By-Product Feedstuffs in Dairy Cattle Diets in the Upper Midwest

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Introduction

The purpose of this paper is to review by-product feedstuffs commonly used in dairy cattle diets in the Upper Midwest. Typical nutrient analyses of most of these feedstuffs are provided in Table 1. Otherwise nutrient composition is listed in the text. Tabular listings of nutrient analyses are average values, and the variation in nutrient content of by-product feedstuffs can be large (Dairy NRC, 2001). Laboratory testing of by-product feedstuffs for actual nutrient content is recommended.

Break-even costs can be calculated using FEEDVAL4 (Howard and Shaver, 1993; http://www.uwex.edu/ces/dairynutrition/spreadsheets.cfm) where blood meal (rumen undegraded protein; RUP), urea (rumen degraded protein; RDP), shelled corn (energy), tallow (fat), dicalcium phosphate (phosphorus) and calcium carbonate (calcium) serve as referee feedstuffs. Break-even costs are not provided herein, because they vary as prices of the referee feedstuffs change from month to month, year to year, supplier to supplier, and location to location. Calculation of relevant breakeven prices is recommended.

Some general guidelines on upper feeding limits for by-product feedstuffs (Howard, 1988) are provided herein, however, actual feeding rates should be determined through formulation of diets to meet specifications for neutral detergent fiber (NDF), nonfiber carbohydrate (NFC), fat and protein fractions (crude protein; CP, RDP, and RUP). Fiber effectiveness factors and feedstuff definitions provided herein were obtained from Armentano and Clark (1992) and The Feed Industry Red Book (1994), respectively.

High-Fiber Byproducts

Beet Pulp is the dried residue from sugar beets which has been cleaned and freed from crowns, leaves and sand, and which has been extracted in the process of manufacturing sugar. Beet pulp with molasses includes the beet molasses obtained in the manufacture of sugar. Beet pulp is bulky and highly palatable. It may be fed dry or wet. It may be sold in either pelleted or meal form. Upper feeding limits on beet pulp are about half of the grain concentrate or 8 to 15 lb of dry matter (DM) per cow per day. Beet pulp is often used to reduce the content of NFC in dairy cattle diets. Much of the NFC in beet pulp is pectin which has a propensity for acetate versus propionate

production in the rumen. The NDF in beet pulp is highly fermentable in the rumen, and it can be used to supply fermentable fiber in the diet. Inclusion of beet pulp in early lactation diets allows the formulation of high NDF, moderate NFC diets of high energy density. Beet pulp is also used as a forage replacer, however, it has limited forage replacement value; effectiveness factor of 0.43 (fraction of NDF) versus 1.0 for forages. The upper limit on forage replacement is 15 to 25% of the forage DM in the diet.

Brewers Dried Grains (BDG) is the dried extracted residue of barley malt alone or in mixture with other cereal grain or grain products resulting from the manufacture of wort or beer and may contain pulverized dried spent hops in an amount not to exceed 3%, evenly distributed. The higher fraction of RUP relative to soybean meal (SBM) makes BDG attractive in diets for lactating dairy cows. BDG are commonly used by the feed industry as a component of protein supplements for dairy cattle. The formula feed industry generally limits BDG to less than 50% of protein supplements and 25% of complete feeds for dairy cattle. BDG are highly palatable. Upper feeding limits on BDG are 5 to 10 lb. of DM per cow per day. BDG have limited value as a source of RUP in high corn silage diets because of their low lysine content. BDG are often used to reduce the content of NFC in dairy cattle diets. BDG are also used as a forage replacer, however, they have limited forage replacement value; effectiveness factor of 0.33 (fraction of NDF) versus 1.0 for forages. The upper limit on forage replacement is 10 to 15% of the forage DM in the diet.

Brewers Wet Grains (BWG) is the extracted residue from the manufacture of wort from barley malt alone or in mixture with other cereal grains or grain products. The guaranteed analysis shall include the maximum moisture. Typical nutrient analyses are similar to BDG, except for moisture content which may range from 70 to 80%. The primary market for BWG is dairy farms and beef cattle feedlots in relatively close proximity to the brewery. The high moisture content of BWG limits its use to livestock operations near the point of production or within a few hundred miles of major breweries. BWG are incorporated directly into rations at the farm. Feeding levels are generally in the range of 20 to 40 lb/cow/day (as fed basis) for dairy cattle. Precautions are generally taken to not increase dietary moisture content above 55%. Adding BWG to diets containing low-moisture hay-crop silages (less than 50% moisture) may increase consumption of a total mixed ration (TMR). The supply should be turned every 7 to 10 days to keep BWG fresh and acceptable to livestock. This limits their use in small herds, but some suppliers avoid this problem by delivering BWG in silage bags which allows on-farm storage for a month or more without spoilage. Comments made in the section on BDG apply here as well.

Corn gluten feed (CGF) is that part of commercial shelled corn that remains after the extraction of the larger portion of the starch, gluten and germ by the processes employed in the wet milling manufacture of corn starch or syrup. It may or may not contain fermented corn extractives and (or) corn germ meal. It may be fed dry or wet. It may be sold in either pelleted or meal form. Wet CGF contains about 45 percent DM. Upper feeding limits on CGF are 12 to 15 lb. and 8 to 12 lb. of DM per cow per day for dry and wet CGF, respectively. For wet CGF, feeding levels are generally in the range

of 15 to 25 lb/cow/day (as fed basis). The supply should be turned every 7 to 10 days to keep wet CGF fresh and acceptable to livestock. This limits its use in small herds. Sulfur concentrations of >0.70% (DM basis) in CGF samples have been reported which may create thiamin-related problems at high inclusion rates; therefore, obtaining an analysis for S on CGF sources so that diets can be adjusted accordingly is recommended. The inclusion rate of CGF is often restricted because of its high content of soluble protein and RDP. Relative to dry CGF, the wet product has a higher content of soluble protein and RDP. The RUP in CGF has limited value because of its low lysine content, particularly in high corn silage diets. CGF is generally used as a grain replacer. Used in this manner it lowers the content of NFC in dairy cattle diets. CGF is also used as a forage replacer; effectiveness factor of 0.56 (fraction of NDF) versus 1.0 for forages. The upper limit on forage replacement is 20 to 25% of the forage DM in the diet.

