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Using food waste as livestock feed

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To ensure a safe and well-balanced diet for their animals, livestock producers should consult an animal nutritionist or veterinarian before feeding food waste.

The costs of growing livestock feed are increasing due to rising fuel and fertilizer costs and the increasing frequency of extreme weather conditions such as the 2012 drought in Wisconsin. As a result, alternative sources of feed ingredients are needed. Food waste may be one such alternative source.

Every year in the United States more than 40% of edible food—about 34 million tons—is wasted (Gunders, 2012). This wasted food accounts for one-fifth of the municipal solid waste entering the nation's landfills (U.S. EPA, 2011). In Wisconsin alone, landfills accepted 455,000 tons of food waste in 2009 (Recycling Connections Corp., 2010). The cost of disposing of food in the nation's landfills is high, estimated to range from $750 million to $2 billion each year (Gunders, 2012). In addition to being costly to deal with, this food waste contributes significantly to global warming, causing almost 20% of U.S. methane gas emissions (U.S. EPA, 2013).

Using food waste in livestock feeds can help farmers reduce feed costs and help food waste generators reduce disposal costs while minimizing the environmental impacts of this waste.

Many different types of food waste—everything from wheat by-products to candy—are palatable and nutritionally beneficial to animals. Guidelines have been developed for feeding alternative food waste and food by-products to cattle and swine.

Although food waste offers a viable alternative feedstuff for livestock, certain restrictions are imposed by federal and Wisconsin state regulations in order to protect animal and human health, and both sets of laws should be reviewed before feeding food waste to livestock.

Federal regulations

The Food and Drug Administration (FDA) and United States Department of Agriculture (USDA) are the federal agencies that regulate the feeding of food waste to livestock.

Livestock, general

With increased concern for the spread of bovine spongiform encephalopathy (BSE, or "mad cow disease"), the FDA, in 2008, strengthened earlier regulations regarding the inclusion of certain animal parts in animal feed and specifically prohibited certain cattle parts from any animal feed. Cattle parts barred from all animal feed include "the entire carcass of BSE-positive cattle; the brains and spinal cords of cattle 30 months of age and older; the entire carcass of cattle not inspected and passed for human consumption… that are 30 months of age or older from which brains and spinal cords were not effectively removed…; mechanically separated beef [as defined later in the regulation]; and tallow [also as defined later]." (USDA, C.F.R., 2008)

Swine

The Swine Health Protection Act of 1982 (Federal Food, Drug, and Cosmetic Act, FFDCA) regulates food waste fed to swine that contains any meat products.

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Compliance with this Act ensures that all food waste fed to swine is properly treated to kill disease organisms. This law mandates that all food waste must be boiled for 30 minutes by a licensed treatment facility prior to arrival at a site where swine are kept, in order to prevent disease transmission. This requirement does not include the following items: "Processed products; rendered products; bakery waste; candy waste; eggs; domestic dairy products (including milk); fish from the Atlantic Ocean within 200 miles of the continental United States or Canada; or fish from inland waters of the United States or Canada which do not flow into the Pacific Ocean." A 2009 amendment also excludes from the boiling requirement "processed products," or those which are deemed by the Animal and Plant Health Inspection Service (APHIS; USDA) to have undergone satisfactory levels of disease organism inactivation.

Ruminants

Animal proteins, defined as follows by the FDA, are prohibited from ruminant feed: "… any protein-containing portion of mammalian animals, excluding blood and blood products; gelatin; tallow containing no more than 0.15 percent insoluble impurities … inspected meat products which have been cooked and offered for human food and further heat processed for feed … milk products … and any product whose only mammalian protein consists entirely of porcine or equine protein." (USDA, C.F.R., 2008)

Wisconsin state regulations

Swine

Though it is federally legal to feed to swine food waste containing animal parts that meet the requirements of the Swine Health Protection Act, it is unlawful (with certain exemptions) under Wisconsin State Statute 95.10 (Feeding of Garbage to Swine) to do so, and **Wisconsin state statutes supersede federal law**. According to the Wisconsin regulation, "it is unlawful for any person to feed public or commercial garbage to swine, or to deposit or receive such garbage on any premises where swine are kept, and no swine having fed on such garbage may be sold or removed from the premises." Garbage is defined as "putrescible animal or vegetable waste containing animal parts (includes dairy-based products), resulting from the handling, preparation, processing, cooking or consumption of food and which is collected from any source, and includes dead animals… [but] does not apply to private household waste not removed from the premises where produced." (see Appendix 7, Wisconsin Statute 95: Animal Health 95.10: Feeding of Garbage to Swine, last page)

Other Livestock

No state laws govern the feeding of food waste to other livestock.

