USE OF BYPRODUCTS TO MEET THE NUTRITIONAL NEEDS OF THE COWHERD

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Introduction

Byproducts from the feed and food industries are generally excellent sources of protein, energy, and minerals for ruminants such as beef cows. In a state with such diverse agricultural systems as is the state of Minnesota, opportunities to purchase and utilize these byproducts abound. However, basic knowledge about nutrient needs of cows, replacement heifers and calves, byproduct nutrient composition and variation in nutrient composition, byproduct characteristics (moisture content, particle size, density, etc.) and byproduct dealer sources and purchasing requirements is necessary to effectively utilize byproducts to their full advantage. An attempt to summarize this basic knowledge regarding byproducts from the corn, small grains, oilseed and beet processing industries is made herein with special emphasis on byproduct characteristics and dealer purchasing requirements as these two items affect efficient utilization of byproducts more than knowledge about cow herd nutrient demands or byproduct composition. Additionally these two items are usually left out of articles discussing byproduct utilization. For the purpose of demonstrating certain examples of byproduct use, the author focused on beef cowherds utilizing hay and corn silage, hay or corn stalks as their main forage supply. For specific situations where cowherds rely on other combinations of these or other forages the reader is referred to individual consultation with a nutritionist.

Corn Processing Byproducts

Corn is an abundant crop in the Midwest for which there are numerous user end-points. Of special interest is the fact that "industrial corn use", production of high-fructose corn syrup, ethanol, or other important products, is on the rise in this region of the country. Current estimates of industrial corn use place it at 19.7% of total crop production (direct use for animal feed was 58% while exports were 22% in 1999). Because corn contains over 60% starch, industrial processes are geared at utilizing starch for its transformation to high-fructose corn syrup or starch, through a process known as wet milling, or ethanol, through a process known as dry milling.

Wet Milling Byproducts

During wet milling, corn processing is carefully monitored to yield the highest amount of the purest form of cornstarch while retaining excellent level or purity in production of corn oil (about 3.8% of the corn kernel is oil). Because corn kernels also contain fiber (11.2%) and protein (8.0%), wet milling of corn kernels produces the basis for two main byproduct streams that can be utilized in feeding livestock: corn gluten feed (CGF, 45% or 90% DM, 21% CP, 2.5% fat, 8% NDF) and corn gluten meal (CGM, 89% DM, 60% CP, 2.5% fat, 1% NDF), respectively. The wet milling process also yields lesser amounts of other byproducts such as corn steep liquor (50% DM and 25% CP), which can be blended with CGF, and corn germ meal (90% DM, 20% CP, 2% Fat, 9.5% NDF), which is usually sold as a carrier of liquid nutrients (Davis, 2001).

Use of corn gluten feed in the beef cowherd. Corn gluten feed (Table 1) may be purchased as is (40% to 45% DM) or dried (60% or 90% DM). Price ranges given (Table 1) represent opportunity costs of CGF for a given base forage and soybean meal price. These values translate to approximate cost factors of 45 (dry CGF) or 20 (wet CGF) relative to corn grain price. Thus, if producers wish to utilize wet CGF when corn price is $2.30/bu, they may spend as much as $46.00/ton ($2.30 X 20).

Because of its relatively high soluble fiber and protein content, CGF is an excellent source of energy (80% TDN) and protein (16% to 22% CP). Additionally, CGF does not seem to cause the depression in forage intake usually observed when supplementing forage-based diets with corn grain (Cordes et al., 1988). Therefore, its use is highly recommended when diets of beef cows, replacement heifers or calves require supplementation of energy or protein. However, because of its high phosphorus (P), and especially sulfur (S) content, caution must be exercised to ensure that the Ca:P ratio of the ration does not reach or exceed 1:1, or S content of the diet does not exceed .4%, respectively.

Dry Milling Byproducts

Dry milling is the process by which starch is hydrolyzed (broken down) to produce long-chain sugars. These sugars are further processed to produce a simple sugar called dextrose. A yeast species, *Saccharomyces cerevisiae* is added to convert dextrose into ethanol. Throughout this process, corn kernels have been immersed in liquid, which together form a mash called "beer". When fermentation is completed (40 to 60 h), ethanol is stripped from the beer and water and solids (protein, fiber and fat) are collected from the distillation base (wet cake). This product yields two byproduct streams: condensed distillers solubles (CDS, 26%DM, 24% CP, 9% fat, 4% NDF) and distillers grains with solubles (DGS, 35% to 90% DM, 25% to 30% CP, 11% fat, 9% NDF).

