Cottonseed meal	91	45.6	.43	76	.79	1.3	19	26	.22	1.21	.55	1.39	.04
Distillers grains, dried	94	23.0	.54	86	.90	9.8	12	17	.11	.43	.07	.18	.10
Distillers grains w/solubles	92	25.0	.47	88	.92	10.3	14	18	.15	.71	.08	.44	.57
Fish meal	92	66.7	.60	73	.76	10.5	---	---	5.65	3.16	.16	.76	.43
Hominy feed	90	11.5	.45[3]	87	.91	7.7	13	55	.05	.57	.26	.65	.09
Meat and bone meal	93	50.2	.49	68	.70	13.7	---	---	12.01	5.82	---	---	---
Molasses, cane	75	5.8	---	72	.74	.1	---	---	1.00	.11	.43	3.84	.22
Peanut hulls	91	7.8	.40[3]	22	.19	2.0	65	74	.26	.07	.17	.95	.13
Peanut meal	93	52.0	.25	83	.87	6.3	6	14	.20	.61	.31	1.25	.23
Peanut skins[5]	92	19.8	---	---	---	24.3	23	39	---	---	---	---	---
Rice bran	91	14.1	.35[3]	70	.73	15.1	18	33	.08	1.70	1.04	1.92	.04
Rice hulls	92	3.3	.60[3]	12	.08	.8	72	82	.10	.08	.83	.57	.12
Soybean hulls	91	12.1	.11[3]	77	.80	2.1	50	67	.49	.21	---	1.27	.01
Soybean meal (48%)	90	55.1	.35	87	.91	1.0	6	8	.29	.70	.32	2.30	.03
Sunflower meal, w/hulls	90	25.9	.28[3]	44	.43	1.2	33	40	.23	1.03	.75	1.06	---
Sunflower meal, w/o hulls	93	44.6	.26	77	.77	8.7	---	---	.42	1.14	.78	1.14	.24
Wheat middlings	89	18.4	.21	69	.71	4.9	10	37	.13	.99	.40	1.13	.19

[1]From NRC (1989) unless otherwise noted.
[2]Protein undegradability.
[3]From Harris & Staples. Feeding by-product feedstuffs to dairy cattle. Univ. of Florida Cooperative Extension Service Bulletin.
[4]Crude fiber.
[5]From West et al. (1993).

Table 2. Protein content and rumen undegradability of protein in selected feeds.

Feed	Crude protein, %	Undegradability
Blood meal	87.2	.82
Brewers dried grains	25.4	.49
Canola meal	38.7	.28
Corn	10.0	.52
Corn gluten feed	22.3	.25
Corn gluten meal	46.8	.55
Cottonseed, whole	23.0	.45
Cottonseed meal	44.8	.43
Distillers dried grains	23.0	.54
Feather meal, hydrolyzed	85.0	.71
Fish meal	71.2	.60
Meat and bone meal	50.2	.49
Meat meal	54.8	.76
Peanut meal	52.0	.25
Soybean meal	49.9	.35
Wheat middlings	18.4	.21

NRC. 1989.

Table 3. Chemical analysis of peanut skins.[1]

Component	%
Crude protein	19.8
Ether extract	24.3
Acid detergent fiber	22.6
Neutral detergent fiber	38.9
Tannins	18.2
Fatty acids	mol/100 mol
$C_{12:0}$	.02
$C_{14:0}$	.16
$C_{16:0}$	10.25
$C_{16:1}$	.14
$C_{18:0}$	1.85
$C_{18:1}$	43.29
$C_{18:2}$	43.99
$C_{18:3}$	.30

West et al. 1993.

Table 4. Suggested upper limits for selected feed ingredients.

Feedstuff	lb/hd/day	Percent of total DM
Bakery product, dry	5	12
Blood meal	2-3	4-6
Brewers grains, wet	30	15
Citrus pulp	12	25
Cottonseed, whole	5-8	10-15
Distillers grains, dried	7-12	15-25
Fish meal	2	4
Meat and bone meal	2-3	4-6
Peanut hulls	4	10
Peanut skins	5-6	12-15
Soybean hulls	7-9	15-20
Wheat middlings	7-9	15-20