Cottonseeds. Whole cottonseed is the unprocessed and unadulterated oilseed which has been separated from the cotton fiber. Delinted cottonseed is the unprocessed and unadulterated oilseed which has been separated from the cotton fiber with less than 5% retained lint. Cottonseeds are fed to high producing dairy cows for a source of fat and fiber. They are often used as a forage replacer. Delinted cottonseed contains slightly more protein, fat and energy, but less fiber, than whole cottonseed. There are both mechanically and acid delinted cottonseed products. The mechanically delinted cottonseed is more palatable than acid delinted cottonseed, and is the preferred delinted product for dairy cows. Little difference in animal performance between whole cottonseed and mechanically delinted cottonseed has been reported (Coppock and Wilks, 1991). Upper feeding limits on cottonseeds are 6 to 7 lb. of DM per cow per day. The inclusion rate of cottonseeds is often restricted because of their high fat content and the use of other high-fat ingredients in the diet. Precautions are generally taken to not supplement dietary fat from high-fat plant sources above 1.5 lb. per cow per day. Cottonseeds are often used as a grain replacer. Used in this manner they lower the content of NFC in dairy cattle diets. Cottonseeds are an excellent forage replacer; effectiveness factor similar to chopped silages. The upper limit on forage replacement is 25 to 35% of the forage DM in the diet. Relative to mechanically delinted cottonseed, whole cottonseed is on the high end of this range for replacement of dietary forage. Gossypol toxicity or adverse subclinical effects of gossypol on reproduction should not be a concern when no more than 15% cottonseed products (cottonseeds and cottonseed meal) are included in the total diet DM. Cottonseeds should be monitored for aflatoxin contamination. This is especially true for gin-run cottonseed that may be high in moisture content causing mold problems in storage. This cottonseed may be offered at a lower price, but may not be a good buy when potential storage problems and the higher moisture content are considered.

Distillers Dried Grains (DDG) is obtained after the removal of ethyl alcohol by distillation from the yeast fermentation of a grain or grain mixture by separating the resultant coarse grain fraction of the whole stillage and drying by methods employed in the grain distilling industry. The predominant grain shall be declared as the first word in the name; barley, cereals, corn, rye, sorghum, and wheat. The higher fraction of RUP relative to SBM makes DDG attractive in diets for lactating dairy cows. DDG are

commonly used by the feed industry as a component of protein supplements for dairy cattle. The formula feed industry generally limits DDG to less than 50% of protein supplements and 25% of complete feeds for dairy cattle. DDG are highly palatable. Upper feeding limits on DDG are listed at 10 to 15 lb. of DM per cow per day, but limits on daily intakes of 5 to 10 lb. of DM per cow are more common. The inclusion rate of DDG is often restricted because of its high fat content and the use of other high-fat ingredients in the diet. Precautions are generally taken to not supplement dietary fat from high-fat plant sources above 1.5 lb. per cow per day. DDG have limited value as a source of RUP in high corn silage diets because of their low lysine content. One quality concern with DDG is heat-damaged protein. Acid detergent insoluble nitrogen (ADIN) is the method typically used by forage testing laboratories to estimate heat damaged protein. DDG can be high in ADIN; ranging from 10 to 40% of CP (Chase. 199 1). Poor performance by lactating dairy cows has been observed when feeding DDG containing 25% to 35% of the CP in the ADIN fraction. Finding some protein in the ADIN fraction is a normal occurrence in protein supplements that undergo heating during processing, and lower concentrations probably do not limit animal performance because a portion of the ADIN is digestible. DDG are often used to reduce the NFC content of dairy cattle diets. DDG are also used as a forage replacer; effectiveness factor is 0.76 versus 1.0 for forages. The upper limit on forage replacement is 20 to 30% of the forage DM in the diet.

Distillers Dried Grains With Solubles (DDGS) is the product obtained after the removal of ethyl alcohol by distillation from the yeast fermentation of a grain or grain mixture by condensing and drying at least three-fourths of the solids of the whole stillage by methods employed in the grain distilling industry. The predominant grain shall be declared as the first word in the name; barley, cereals, corn, rye, sorghum, and wheat. Comments made in the section on DDG apply here as well.

Distillers Solubles is obtained after the removal of ethyl alcohol by distillation from the yeast fermentation of a grain or grain mixture by condensing the thin stillage fraction and drying it by methods employed in the grain distilling industry. The predominant grain shall be declared as the first word in the name; barley, cereals, corn, rye, sorghum, and wheat. Most distilleries add the liquid solubles to the grains and do not produce dried solubles. Condensed distillers solubles is obtained after the removal of ethyl alcohol by distillation from the yeast fermentation of a grain or grain mixture by condensing the thin stillage fraction to a semisolid. The predominant grain shall be declared as the first word in the name. Condensed distillers solubles can be marketed as a liquid feed ingredient. Contents of DM from 8 to 26% and CP from 30 to 35% (DM basis) for condensed distillers solubles have been reported in research trials (Chase, 1991). Cornell workers added condensed distillers solubles (26% DM) to rations for early lactation dairy cows at 0, 8, and 16% of total ration DM (Chase, 1991). Feed intake, milk production, and milk composition were similar for the three rations. Maximum daily intake of condensed distillers solubles was about 30 lb per cow (8 lb per cow of DM).

Distillers Wet Grains (DWG) is the product obtained after the removal of ethyl alcohol by distillation from the yeast fermentation of a grain or grain mixture. The guaranteed analysis shall include the maximum moisture. Typical nutrient analyses are similar to distillers dried grains, except for moisture. DWG is usually about 35% DM. A partially-dried DWG marketed as “modified” DWG is usually about 48% DM. Feeding limits are similar to those provided for DDG on DM basis. Comments made in the section on BWG regarding storage and handling apply here as well.