Use of distillers grain with solubles in the beef cowherd. Distillers grains with solubles (Table 1) may be purchased as is (35% to 45% DM) or dried (90% DM). Price ranges given (Table 1) represent opportunity costs of DGS for a given base forage and soybean meal price. These values translate to approximate cost factors of 60 (dry DGS) and 30 (wet DGS) relative to corn grain price. Thus, if producers wish to utilize dry DGS when corn price is $2.30/bu, they may spend as much as $138.00/ton ($2.30 X 60).

Because of its relatively high soluble fiber and rumen-undegradable protein content, DGS is an excellent source of energy (86% to 126% TDN) and protein (25 to 30% CP). Therefore, its use is highly recommended when diets of beef cows, replacement heifers or calves require supplementation of energy or protein. However, because of its high phosphorus (P), and rumen-undegradable protein content, caution must be exercised to ensure that the Ca:P ratio of the ration does not reach or exceed 1:1, or that sufficient degradable protein is supplied to optimize forage use. Additionally, as for CGF, sulfur content of DGS is relatively high.

Use of condensed distillers solubles in the beef cowherd. Condensed distillers solubles may be purchased at price ranges given (Table 1). These prices represent opportunity costs of CDS for a given base forage and soybean meal price. These values translate to an approximate cost factor of 15 relative to corn grain price. Thus, if producers wish to utilize CDS when corn price is $2.30/bu, they may spend as much as $34.50/ton ($2.30 X 15).

Condensed distillers solubles is an excellent source of energy (90% TDN) and protein (24% to 28% CP). Therefore, its use is highly recommended when diets of beef cows, replacement heifers or calves require supplementation of energy or protein. However, because of its high P, caution must be exercised to ensure that the Ca:P ratio of the ration does not reach or exceed 1:1.

Small Grain Processing Byproducts

Wheat, barley and oats are relatively abundant in the northern regions of the Upper Midwest for which the greatest uses may be malting and processing to produce edible grains, grain products and beer for consumption by humans. Because most kernel fractions of small grains, especially wheat and barley, are used for human consumption (starch from the endosperm for flour or malted to produce alcoholic drinks, germ and bran), byproduct streams resulting from small grain processing are usually rejected kernels (due to sprouting, small size or contamination with other grains or mycotoxins), hulls, a combination thereof (screenings or middlings), or co-products of barley malting. Therefore, these byproducts tend to be low in moisture and somewhat variable in nutrient composition. Additionally, care must be exercised when purchasing, storing and feeding small grain processing byproducts because of potential contamination with various anti-quality factors such as mycotoxins, fungus (ergot) or blight.

Use of Barley Malting Co-products in the Beef Cowherd

Barley malting co-products (BMC) may be purchased together at price ranges given (Table 1) or as components. These ranges represent opportunity costs of BMC for a given base forage and soybean meal price. These values translate to an approximate cost factor of 40 relative to corn grain price. Thus, if producers wish to utilize BMC when corn price is $2.30/bu, they may spend as much as $92.00/ton ($2.30 X 40).

Because of its relatively high soluble fiber and protein content, and high palatability, BMC is an excellent source of energy (74% TDN) and a moderate source of protein (14% to 19% CP). Therefore, its use is highly recommended when diets of beef cows, replacement heifers or calves require supplementation of energy or moderate amounts of protein. In many cases, this combination of energy and protein satisfies supplementary needs of grazing calves (creep feed). Because of a relatively balanced profile of minerals, price and availability appear to be the only limiting factors when incorporating BMC in diets for the cowherd.

Use of Grain Screenings in the Beef Cowherd

Grain (and wheat) screenings (GS) are the result of combining various waste streamlines (light or broken kernels, weed seeds, hulls, chaff, straw, elevator dust and floor sweepings) from the process of cleaning grain and may be purchased at price ranges given (Table 1). These ranges represent opportunity costs of GS for a given base forage and soybean meal price. These values translate to an approximate cost factor of 30 relative to corn grain price. Thus, if producers wish to utilize GS when corn price is $2.30/bu, they may spend as much as $69.00/ton ($2.30 X 30).

Grain screenings are a variable source of energy (70 to 72% TDN) and a moderate source of protein (14% CP). Therefore, its use is highly recommended when diets of beef cows, replacement heifers or calves require supplementation of energy or moderate amounts of protein. In many cases, this combination of energy and protein satisfies supplementary needs of cows, replacement heifers and grazing calves (creep feed).