Other considerations

The regulations cited above only define the legal requirements for feeding food waste to livestock. They do not address the nutritional needs of livestock animals or the nutritional quality of the various kinds of food waste. To ensure a safe and well-balanced diet for their animals, livestock producers should consult an animal nutritionist or veterinarian before feeding food waste.

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Appendices

Appendix 1

By-Product Feedstuffs in Dairy Cattle Diets in the Upper Midwest, Randy Shaver Professor and Extension Dairy Nutritionist, Department of Dairy Science, College of Agricultural and Life Sciences, University of Wisconsin–Madison, University of Wisconsin-Extension, 18 pages.

Appendix 2

Feeding Cull Potatoes to Dairy and Beef Cattle, Ken Schroeder, UW-Extension Agriculture Agent, Portage County, UW-Extension, October 2012, 4 pages.

Appendix 3

Feeding Cabbage Waste, Liz Binversie, UW-Extension Dairy and Livestock Educator, Outagamie County; Zen Miller, UW-Extension Dairy and Livestock Agent, Outagamie County; UW-Extension, May 2013, 2 pages.

Appendix 4

By-Product Feed Ingredients for Use in Swine Diets, Nutrition Guide, Bob Thaler, South Dakota State University; Palmer Holden, Iowa State University, National Swine, 12 pages.

Appendix 5

Alternative Feed Ingredients in Swine Diets II: Use, Advantages and Disadvantages of Common Alternative Feedstuffs, Pork Checkoff, National Pork Board, 25 pages.

Appendix 6

Animal Proteins Prohibited in Ruminant Feed & Cattle Materials Prohibited in All Animal Feed, Washington State Department of Agriculture, Agr Pub 631-282 (N/10/09), 8 pages.w

Appendix 7

Wisconsin Statute 95: Animal Health 95.10: Feeding of Garbage to Swine

Appendix 1

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 NEl/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 NEl/lb, 0.07% calcium, 0.17% phosphorus, and 22.4% EE, 13.0% CP, 12.1 % ADF, 1.07 Mcal NEl/lb, 0.13% calcium, 0.20% phosphorus, and 17% EE, and 12.9% CP, 4% ADF, 1.30 Mcal NEl/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 NEl/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 NEl/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 NEl/lb, 0.02% calcium, 0.24% phosphorus, and 0.4% EE and 8% CP, 6% ADF, .87 Mcal NEl/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 NEl/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 NEl/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 NEl/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 NEl/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.

Appendix 2

Feeding Cull Potatoes to Dairy and Beef Cattle

Ken Schroeder, UW-Extension Agriculture Agent, Portage County

October 2012

In a year where feed is in short supply and grain prices are high, dairy and beef cattle producers begin looking for alternative feedstuffs. One option worth considering is cull potatoes. In Wisconsin we grow potatoes on about 62,000 acres and produce almost 26 million hundredweight (cwt) of potatoes or 1.3 million tons annually. The 2012 North American potato crop is expected to surpass 2011 production by 42.5 million cwt, or 8.1%. US production is forecast to increase by 8.4%, while the Canadian crop is up 7.1%. At 564.0 million cwt, the forecast would make this North America's largest potato crop since 2004.

Potatoes unsalable because they do not meet size, grade, or quality standards, or potatoes disposed of because of low market value due to over production are considered cull potatoes. This culling occurs at harvest as potatoes go into storage and then again when they are removed from storage and packed for sale. Those that are diseased, damaged, out of grade, or in oversupply are culled and discarded. 2012 is shaping up to have some overages and potato packers and processers will likely be looking to move those extra potatoes.

Feeding potatoes to dairy cattle: Potatoes can be incorporated into properly balanced dairy rations. Studies show it is best to limit the amount of potatoes fed to not more than 25 to 35 lbs. as-fed per cow per day or 5 to 8 lbs. on a dry matter (DM) basis. Introduce at a rate of two to three lbs. as-fed per head per day until desired rate is reached. Avoid replacing more than 20% of the overall ration DM with potatoes. Higher levels may cause milk fat depression. When feeding cull potatoes to dairy cattle it is best to use washed potatoes. Quite often potatoes coming out of storage are washed prior to sorting and thus the culls are washed as well. Check with your supplier.

Halliday 2010

Feeding potatoes to beef cattle: A total mixed ration of forage, grain, potato, minerals, and vitamins makes a good feedlot ration. Introduce into the ration with increasing amounts over a two to three week period. Start at 3 to 4 lbs. as-fed per head per day and increase to 25 lbs. per day for yearlings and 35 to 40 lbs. per head per day for 1100 lb. cows. Avoid replacing more than 50% of the ration on an as-fed basis with potatoes as performance usually drops beyond this point. Cull potatoes fed to livestock should be reasonably clean and free from dirt.