Hominy feed is a mixture of corn bran, corn germ and part of the starchy portion of either white or yellow corn kernels or mixture thereof, as produced in the manufacture of pearl hominy, hominy grits, or table meal, and must contain not less than 4 percent fat. The fiber, starch and fat content of hominy feed can vary; laboratory analysis is recommended. Hominy feed is generally used as a grain replacer. It is similar to ear corn in content of fiber and non-fiber carbohydrates and energy. The physical form of hominy feed is fine relative to dry corn that is typically processed on-farm, which enhances its energy value and content of ruminally-fermentable carbohydrate. Upper feeding limits on hominy feed are 10 to 15 lb. of DM per cow per day. The inclusion rate for hominy feed may need to be restricted if it tests high in fat content and other high-fat ingredients are being used in the diet. Precautions are generally taken to not supplement dietary fat from high-fat plant sources above 1.5 lb. per cow per day.

Malt Sprouts are obtained from malted barley by the removal of the rootlets and sprouts, which may include some of the malt hulls, other parts of malt, and foreign material unavoidably present. It must contain not less than 24% CP. The term "malt sprouts" when applied to the corresponding portion of other malted cereals must be used in qualified form, as, for example: "rye malt sprouts" and "wheat malt sprouts". Malt sprouts are commonly used by the feed industry as a component of protein supplements for dairy cattle. Upper feeding limits on malts sprouts are the same as for BDG. Malt sprouts are often used to reduce the NFC content of dairy cattle diets and as a forage replacer. However, they have limited forage replacement value; effectiveness factor of 0.48 versus 1.0 for forages. The upper limit on forage replacement is 15 to 25% of the forage DM in the diet.

Soy Hulls consist primarily of the outer covering of the soybean. Upper feeding limits on soy hulls are 8 to 12 lb. of DM per cow per day. Soy hulls are often used to reduce the content of NFC in dairy cattle diets. The NDF in soy hulls is highly fermentable in the rumen, and it can be used to supply fermentable fiber in the diet. Inclusion of soy hulls in early lactation diets allows the formulation of high NDF, moderate NFC diets of high energy density. Soy hulls have limited value as a forage replacer; effectiveness factor at 0.25 (fraction of NDF) and the upper limit on forage replacement at 10% of the forage DM in the diet. Soybean mill feed is composed of soybean hulls and the offal from the tail of the mill which results from the manufacture of soy grits or flour. It must contain not less than 13.0% CP and not more than 32.0% crude fiber. The protein, fiber and fat content of soybean mill feed can vary; laboratory analysis is recommended. One product, soybean screenings, has a typical nutrient analysis (DM basis) of 30% CP, 20% ADF, 30% NDF and 12% EE. This product can have a high percentage of weed

seeds. Its inclusion rate is restricted to 5 to 10 lb. per cow per day because of its high fat content and the use of other high-fat ingredients in the diet. Precautions are generally taken to not supplement dietary fat from high-fat plant sources above 1.5 lb. per cow per day.

Wheat By-Products. Wheat bran is the coarse outer covering of the wheat kernel as separated from cleaned and scoured wheat in the usual process of commercial milling. Wheat middlings consist of fine particles of wheat bran, wheat shorts, wheat germ, wheat flour, and some of the offal from the tail of the mill. This product must be obtained in the usual process of commercial milling and must contain not more than 9.5% crude fiber. It may be sold in either pelleted or meal form. Upper feeding limits on wheat bran and wheat middlings are 5 to 10 lb. and 10 to 15 lb. of DM per cow per day, respectively. Wheat bran is palatable, mildly laxative and highly bulky making it fairly popular in concentrates for dry cows. The inclusion rate of wheat midds in milking cow diets are often restricted because of their high content of RDP. Wheat midds are generally used as a grain replacer. Used in this manner they lower the content of NFC in dairy cattle diets. Wheat midds are also used as a forage replacer; effectiveness factor of 0.57 (fraction of NDF) versus 1.0 for forages. The upper limit on forage replacement is 20 to 25 percent of the forage DM in the diet.

High-Protein Byproducts

Plant Sources

Canola Meal consists of the meal obtained after the removal of most of the oil, either by direct or prepress solvent extraction processes, from rapeseed (Brassica spp.), the oil component of which contains less than 2% erucic acid and the solid component of which contains less than 30 micromoles of glucosinolates per gram of air-dry, oil-free solid. It must contain a minimum of 35% protein, a maximum of 12% crude fiber, and a maximum of 30 micromoles of glucosinolates per gram. Upper feeding limits for canola meal are 5 to 8 lb. of DM per cow per day. The inclusion rate of canola meal in milking cow diets is often restricted because of its high content of RDP.

Corn Gluten Meal (CGM) is the dried residue from corn after the removal of the larger part of the starch and germ, and the separation of the bran by the process employed in the wet milling manufacture of corn starch or syrup, or by enzymatic treatment of the endosperm. It may or may not contain fermented corn extractives and (or) corn germ meal. Upper feeding limits on CGM are 2 to 3 lb. of DM per cow per day. Palatability may be a problem when fed in a protein top-dress. The higher fraction of RUP relative to SBM makes CGM attractive in diets for lactating dairy cows. CGM is commonly used by the feed industry as a component of protein supplements for dairy cattle. The RUP in CGM has limited value because of its low lysine content, particularly in high corn silage diets. However, CGM is high in methionine and is often combined with high lysine bypass protein supplements like animal-marine protein by-products and heat-treated soybean products in protein blends. As with DDG, high ADIN may also be a concern for corn gluten meal.

Cottonseed Meal (CSM) is the product obtained by finely grinding the flakes which remain after removal of most of the oil from cottonseed by a solvent extraction process (solvent-extracted meal) or by finely grinding the cake which remains after removal of most of the oil from cottonseed by a mechanical extraction process (mechanically-extracted meal). It must contain not less than 36% CP. Its fiber content is higher and energy content lower than SBM. There are no feeding limits for CSM, but restrictions are generally imposed through formulation of diets to meet specifications for CP, RUP and RDP. Protein degradability is fairly high and similar to SBM. Gossypol toxicity or adverse subclinical effects of gossypol on reproduction should not be a concern when no more than 15% cottonseed products (cottonseeds and cottonseed meal) are included in the total diet DM. This upper feeding limit should be monitored when both whole cottonseeds and cottonseed meal are fed.