However, when large concentrations of straw or weed seeds are present, nutritive value of screenings is reduced. Also, there is the threat of spreading weed seeds when spreading manure. Therefore, grinding screenings, composting manure from screenings-fed cattle or applying this manure onto thick sod stands, common of grazing lands, will reduce weed infestations (Lardy and Anderson, 1999).

Pigeon grass screenings are another type of grain screenings with similar CP value (14% CP), but lower in energy (65% TDN). Pigeon grass screenings need to be ground before feeding due to the hard seed coat. Also, because of the threat of seed germinating from manure of cattle feed pigeon grass screenings, composting manure for 2 to 3 months is recommended to reduce this threat (Lardy and Anderson, 1999).

Use of Wheat Middlings in the Beef Cowherd

Wheat middlings (mill feed or mill run, WM) are the result of combining various waste streamlines (screenings, hulls, germ, flour remnants, and mill tailings) from the process of milling durum wheat for semolina or wheat for flour and may be purchased at price ranges given (Table 1). These ranges represent opportunity costs of WM for a given base forage and soybean meal price. These values translate to an approximate cost factor of 40 relative to corn grain price. Thus, if producers wish to utilize WM when corn price is $2.30/bu, they may spend as much as $92.00/ton ($2.30 X 40).

Wheat middlings are an excellent source of energy (80% to 83% TDN) and rumen-degradable protein (14% to 18% CP). Additionally, the fiber in wheat middlings is highly degradable in the rumen; although, it may not be as effective in buffering the effects of starch digestion and acid accumulation in the rumen. Therefore, introduction of WM diets of beef cows, replacement heifers or calves should be in small increments over time (Dhuyvetter et al., 1999). Because of their balanced energy, protein and mineral content, WM works quite well in diets of cows, replacement heifers and growing calves.

Mycotoxin or Mold Contamination of Small Grain Byproducts

Producers who wish to utilize byproducts from small grain processing streams must always be aware of the potential for contamination by molds (blight, scab, smut, ergot) or their byproducts (mycotoxins). Because in many instances the process to mill small grains concentrates molds or mycotoxins in the byproduct streamline, significant human and animal health concerns exist when handling, storing, mixing, or feeding these byproducts.

Effects on animal health include abortions, reduced intake, reduced ovulation and/or conception rates, reduced gain and feed conversion. Humans and other monogastrics (pigs and poultry) are more susceptible to health disturbances when inhaling or consuming molds or mycotoxins (DiCostanzo and Murphy, 1994).

In general, when contamination of byproducts is suspected, a thorough evaluation of potential contaminants must be conducted. Molds become visible when concentrations are greater than 1'000,000 cfu/g (DiCostanzo and Murphy, 1994). At this point (when mold is visible), producers are advised to test feed to determine what type of molds and mycotoxins may be present and what to do about it (DiCostanzo and Murphy, 1994). However, because of the small particle size and intense processing, molds may not be visible in screenings or middlings; therefore, producers are encouraged to test byproduct sources for molds and mycotoxins when growing conditions have been extremely wet or extremely dry, or when fields have been known to contain scab, ergot or rot. Mold and mycotoxin analyses cost between $40 and $100/sample. In comparison, a single abortion may cost up to $177 (Wittum et al., 1993).

If mold or mycotoxin contamination is suspected, the type of mycotoxin or mold must be determined before formulating a ration for any type of cattle (DiCostanzo and Murphy, 1994). In general, unless mold or mycotoxin contaminated feeds contain aflatoxin, these feeds must be mixed to dilute toxin and mold concentrations below concentrations known to cause health or reproductive problems.

Oilseed Processing Byproducts

Byproducts from the oilseed processing industry are another alternative cow-calf producers have for supplementing mainly protein and, to a lesser extent (due to cost), energy to their cowherds. Most oilseed byproducts are the result of oil extraction processes. Although specific extraction methods vary between plants and types of oilseeds, there are three stages common to the process: preparation of oilseed for extraction (breaking and de-hulling), which leads to a single byproduct stream: hulls (soybean hulls, sunflower hulls, etc.), extraction and meal preparation. In some cases, such as soybean processing, hulls are roasted to decrease urease activity (Hoy, 1991). Oil is extracted during the second stage. Remaining flakes such as those from soybeans are treated to reduce urease activity, and further dried down to yield high-protein meals. At some point, these oilseed meals were considered byproducts; however, today, due to adoption of most of these oilseed meals as animal feed, these meals are considered common commodities, as consistent in quality and influential on price of other proteins as cereal grains themselves. Soybean hulls are an excellent source of energy and protein (80% to 90% TDN, 12% CP), but sunflower hulls are not (40% TDN, 5% CP); therefore, only soybean hulls will be discussed. Because of the similarities in nutrient composition and degradability, oilseed meals of various oilseed types (soybeans, sunflowers and canola) will be discussed jointly.

Use of Soybean Hulls in the Beef Cowherd

Soybean hulls (SBH) are the result of breaking and separating soybean hulls from "bean meats" prior to extracting oil. Price ranges represent opportunity costs of SBH for a given base forage and soybean meal price. These values translate to an approximate cost factor of 30 relative to corn grain price. Thus, if producer wish to utilize SBH when corn price is $2.30/bu, they may spend as much as $69.00/ton ($2.30 X 30).

Soybean hulls provide an excellent source of energy, derived mostly from the fermentation of highly digestible hemi-cellulose in the rumen, a process that does not compromise digestion of the forage component of the diet. Additionally, the CP fraction in SBH is highly degradable. Therefore, SBH can be used without great issues of concern in diets of cows. Diets of growing heifers and calves may need to be further supplemented with protein.

Use of Oilseed Meals in the Beef Cowherd

Oilseed meals (OSM) are the result of extracting oil from "bean meats". Price ranges represent opportunity costs of OSM for a given base forage and soybean meal price. These values translate to approximate cost factors of 75% (sunflower meal) and 85% (canola meal) relative to soybean meal price. Thus, if producer wish to utilize canola meal when soybean meal price is $170/ton, they may spend as much as $144.50/ton ($170 X .85).

Oilseed meals are excellent sources of protein and energy. Additionally, the CP fraction in OSM is highly degradable. Typically, however, oilseed meals are the basis for protein supplementation in various livestock diets; therefore, prices of OSM are generally driven by demand for protein in various other production systems.

Sugar Beet Processing Byproducts

Sugar beet processing byproducts are another excellent source of energy for cowherds in the Upper Midwest. These byproducts are derived during the refining process whereby sugar is extracted from the rest of the plant material. Sugar is removed by soaking sliced beets in hot water. Sugar compounds are then refined from this liquid phase, and the remaining plant material is further processed to obtain two byproduct streams. Byproducts from this process include molasses and beet pulp. Additionally, rejected beets (small, broken or damaged), soil and other foreign material are also available (beet tailings). Because tailings are separated only during harvest, their availability is limited to late in the fall every year. Beet pulp may be available wet during harvest and winter, but it is available dry throughout the year.

Use of Beet Pulp in the Beef Cowherd

Beet pulp may be purchased wet or dry at price ranges (Table 1), which represent opportunity costs of BP for a given base forage and soybean meal price. These values translate to approximate cost factors of 30 (dry BP) and 8 (wet BP) relative to corn grain price. Thus, if producers wish to utilize dry BP when corn price is $2.30/bu, they may spend as much as $69.00/ton ($2.30 X 30).

Beet pulp is an excellent source of energy, derived mostly from the fermentation of highly digestible fiber in the rumen, a process that does not compromise digestion of the forage component of the diet. However, the protein concentration of BP is relatively low; although in many cases sufficient to maintain a pregnant beef cow. Therefore, BP can be used without great issues of concern in diets of cows. Diets of growing heifers and calves will need to be further supplemented with protein.

Beet molasses is also an excellent source of energy, but due to the fact that it is liquid and highly sought by feed manufacturers (it is often procured in large amounts), its availability and storage requirements make it a byproduct of limited usefulness for most individual cow-calf producers. When using beet molasses, inclusion in diets of mature and young cattle must be limited to less than 15% and 8% of the diet (dry basis), respectively, because of its laxative effects (Lardy and Anderson, 1999).

Use of Beet Tailings in the Beef Cowherd

Beet tailings are often available at the cost of freight from many of the beet processing plants during harvest. Price ranges (Table 1) which represent opportunity costs of BT for a given base forage and soybean meal price. These values translate to an approximate cost factor of 5 relative to corn grain price. Thus, if producers wish to utilize BT when corn price is $2.30/bu, they may spend as much as $11.50/ton ($2.30 X 5).