Linseed Meal is the product obtained by grinding the flakes which remain after the removal of most of the oil from flaxseed by a solvent extraction process (solvent extracted meal) or by grinding the cake or chips which remain after removal of most of the oil from flaxseed by a mechanical extraction process (mechanically-extracted meal). There are no feeding limits for linseed meal, but restrictions are generally imposed through formulation of diets to meet specifications for CP, RUP and RDP. Protein degradability is high and similar to SBM. Linseed meal is palatable and mildly laxative. Its fiber content is higher and energy content lower than SBM.

Soybean Meal (SBM) is the product obtained by grinding the flakes which remain after removal of most of the oil from either whole or dehulled soybeans by a solvent extraction process (solvent extracted meals). The product resulting from whole soybeans must contain not more than 7.0% crude fiber and not more than 12.0% moisture. The product resulting from dehulled soybeans must contain not more than 3.5% crude fiber and not more than 12.0% moisture. Mechanically extracted SBM is the product obtained by grinding the cake or chips which remain after removal of most of the oil from whole soybeans by a mechanical extraction process. It must contain not more than 7.0% crude fiber and not more than 12.0% moisture. Meals resulting from whole and dehulled soybeans contain 44% and 48% CP (as fed basis), respectively. Mechanically-extracted (expeller) meals contain more fat than solvent extracted meals. Expeller meals are also higher in RUP than solvent-extracted meals. The CP and RUP contents of SBM are highly variable. The higher fraction of RUP makes heat-processed SBM attractive in diets for lactating dairy cows. The RUP in heat-processed SBM has high value because of its high lysine content. There are no feeding limits for SBM, but restrictions are generally imposed through formulation of diets to meet specifications for CP, RUP and RDP.

Soybeans are processed to remove the oil for use as edible fats. The defatted by-product, SBM, is the most widely used protein concentrate in the animal feed industry. Full-fat soybeans however, are often used as a fat and protein supplement by dairy producers in soybean cropping areas. Relative to SBM, soybeans are lower in CP, but heat-processed soybeans are higher in RUP while the RUP content of raw soybeans is

low. The RUP content of heat-processed soybeans is highly variable. Soybeans contain 18% to 20% fat. The inclusion rate of soybeans is often restricted because of their high fat content and the use of other high-fat ingredients in the diet. Precautions are generally taken to not supplement dietary fat from high-fat plant sources above 1.5 lb. per cow per day. This limits consumption of soybeans to less than 7 lb. of DM per cow per day. Raw soybeans are generally limited to less than 3 to 4 lb. of DM per cow per day because of their high RDP and potential detrimental effects of trypsin inhibitor on protein digestion in the small intestine. Lower restrictions are often imposed through formulation of diets to meet specifications for RUP. It is generally recommended that soybeans be rolled or cracked prior to feeding. The higher fraction of RUP relative to SBM and raw soybeans makes heat processed soybeans attractive in diets for lactating dairy cows. The RUP in heat-processed soybeans has high value because of its high lysine content. Roasting and extrusion are the two common methods of heat treatment. Roasted soybeans are passed through a flame. In a drum roaster soybeans fall through a flame as they move through a rotating drum. Popping exposes soybeans beans to dry heat; transit time may be controlled by a conveyor system. It is becoming more popular to steep the soybeans after roasting or popping. Satter and co-workers (1993) recommended that soybeans should be heated to 295 degrees F and then steeped for 30 minutes for proper treatment. This helps ensure a high RUP value and reduces its variability. Proper heat treatment also eliminates concern about the anti -nutritional factors, trypsin inhibitor and urease and lipase-like enzymes, found in raw soybeans. Satter and co-workers (1993) also recommended using the protein dispersibility index (PDI) to evaluate the quality of roasted soybeans. It was recommended that soybeans be roasted to a PDI of 9 to 11. A PDI of 11 to 13 indicates a marginally low UIP value. A PDI of 13 to 15 suggests that soybeans have been under roasted. Extruded soybeans pass through a machine with a spiral, tapered screw that forces them through a tapered head. In the process the soybeans are ground and heated, producing a ribbon-like product. This releases the free oil from the soybean, which is the primary difference between unground roasted soybeans and extruded soybeans. This may lead to milkfat test depression when extruded soybeans are fed at more than 3 to 4 lb. of DM per cow per day.

Sunflower Meal (SFM) is obtained by grinding the residue remaining after extraction of most of the oil from either whole or dehulled sunflower seed by either solvent (solvent-extracted meal) or mechanical extraction (mechanically-extracted meal) processes. Dehulled SFM contains more fiber and less energy than SBM. SFM with hulls is lower in protein (28% vs. 45%) and energy and higher in fiber than dehulled SFM. There are no feeding limits for dehulled SFM, but restrictions are generally imposed through formulation of diets to meet specifications for CP, RUP and RDP. The inclusion rate of SFM in milking cow diets is often restricted because of its high content of RDP. Upper feeding limits on SFM with hulls are 5 to 8 lb. of DM per cow per day. The hulls in SFM are low in digestibility. This restricts the energy value of SFM with hulls, and thus the feeding rate. However, this gives it some value as a forage replacer; the upper limit on forage replacement value of sunflower meal with hulls is 10 to 15% of the forage DM in the diet.

Animal-Marine Sources

Blood Meal is produced from clean, fresh animal blood, exclusive of all extraneous material such as hair, stomach belchings, and urine except in such traces as might occur unavoidably in good manufacturing processes. Types of blood include conventional cooker dried, flash dried, and spray dried. Spray drying produces a product that readily takes up and retains moisture and is not suitable for feed use. Cooker drying is an older process that has been used for many years, but the results are not uniform. Flash drying is a newer process which produces a product uniform in color with high lysine content (about 9% of CP).

Hydrolyzed Feather Meal results from the treatment under pressure of clean, undecomposed feathers from slaughtered poultry, free of additives and (or) accelerators. Not less than 75% of CP must be digestible as measured by the pepsin digestibility method.