Beet tailings are somewhat lower in energy than beet pulp. As for beet pulp this energy is derived mostly from the fermentation of highly digestible fiber in the rumen, a process that does not compromise digestion of the forage component of the diet. However, the protein concentration of BT is relatively low; although in many cases sufficient to maintain a pregnant beef cow. Additionally, due to the presence of soil and other contaminants, the variability in nutrient content of this byproduct is quite large. Diets of mature cows may not require further protein supplementation when using BT; however, those of growing heifers and calves will need to be further supplemented with protein.

Formulating Diets with Byproduct Feeds

Examples of diets for cows Table 2 (as-fed basis), replacement heifers and heifer calves Table 3 (as-fed basis) are presented as guidelines for the reader to explore the feasibility of using various byproduct feeds. These diets are presented for the sake of demonstration, are not guaranteed to be least cost, and are not intended to fit any specific situation. A supplement formulated to contain vitamins and minerals to meet requirements of these classes of animals must also be supplied. Furthermore, it is critical that producers who are interested in utilizing any of these byproducts determine the nutrient content of the byproduct in question, and that they are willing to sample and analyze this byproduct on a regular basis. Additionally, when producers are presented with a diet formulation such as those presented herein, they are strongly encouraged to feed as close to the formulation as it is possible to prevent excesses or shortages in nutrient supply. Either situation will lead to reduced return on investment in feeds for their cowherds.

For the purpose of simplifying this process, only corn stalks (last trimester cows only), corn silage and hay or hay diets were evaluated. Where additional energy or protein was required, corn grain or soybean meal were used to balance each of these nutrients, respectively. Also, byproduct feeds were further grouped (Tables 2 and 3) according to their nutrient composition: byproducts with relatively low TDN and CP (beet pulp and grain screenings), byproducts with high TDN and low CP (soybean hulls and barley malting co-products), byproducts with high TDN and moderate CP (corn gluten feed) and byproducts with high TDN and high CP (distillers grains with solubles and condensed distillers solubles). No wet byproducts were used to formulate these examples. To obtain proper amounts of wet corn gluten feed, distillers grains with solubles and beet pulp, multiply values for dry corn gluten feed, distillers grain with solubles listed in Tables 2 and 3 by 2, 2.6 and 3.6, respectively.

Hay-based diets of cattle with greatest energy and protein needs such as replacement heifers (open or due with their first calf) or lactating cows all required between 3 and 9 lb corn grain/head in addition to the byproduct that is to be utilized (Tables 2 and 3). This is because hay utilized in these examples was low in energy (55% TDN). Also, corn is an excellent energy source at a low price. Thus, energy or energy- and protein-containing byproducts only came into the diet to supply any protein shortage caused by introducing corn grain to hay only diets. Based on this, 3 to 5 lb or 4 to 5 lb corn processing byproducts (dry DGS or dry CGF, respectively)/head in combination with 5 to 7 lb or 9 lb corn grain/head were required to supplement hay-based diets for open replacement heifers and lactating cows, respectively (Tables 2 and 3). Diets of pregnant replacement heifers required 6 lb corn grain/head and 1 to 2 lb corn processing byproducts/head. Grain screenings were held to 6 lb/head (heifers) or 10 lb/head (cows); thus, approximately 5 to 8 lb corn grain/head were required to balance hay-based diets of lactating cows and replacement heifers.

In contrast, corn silage and hay diets of replacement heifers and lactating cows required fewer amounts of byproduct feeds and no supplemental corn grain (Tables 2 and 3). Diets of pregnant replacements and lactating cows required 3 to 4 lb corn processing byproducts (dry DGS or dry CGF)/head. Limiting grain screenings led to a need to supplement protein (.5 lb to 2 lb soybean meal/head) in corn silage and hay diets of replacement heifers and lactating cows, while 5 to 8 lb wheat midds/head supplied any shortages in energy and protein in corn silage and hay diets (Tables 2 and 3).

Diets of pregnant (last trimester) cows are the easiest to formulate because of the reduced energy and protein needs; thus, corn stalks or hay was used as the base forage (Table 2). Regardless of base forage, approximately 25 lb to 30 lb forage/head and 2 or 5 to 6 lb wheat midds or corn processing byproducts/head were required to balance energy needs of hay and corn stalks diets, respectively. Approximately 7 or 8 lb grain screenings/head were needed to balance hay or corn stalks diets, respectively.

Additional Considerations

Utilization of byproduct feeds demands a thorough knowledge of nutrient supply (forage inventories and testing) and nutrient needs (nutrient requirements of all classes of cattle). However, additional considerations must be made when determining whether byproduct feeds are to be utilized. Considerations with regards to location of byproduct supplier, minimum amount of byproduct required to purchase, financial arrangements required to purchase, and byproduct characteristics which may enhance or limit storage, mixing or delivery.

Purchasing Considerations

Most byproduct feeds procured in amounts typically required by cowherds are available from local feed elevators and dealers, especially those byproducts that contain little moisture. Although conditions vary amongst elevators and dealers, most local elevators and dealers are willing to sell dry byproducts in amounts as little as 1 ton/delivery. Thus, producers can drive their pick-ups or cattle trailers pay and load. However, producers are encouraged to contact their local elevators and dealers to determine specific purchasing considerations beyond those listed herein.

When wet byproducts are sought, certain purchasing restrictions may apply to specific byproducts. For instance, some plants require that wet corn gluten feed be purchased in semi-loads (26 ton). Producers wishing to utilize this byproduct must either group together to purchase a semi-load at regular intervals of two weeks or less, or purchase singly and be prepared to preserve a semi-load at less regular intervals. Some ethanol plants in Minnesota, North and South Dakota have more liberal purchase amount minimums (1 ton/purchase). Wet byproducts of the sugar beet processing industry are only available around harvest time.

Storage Considerations

Dry byproducts require relatively minimum storage needs. Selecting and preparing a site that is high, dry and protected from the elements are quite important steps to prevent losses from wind or moisture. Certain byproducts such as loose wheat midds will cake and harden when stored in high humidity or moist areas. Storage areas (old sheds or high-ground sites walled off with large bales) can be surfaced with hardened clay, gravel, blacktop or cement and covered with tin sheets and/or heavy tarps. Delivery and loading areas must face away from prevailing winds (usually to the East). Natural (tree shelter belt) or manufactured (tin and lumber or large bales) located to the North and West of the storage area should prevent excessive wind losses. Also, protecting delivery and loading areas (using heavy rubber to protect elevator chutes or loading wagons or trucks within a protected area will reduce wind losses.

Wet byproducts require more elaborate storage because heavy losses can occur from spoilage. Ensiling wet byproducts will help preserve them. However, investments in silo structures or bags need to be evaluated carefully to prevent excessive storage costs that will offset advantages of using byproducts. Silage wedges made within walls made up of large bales may reduce investment; however, care must be taken to ensure that the wedge is firmly packed. Wet corn gluten feed can be stored by spreading two 50-lb bags of livestock salt on top of the wedge left behind by the semi-trailer as it delivers the load (Durham, 2001).

Mixing and Delivery Considerations

When a single forage and a single byproduct feed are needed to balance a diet, mixing and delivery considerations are relatively easy. The producer may choose to feed the forage in a site, such as a hay ring, and deliver the byproduct feed on the frozen ground or a feed trough (old turned-out tires, old conveyor belts, wooden or concrete bunks) using anything from a bucket, bushel basket, front-end loader or feeder wagon. As indicated before, precautions must be taken to prevent wind and spoilage losses.

When more than one feed will be used to supplement locally grown forages, considerations must be made to mix these feeds prior to delivery. Combinations of dry feeds with largely different particle sizes (grain screenings and corn grain) are difficult because insufficient mixing (shorter or longer than required) will permit one of the ingredients to fall out of the mix. Grinder-mixers may work sufficiently well for mixing ground grain and other meal ingredients. Also, using a silage wagon may help mixing dry and wet ingredients when delivering the load. However, if one ingredient is required in large amounts relative to the other, mixing will not be complete.

Perhaps the most difficult challenge when attempting to feed byproducts is determining the appropriate amount to deliver. As indicated earlier, shortages or excesses in either the forage or supplemental feed will increase diet cost (due to cattle not receiving enough nutrients for adequate performance, or receiving excesses that do not result in additional performance responses) relative to the formulation cost. Thus, producers are strongly encouraged to invest in adaptations to front-end loaders (hydraulic pressure gauges), scales or other devices (graded buckets) to ensure that they deliver feed amounts as close to those on the formulation sheets as possible. These investments, although initially perceived as large, are readily offset by savings in feed costs.