Fish Meal is the clean, dried, ground tissue of undecomposed whole fish or fish cuttings, either or both, with or without the extraction of part of the oil.

Meat and Bone Meal is the rendered product from mammal tissues, including bone, exclusive of blood, hair, hoof, horn, hide trimmings, manure, stomach and rumen contents, except in such amounts as may occur unavoidably in good processing practices. It shall contain a minimum of 4% phosphorus and the calcium level shall not be more than 2.2 times the actual phosphorus level. It shall not contain more than 14% pepsin indigestible residue and not more than 11% of the CP in the product shall be pepsin indigestible. The label shall include guarantees for minimum CP, minimum crude fat, maximum crude fiber, and minimum phosphorus. Meat meal is defined the same as meat and bone meal except that no minimum phosphorus level is required. Meat & bone meal and meat meal that are fed to cattle must be derived from non-cattle sources, i.e. pork, according to FDA regulations.

Poultry By-Product Meal consists of the ground, rendered, clean parts of the carcass of slaughtered poultry, such as necks, feet, undeveloped eggs, and intestines, exclusive of feathers, except in such amounts as might occur unavoidably in good processing practices. The label shall include guarantees for minimum CP, minimum crude fat, maximum crude fiber, and minimum phosphorus. The calcium level shall not exceed the actual level by more than 2.2 times.

Animal-marine protein by-products are concentrated sources of protein ranging from 54% to 90% CP (DM basis). They are also high in RUP ranging from 50% to 80% of CP. The CP content of animal-marine protein by-products and their RUP are highly variable. The higher fraction of RUP relative to soybean meal makes animal-marine protein by-products attractive in diets for lactating dairy cows. The RUP in blood meal and fish meal has high value because of its high lysine content. Fish meal is also high in methionine. Fish meal has an amino acid profile close to that believed to be required for milk production. The RUP in meat and bone meal and poultry byproduct meal is

relatively high in lysine. Although feather meal has a relatively poor balance of amino acids, particularly lysine and methionine, it is a good source of sulfur and sulfur amino acids because of its high cystine content. This high content of cystine may conserve some of the methionine in the ration making the amino acid profile of feather meal appear more favorable, but research is needed. Fish meal, meat and bone meal, and poultry by-product meal are high in calcium and phosphorus. Because the relative biological availabilities of calcium and phosphorus are good, supplemental inorganic mineral needs are reduced when these ingredients are fed. One of the major concerns about using animal-marine protein by-products as feed ingredients is their quality and nutrient consistency. Variation in nutritive value of animal-marine protein by-products is related to variation in source of raw materials available to rendering operations and(or) processing conditions such as pressure, temperature, and cooling time at different locations and at different times. For example, the RUP content of fish meal can vary from 30 to 70 percent depending on processing conditions. These include the length of time the raw fish are stored before processing, type of dryer used, duration of heating, and extent of solubles add-back. Another concern is the variability in content of digestible protein in hydrolyzed feather meal. Research also shows that RUP and post-ruminal protein digestibility of meat and bone meal are highly variable. The calcium and phosphorus contents of meat and bone meal are highly variable. Purchase ingredients from reputable suppliers of animal-marine protein byproducts or feed dealers who are willing to assure minimum quality standards. Meat and bone meal must be stored and handled properly to avoid problems with salmonella contamination. Meat and bone meal should be stored in a clean, dry bin or container covered to prevent contact with dogs, cats, rodents, and birds. Typical feeding rates for blood meal, hydrolyzed feather meal, fish meal, meat and bone meal, and poultry byproduct meal are .5-1.0, 1.0-1.5, 1.0-1.5, 1.0-2.0, and 1.0-1.5 pounds per cow per day, respectively. Lower restrictions are often imposed because of problems with palatability. Feeding animal-marine protein byproducts as a top-dress is difficult. Blending animal-marine protein by-products with the grain or forage at the time of feeding can help alleviate palatability problems. Animal-marine protein by-products can be mixed at about 10% of the protein concentrate with reasonable palatability of the top-dress. Even at this low inclusion rate cows should be adapted to animal-marine protein by-products gradually, and molasses addition to the protein concentrate may improve its palatability. Inclusion of animal-marine protein by-products into a TMR must also be done gradually to prevent depression of intake of the TMR. Monitor TMR intakes of fresh cows closely when feeding animal-marine protein by-products.

Unusual By-Product Feedstuffs

This section was adapted from a Western Regional Extension publication (Bath and co-workers, 1982) and the Proceedings of the Dairy Feeding Systems Symposium (Adams, 1990).

Bakery Wastes. Stale bread and other pastry products from stores or bakeries can be fed to dairy cattle in limited amounts. These products are sometimes fed as received without drying or even removal of the wrappers. They may be run through a forage

chopper to facilitate feeding. Some distributors and dairy producers dry and grind the material for inclusion into a concentrate or TMR. The feeding rate of bakery wastes must be limited to avoid milk fat test depression, because they are relatively high in cooked starch. The upper feeding limit for dried bread is 20% of concentrate DM and 10% of TMR DM. Higher levels may be fed to replacement heifers and dry cows. For bakery wastes that are relatively high in fat (i.e. donuts at 25% fat), the feeding rate should be limited so that no more than one pound of added fat per cow per day is consumed. This level may need to be reduced if other sources of non-rumen inert fat are included in the diet. Dried bakery product is a fairly standardized ingredient used by the feed industry. It generally consists of a mixture of bread, cookies, cake, crackers, flours and doughs.

Beans. Cull dried beans or peas contain about 25% CP (DM basis). They may comprise up to 15-20% of concentrate DM or 7- 10% of TMR DM. Palatability and protein quality restrict their use to these levels. It is generally recommended that they be rolled prior to feeding. An anti-nutritional component of raw navy beans, lectins, reduces nutrient absorption in the small intestine and limits their feeding rate to less than 2 lb per cow per day. Typical nutrient analyses (DM basis) for dried navy beans are 24% CP, 8% ADF, 0.88 Mcal NEI/lb, 0.15% calcium, 0.59% phosphorus, and 1.4% EE. Raw beans are high in RDP (70-80% of CP). Heat processing will minimize the detrimental effects of lectins on nutrient digestion and increase the RUP value of beans.

Corn Screenings. Corn screenings are normally similar to shelled corn in nutrient content. They are generally fine enough so that no additional processing is necessary. They often sell for less than corn or hominy. Corn screenings should be tested for mycotoxins because these toxins tend to associate with the fines when mold problems exist in corn. Vomatoxin is an indicator of mycotoxin contamination.

Candy. Candy products are available through a number of distributors and sometimes directly from smaller plants. They are often economical sources of nutrients, particularly fat. They may be high in sugar and (or) fat content. Milk chocolate and candy may contain 48% and 22% fat, respectively. They are sometimes fed in their wrappers. Candies, such as cull gummy bears, lemon drops or gum drops, are high in sugar content. Several ingredient firms that handle food processing wastes produce blends of candy or chocolate with other ingredients, such as pasta or peanut skins. These are generally standardized to a certain content of protein and fat. Typical nutrient analyses (DM basis) for candy, blended candy products, and chocolate are 5.2% CP, 5% ADF, 1.10 Mcal NEI/lb, 0.07% calcium, 0.17% phosphorus, and 22.4% EE, 13.0% CP, 12.1 % ADF, 1.07 Mcal NEI/lb, 0.13% calcium, 0.20% phosphorus, and 17% EE, and 12.9% CP, 4% ADF, 1.30 Mcal NEI/lb, 0.07% calcium, 0.17% phosphorus, and 48.7% EE, respectively. The upper feeding limits for candy or candy blends and chocolate are 5 and 2 lb. per cow per day, respectively. This is approximately 15% of concentrate DM or 10% of TMR DM for candy and candy blends and 6% of concentrate DM or 4% of TMR DM for chocolate. The feeding rate of high-sugar candies should be limited to 2 to 4 lb. per cow per day.

Fat. Commonly used fat sources include whole oilseeds, animal fat, and various ruminally-inert granular fat products. Most herds supplementing fat are using a combination approach. Intake of supplemental fat from whole oilseeds should be limited to about 1.5 lb. per cow per day or 3% of TMR DM. This limits intake of whole oilseeds to less than 7 lb. of DM per cow per day or 15% of TMR DM. Additional supplemental fat should come from a source relatively insoluble or inert in the rumen, such as beef tallow and (or) granular fats, depending upon handling, feeding, palatability and cost considerations. Many herds have experienced good success feeding beef tallow at up to 2% of ration DM (about a pound per cow per day). Feeding choice white grease may be a concern in corn silage based diets from the standpoint of milk fat test depression. Restaurant grease is not recommended for lactating dairy cows because of concerns about milk fat test depression related to trans fatty acids found in hydrogenated vegetable oils. Because the fatty acid profile of vegetable oil is more highly unsaturated than animal fat, its feeding rate should be limited to 0.5 lb per cow per day and it should not be fed along with whole oilseeds. Total ration fat levels for lactating dairy cows are typically 5% to 6.5% of ration DM.

Liquid Whey. Because this by-product of cheese manufacture presents a disposal problem for many cheese plants, it is often delivered to dairy farms free of charge or for a small transportation fee. Liquid whey consists primarily of lactose, protein, minerals and water. Most liquid whey's contain only 4 to 7% DM, but the solids fraction is relatively high in feeding value. Sometimes condensed or higher solids whey is provided. Whey has a variable protein content ranging from 9% to 30% CP (DM basis). However, most whey's contain 11% to 13% CP (DM basis) and have an energy value close to ear corn. Some whey's contain 7% to 8% fat, but most contain only 0.2% to 1% fat (DM basis). It is important to have an expected nutrient analyses provided by the plant, and it is recommended that the delivered material be tested periodically. Whey is best provided using a tank or watering device. Frost-free, low energy waterers may be used to provide whey under pressure or gravity feed. This method minimizes fly problems. Air or another agitation system should be used to prevent the solids from settling out before the whey is consumed. Both sweet whey from hard cheese manufacture and acid whey from cottage cheese manufacture are available. Both reach a low pH of 3 to 4 shortly after delivery which keeps spoilage problems to a minimum. Plastic lines and valves should be used when piping stall barns for feeding whey through drinking cups. Holstein cows usually will drink 80 to 100 lb per day of low-solids whey when it is offered free-choice. This may reduce forage consumption if adjustments are not made in concentrate feeding. It is recommended that the ration be balanced and the amount of concentrate and its nutrient specifications be adjusted according to the nutrients provided by the whey. Whey should be treated as a wet concentrate in ration formulation. Generally, few problems are encountered when feeding liquid whey to dairy cattle. However, bloat or acidosis and even death may occur if the supply is allowed to run out and hungry animals over-consume whey in a short time. Whey should be available at least 18 to 20 hours daily. It is important that animals fed liquid whey are allowed access to water. They may reduce water consumption on their own, but water must be available at all times. However, it may be necessary in some cases to restrict water intake for 5 to 10 hours each day for several days when initially starting to feed

whey to encourage cows to drink it. It is recommended that intakes of liquid whey be limited to not more than 100 to 150 lb per cow per day. Liquid whey can also be used in feeding programs for replacement heifers.

Nuts. Peanuts, cashews, and various nuts or nut mixtures are sometimes available from processors. Most contain 18% to 27% CP and 45% to 65% fat (as fed basis). This high fat content restricts their use to less than 2 to 3 lb per cow per day. Nuts and nut mixtures should be analyzed frequently, particularly for fat and protein content, because the different kinds and mixtures are highly variable.

Pasta is available from pasta plants and some ingredient distributors as straight pasta or in blends with other ingredients, such as candy. Pasta must be used in limited amounts to avoid depression of milk fat test, because it is mostly starch. It does not have as much of a propensity for depression of milk fat test as cooked starch or bread. Typical nutrient analyses (DM basis) for pasta are 14.6% CP, 3% ADF, 0.90 Mcal NEI/lb, 0.02% calcium, 0.16% phosphorus, and 1.6% EE. Pasta can be fed at up to 4 to 8 lb of DM per cow per day depending on the starch content of the diet.