Use of Other Byproducts in the Cowherd

The current review of byproducts is by no means comprehensive. Therefore, when byproducts not listed herein are being considered, the reader is referred to various other sources (Chandler et al., 1991; Satter et al., 1991; Blasi et al., 1995; Lardy and Anderson, 1999) for details about nutrient concentration, feeding guidelines or other concerns about storage and feed delivery of byproducts not found in this review.

However, an astute cow-calf producer considering use of byproducts listed herein, or any other alternative feed is advised to consider the following steps:

1. Inventory and test home-grown forage and other feeds.
2. Determine any potential shortfalls in dry matter or nutrient supply.
3. Identify potential feed and byproduct sources that may best meet nutrient shortage according to price, storage and feed delivery capabilities.
4. Determine price, purchasing, trucking, storage, mixing and delivery requirements, samples and feed analyses of potential ingredients to utilize.
5. Formulate a diet that will meet nutrient shortage while preventing excessive supplementation costs.
    a. Attention must be paid to physical and chemical properties of ingredients in the blend to prevent excessive starch loads in the rumen or deleterious effects on health (excessive mineral content).
    b. The impact of purchasing, trucking, storage, mixing and delivery requirements of specific byproducts needs to be added to the price of the byproduct FOB at the source.
6. Feed diet according to diet formulation guidelines with sufficient adjustments for changes in intake and impact of climatic conditions.
7. Monitor impact of diet using BCS, weight or both.
8. Re-analyze and re-formulate diet if necessary.
    a. When performance is not what was expected.
    b. When production stage of cattle (weight, pregnancy status, etc.) changes.
    c. When home-grown forage supply changes.
    d. When price of byproduct changes.
    e. When nutrient composition of byproduct changes.

9. When feeding period is completed, evaluate whether byproduct was used efficiently.
    a. Was nutrient shortage eliminated?
    b. At what actual cost?
    c. Was cattle performance up to expectations?
    d. Was it a reliable byproduct source?
    e. Is it a byproduct that you would feed again (were trucking, storage, mixing and delivery manageable)?

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Table 1. Nutrient composition[a] and opportunity prices[b] for various byproducts when the herd's base forage is corn silage, corn stalks or hay.

Item	Type[c]	DM, %	TDN, %	CP, %	Ca, %	P, %	%/ton when forage base is:		
							Corn silage	Corn stalks	Hay
Other Forage									
Corn silage	E	35	70	8	.38	.31	--	12.09	26.75
Corn stalks	E	83	48	6	.57	.10	30.57	--	32.95
Hay	B	85	55	12	.26	.27	55.56	36.45	--
Corn Processing									
Condensed distillers solubles	B	26	90	24	.17	1.45	32.93	19.84	41.22
Corn	E	88	90	9	.02	.31	2.16	1.12	2.60
Corn gluten feed, dry	B	90	80	20	.04	.67	92.82	52.55	118.31
Corn gluten feed, wet	B	45	80	18	.04	.67	43.22	23.09	55.97
Distillers grains, dry	B	90	86	30	.02	.49	129.74	86.45	157.14
Distillers grains, wet	B	35	126	30	.02	.49	63.55	36.45	79.17
Small Grains									
Barley	E	88	86	13	.05	.38	1.77	.76	2.42
Barley malting	B	89	74	19	.21	.55	83.65	46.81	106.97
Grain screenings	E	90	70	14	.48	.43	65.31	30.06	87.63
Wheat midds	B	90	83	17	.16	1.01	85.78	44.00	112.22
Oilseed									
Soybean hulls	E	90	80	12	.59	.17	67.32	27.05	92.81
Soybean meal	P	88	87	48	.29	.71	183.81	140.98	210.92
Sunflower meal	P	90	64	39	.39	1.06	139.91	107.70	160.30
Canola meal	P	90	72	42	.64	.97	156.21	119.97	179.15
Beet Processing									
Beet pulp, dry	E	90	72	9	.72	.20	63.77	34.86	73.96
Beet pulp, wet	E	25	72	9	.72	.20	17.71	9.68	20.54
Beet tailings	E	18	65	9	2.35	.27	11.58	6.50	13.17

[a]Complied from various sources.
[b]Calculated based on contributions of energy and protein from each byproduct to corn silage ($23/ton), corn stalks ($15/ton) or hay ($60/ton) and soybean meal ($170/ton).
[c]Classified as providing energy (E), protein (P) or both nutrients (B).