Peanut Skins are available from ingredient suppliers either straight or in blends with other ingredients. Typical nutrient analyses (DM basis) for peanut skins are 17.4% CP, 16.3% ADF, 0.68 Mcal NEI/lb, 0.16% calcium, 0.07% phosphorus, and 26% EE. The protein is poorly digested and should be discounted by half when formulating rations. Peanut skins have a low energy value despite their high fat content, because of poor digestibility. Peanut skins should be limited to less than 15% of concentrate DM or 7% of TMR DM, because of their poor palatability and high fat content.

Potato Waste is available in potato processing areas, and includes cull potatoes, french fries and potato chips. Cull fresh potatoes that are not frozen, rotten, or sprouted can be fed to cows either whole or chopped. Potato waste straight from a processing plant may contain varying amounts of inedible or rotten potatoes. french fries or chips, skins, and fats or oils from frying operations. Potato waste usually contains 75% to 80% moisture. It should be treated as a wet, starchy concentrate in ration formulation, and limited to not more than 25 to 35 lb as fed or 5 to 8 lb of DM per cow per day. Typical nutrient analyses (DM basis) for cull potatoes and potato waste are 10% CP, 3% ADF, 0.83 Mcal NEI/lb, 0.02% calcium, 0.24% phosphorus, and 0.4% EE and 8% CP, 6% ADF, .87 Mcal NEI/lb, 0.16% calcium, 0.25% phosphorus, and 5% EE, respectively.

Snap Bean Cannery Waste typical nutrient analyses (DM basis) are 10% DM, 23.5% CP, 17% ADF, 0.75 Mcal NEI/lb, and 3% EE. It can be used to replace some of the hay or silage in the ration. However, it should be limited to not more than 30 to 40 lb as fed per cow per day because of its high moisture content. Storage life in piles probably does not exceed a few days to prevent heating and spoilage.

Soy Cakes are a by-product of the production of soy sauce. Typical nutrient analyses (DM basis) are 70-75% DM, 27-30% CP, 15-20% ADF, 0.90-.95 Mcal NEI/lb, 0.60-0.70% calcium, 0.15-0.20% phosphorus, and 10% EE. Soy cakes contain 8% to 10%

salt. This limits their use to not more than 5 lb as fed per cow per day. No additional salt is needed in the diet when soy cakes are fed at their upper limit, but cows can be allowed access to free-choice salt. Supplemental trace minerals will need to be provided from another source if previously provided from trace-mineralized salt. Soy cakes should not be fed to dry cows, because of concerns about causing udder edema. It is recommended that the salt content of soy cakes be checked periodically. Soy cakes resulting from the production of low-sodium soy sauce will be lower in salt content. More supplemental salt will need to be included in the diet when this type of product is fed. Soy cakes with a low salt content may undergo excessive heating in storage and have a shorter storage life due to their high moisture content.

Starch. Unheated starch is available from some candy manufacturers and sometimes may contain pieces of candy. Typical nutrient analyses (DM basis) for waste starch are 10.8% CP, 4.4% ADF, 0.85 Mcal NEI/lb, 0.13% calcium, 0.18% phosphorus, and 0.4% EE. It may comprise up to 15-20% of concentrate DM or 7-10% of TMR DM depending on the starch content of the diet. It is most effective when used in rations needing more rumen fermentable starch.

Sunflower Seeds. Typical nutrient analyses (DM basis) for oilseed and confectionery varieties are 19.6% CP, 16.5% ADF, 1.38 Mcal NEl/lb, 0.26% calcium, 0.67% phosphorus, and 44% EE and 23.5% CP, 28.5% ADF, 0.97 Mcal NEI/lb, 0.30% calcium, 0.60% phosphorus and 25% EE, respectively. Oilseed varieties comprise about 95 percent of all sunflowers grown in the U.S. Intake of supplemental fat from whole oilseeds should be limited to about 1.5 lb. per cow per day or 3% of TMR DM. This limits intake of oilseed sunflower varieties to less than 3.5 lb of DM per cow per day or 7% of TMR DM. The limit on confectionery sunflower varieties is 6 lb of DM per cow per day or 12% of TMR DM. Sunflower seeds can be fed whole without any processing. Research trials at South Dakota State University (Schingoethe, 1992) showed no advantage to rolling or cracking sunflower seeds. There are no palatability problems when sunflower seeds are fed in TMRs. However, cows may not readily consume sunflower seeds when top-dressed or fed separately from other ration ingredients. Sunflower seeds have some value as a forage replacer; the upper limit on forage replacement value of sunflower seeds is 5 to 10 percent of the forage dry matter in the diet. The low digestibility of the fiber in sunflower seeds relative to whole cottonseeds is a disadvantage of sunflowers.

Sweet Corn Cannery Waste results from sweet corn that is canned or frozen. Cannery waste consists primarily of husks, cobs, cull ears, and missed kernels. The feeding value on a DM basis of cannery waste is about the same as poorly-eared field-corn silage. The primary difference being its moisture content; this is about 75-80%. Its nutrient composition is highly variable and periodic testing is recommended. It is generally stored as silage in bunker or trench silos. It works best in rations for low producing cows, dry cows and older replacement heifers, because its high moisture and acid content may limit intake of high producing cows. It can be used to replace some of the hay or silage in the ration, but it should be limited to not more than 25 to 35 lb as fed

per cow per day because of its variable nutrient composition and high moisture and acid content.

Vegetable Tops and Trims are available from vegetable processing and packaging plants. They consist primarily of carrot and beet tops, spinach, celery, and outer leaves of lettuce and cabbage. Most contain 15% to 30% CP and 10% to 20% ADF (DM basis). They are usually fed fresh but sometimes are ensiled mixed with other forages. Storage life in piles probably does not exceed a few days to prevent heating and spoilage. They should be analyzed for nutrient content periodically and whenever there is an obvious change in the material. They should be treated like wet (85-95% moisture) forages when formulating rations because of their large particle size, high ash content, and estimated energy content (0.62-0.68 Mcal NEl/lb of DM).

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Table 1. Nutrient composition (DM basis) of byproduct feeds (Dairy NRC, 2001)[1].

Ingredient	DM %	CP %	RUP %[2]	TDN %	NDF %	NFC %	Fat %	Ca %	P %	Mg %	K %	S %
Alfalfa Meal	90.3	19.2	41	56.4	41.6	28.8	2.5	1.47	0.28	0.29	2.37	0.26
Beet Pulp	88.3	10.0	76	69.1	45.8	41.3	1.1	0.91	0.09	0.23	0.96	0.30
Bakery												
Meal	84.7	12.5	24	93.5	13.9	62.6	9.5	0.20	0.36	0.13	0.42	0.14
Bread	68.3	15.0	24	89.3	8.9	71.7	2.2	0.14	0.20	0.05	0.23	0.17
Cereal	88.5	9.1	21	87.6	10.0	77.4	3.5	0.17	0.29	0.10	0.33	0.10
Cookies	90.1	9.7	24	95.0	12.7	65.9	10.6	0.23	0.29	0.13	0.46	0.13
Blood Meal	90.2	95.5	78	76.4	--	--	1.2	0.30	0.30	0.03	0.33	0.77
BDG	90.7	29.2	57	71.3	47.4	23.0	5.2	0.30	0.67	0.26	0.50	0.38
BWG	21.8	28.4	35	71.6	47.1	23.7	5.2	0.35	0.59	0.21	0.47	0.33
Canola Meal	90.3	37.8	36	69.9	29.8	25.9	5.4	0.44	0.68	0.21	0.91	0.42
Citrus Pulp	85.8	6.9	32	79.8	24.2	57.2	4.9	1.92	0.12	0.12	1.10	0.10
Chocolate	95.2	11.9	18	102.7	23.8	41.7	20.5	0.22	0.30	0.22	1.18	0.11
Corn, Shelled	88.1	9.4	47	88.7	9.5	76.1	4.2	0.04	0.30	0.12	0.42	0.10
CGF	89.4	23.8	30	74.1	35.5	34.0	3.5	0.07	1.00	0.42	1.46	0.44
CGM	86.4	65.0	75	84.4	11.1	21.7	2.5	0.06	0.60	0.14	0.46	0.86
Cottonseed												
w/Lint	90.1	23.5	23	77.2	50.3	8.2	19.3	0.17	0.60	0.37	1.13	0.23
Hulls	89.0	6.2	56	34.3	85.0	6.5	2.5	0.18	0.12	0.17	1.16	0.07
Meal	90.5	44.9	48	66.4	30.8	18.9	1.9	0.20	1.15	0.61	1.64	0.40
DDGS	90.2	29.7	51	79.5	38.8	24.9	10.0	0.22	0.83	0.33	1.10	0.44
Fish Meal	91.2	68.5	66	79.9	--	--	10.4	5.34	3.05	0.20	0.74	1.16
HFM	93.3	92.0	65	72.8	--	--	4.6	0.33	0.50	0.22	0.33	1.39
Hominy	88.5	11.9	31	83.1	21.1	61.6	4.2	0.03	0.65	0.26	0.82	0.12
Linseed Meal	90.3	32.6	53	65.4	36.1	31.0	1.7	0.40	0.83	0.55	1.22	0.37
Malt Sprouts	90.5	20.1	27	66.4	47.0	26.9	2.3	0.24	0.51	0.18	1.19	0.29
MBM	94.0	54.2	58	61.9	--	--	10.4	10.6	4.73	0.24	1.02	0.39
Molasses	74.3	5.8	18	81.0	0.2	80.3	0.4	1.00	0.10	0.42	4.01	0.47
Peanut Meal	92.3	51.8	13	74.8	21.4	25.4	1.4	0.20	0.64	0.32	1.32	0.32
Potato Meal	35.4	10.5	76	80.7	22.1	49.0	10.8	0.49	0.29	0.11	1.04	0.11
Soybean												
Raw	90.0	39.2	30	101.0	19.5	14.9	19.2	0.32	0.60	0.25	1.99	0.31
Heated	91.0	43.0	40	98.8	22.1	12.9	19.0	0.26	0.64	0.25	1.99	0.32
Hulls	90.9	13.9	45	67.3	60.3	21.8	2.7	0.63	0.17	0.25	1.51	0.12
SBM												
44% solv.	89.1	49.9	35	80.0	14.9	27.7	1.6	0.40	0.71	0.31	2.22	0.46
48% solv.	89.5	53.8	43	81.4	9.8	29.6	1.1	0.35	0.70	0.29	2.41	0.39
Expeller	89.6	46.3	69	88.5	21.7	28.0	8.1	0.36	0.66	0.30	2.12	0.34
Sunflower												
Whole	91.8	19.2	11	122.3	24.0	12.7	41.9	0.71	0.51	0.34	1.06	0.21
Meal	92.2	28.4	16	59.9	40.3	27.7	1.4	0.48	1.00	0.63	1.50	0.39
Tallow	99.8	--	--	147.4	--	--	99.8	--	--	--	--	--
Vegetable Oil	100.0	--	--	184.0	--	--	99.9	--	--	--	--	--
Wheat												
Bran	89.1	17.3	21	71.5	42.5	32.4	4.3	0.13	1.18	0.53	1.32	0.21
Middlings	89.5	18.5	24	73.3	36.7	38.1	4.5	0.16	1.02	0.42	1.38	0.18
Whey, wet	20.8	14.6	6	80.3	--	74.9	0.7	1.37	1.04	0.22	3.22	1.15

[1]BDG=Brewers Dried Grains; BWG=Brewers Wet Grains; CGF=Corn Gluten Feed; CGM=Corn Gluten Meal; DDGS=Distillers Dried Grains w/Solubles; HFM=Hydrolyzed Feather Meal; MBM=Meat & Bone Meal; SBM=Soybean Meal.

[2]RUP expressed as a percentage of CP; Dairy NRC calculations assumed 50% forage diet (DM basis) and DMI=4% of body weight.