Table 2. Examples of daily rations balanced[a] (lb as-fed/head) to meet energy and protein requirements[b] of pregnant (last trimester) and lactating (first trimester) beef cows fed corn silage and hay, hay or corn stalks.

Base forage:	**Corn stalks**				**Hay**			
Byproduct composition:	**> 70% TDN < 14% CP**	**> 80% TDN < 14% CP**	**> 80% TDN < 20% CP**	**> 80% TDN > 20% CP**	**> 70% TDN < 14% CP**	**> 80% TDN < 14% CP**	**> 80% TDN < 20% CP**	**> 80% TDN > 20% CP**
Pregnant cow diets								
Corn stalks	25	29	28	29	--	--	--	--
Hay	--	--	--	--	24	30	30	30
Corn grain	1	--	--	--	--	--	--	
Energy feed	8	5	--	--	7	2	--	--
Soybean meal	--	.75	--	--	--	--	--	--
Energy and protein feed	--	--	6	5	--	--	2	2

Base forage:	**Corn silage**				**Hay**			
Byproduct composition:	**> 70% TDN < 14% CP**	**> 80% TDN < 14% CP**	**> 80% TDN < 20% CP**	**> 80% TDN > 20% CP**	**> 70% TDN < 14% CP**	**> 80% TDN < 14% CP**	**> 80% TDN < 20% CP**	**> 80% TDN > 20% CP**
Lactating cow diets								
Corn silage	41	38	47	51	--	--	--	--
Hay	8	14	11	11	16	21	20	21
Corn grain	--	--	--	--	8	3	9	9
Energy feed	10	6	--	--	10	10	--	--
Soybean meal	.5	--	--	--	--	--	--	--
Energy and protein feed	--	--	4	3	--	--	5	4

[a] Using corn silage (35% DM, 70% TDN, 8% CP), corn stalks (83% DM, 48% TDN, 6% CP) and hay (85% DM, 55% TDN, 12% CP) and byproducts arranged from those listed in Table 1.

[b] Adjusted for exposure to cold in cows or heifers not needing to recover body weight. These diets are presented for the sake of demonstration, are not guaranteed to be least cost, and are not intended to fit any specific situation. A supplement formulated to contain vitamins and minerals to meet requirements of these classes of animals must also be supplied.

Table 3. Examples of daily rations balanced[a] (lb as-fed/head) to meet energy and protein requirements[b] of pregnant first-calf and replacement heifers fed corn silage and hay or hay.

Base forage:	**Corn silage**				**Hay**			
Byproduct composition:	**> 70% TDN < 14% CP**	**> 80% TDN < 14% CP**	**> 80% TDN < 20% CP**	**> 80% TDN > 20% CP**	**> 70% TDN < 14% CP**	**> 80% TDN < 14% CP**	**> 80% TDN < 20% CP**	**> 80% TDN > 20% CP**
Pregnant first-calf heifer								
Corn silage	24	13	22	25	--	--	--	--
Hay	12	17	15	15	17	20	20	20
Corn grain	--	--	--	--	5	5	6	6
Energy feed	6	5	--	--	6	3	--	--
Soybean meal	1	--	--	--	--	--	--	--
Energy and protein feed	--	--	4	3	--	--	2	1.5
Base forage:	**Corn silage**				**Hay**			
Byproduct composition:	**> 70% TDN < 14% CP**	**> 80% TDN < 14% CP**	**> 80% TDN < 20% CP**	**> 80% TDN > 20% CP**	**> 70% TDN < 14% CP**	**> 80% TDN < 14% CP**	**> 80% TDN < 20% CP**	**> 80% TDN > 20% CP**
Replacement heifer								
Corn silage	30	7	20	25	--	--	--	--
Hay	2	9	6	5	8	10	10	10
Corn grain	--	--	--	--	7	2	5	7
Energy feed	4	8	--	--	4	7	--	--
Soybean meal	2	--	--	--	1	--	--	--
Energy and protein feed	--	--	6	5	--	--	5	3

[a] Using corn silage (35% DM, 70% TDN, 8% CP), corn stalks (83% DM, 48% TDN, 6% CP) and hay (85% DM, 55% TDN, 12% CP) and byproducts arranged from those listed in Table 1.

[b] Adjusted for exposure to cold in cows or heifers not needing to recover body weight. These diets are presented for the sake of demonstration, are not guaranteed to be least cost, and are not intended to fit any specific situation. A supplement formulated to contain vitamins and minerals to meet requirements of these classes of animals must also be supplied.