Nutritional value of potatoes: Potatoes are high in energy, very palatable, and medium to low in protein and vitamin A. Their high starch content puts them in the same category as feed grains in terms of energy on a DM basis. Potatoes should be considered a high moisture grain, not forage. DM content of potatoes varies from 15 to 25% depending on potato variety, storage conditions, and length of time in storage. Therefore, it takes 400 to 450 lbs. of potatoes as-fed to equal 100 lbs. of grain on an energy basis. On a DM basis, potatoes have as much crude protein as shelled corn, slightly more than corn silage, and about 60% that of alfalfa. Phosphorous content is equal to corn, corn silage, and alfalfa. Potassium content is as high as alfalfa, double that of corn silage, and over five times that of shelled corn. Typical nutrient analyses on a DM basis for cull potatoes is 10% crude protein, 3% ADF, 0.83 Mcal Nel/lb, 0.02% calcium, 0.24% phosphorous, and 0.4% EE.

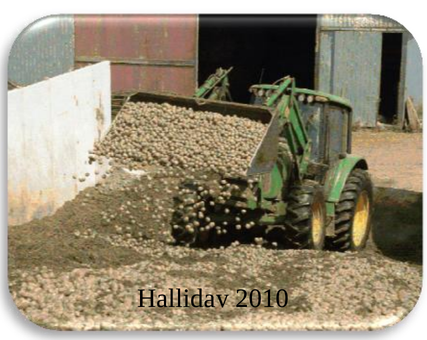
Feeding and handling methods: Potatoes are most often fed in a total mixed ration. They can be used whole, chopped, or crushed. Avoid feeding whole frozen potatoes. If fed whole be sure to have adequate feed bunk space to avoid competition at the feeder. Competition increases the likelihood of cattle gulping down feed and increases the possibility of choking. Additionally, one can use a rail placed 2.5 to 3 feet above the bunk to prevent cattle from raising their heads while eating. As long as their heads remain down there is little chance of choking. When potatoes are left whole there may also be some sorting of the potatoes.

Chopping or crushing potatoes prior to feeding will eliminate the sorting issue and greatly reduce the risk of choking. Some possibilities for processing include using a tub grinder, running them through a forage harvester, crushing between rollers, or driving over the potatoes with a heavy tractor or loader. Keep in mind that once chopped or crushed, storage time will be greatly reduced.


Pavlista

Also of concern are green and sprouted potatoes. Avoid feeding large quantities of green or sprouted potatoes because they contain high levels of glycoalkaloids that can be toxic to cattle. Note: Potatoes exposed to light will turn green over time. Always monitor stockpiles if stored outside and uncovered.

Storing cull potatoes on the farm can reduce palatability. Especially during warm weather, potatoes will break down quickly reducing their feed value. Rapid feedout is recommended any time of year.


Hallidav 2010

Ensiling potatoes: Potatoes can be ensiled to increase their storage life. For proper fermentation, potatoes need to be mixed with dryer forages to bring the overall moisture content down to 65 to 70% for bunker silos, 60 to 70% for silage bags, and 60 to 65% for upright concrete stave silos. One successful combination mixed 500 lbs. potatoes with one ton of corn silage. Another possibility is using 400 to 500 lbs. of chopped dry hay, corn stover, or straw per ton of potatoes. Ensiling and fermentation also reduces the risk of cattle choking.

What is a reasonable price to pay for cull potatoes?

Cull potatoes are considered an energy source in dairy and beef rations and contain as much protein as shelled corn on a DM basis. Most likely they will be used to replace corn in the diet. We can then calculate a comparable price for cull potatoes based on current prices of dry shelled corn and soybean meal using FeedVal 2012 http://dairymgt.info/tools/feedval_12/index.php (Table 1). FeedVal 2012 is a decision support tool developed by Victor E. Cabrera, L. Armentano, and R.D. Shaver, Department of Dairy Science, University of Wisconsin-Madison to evaluate the actual value of feed ingredients and to help producers, nutritionists, and farm consultants make economical optimal decisions for purchasing and using feed ingredients in feed rations.

Table 1. Value of one ton of cull potatoes based on shelled corn and 48% soybean meal prices.*

Price of soybean meal 48%[Z] ($/ton)	Price of shelled corn[Y] ($/bu.)										
	$4.00	**$4.50**	**$5.00**	**$5.50**	**$6.00**	**$6.50**	**$7.00**	**$7.50**	**$8.00**	**$8.50**	**$9.00**
$300	$23.36[X]	$25.97	$28.57	$31.18	$33.78	$36.39	$39.00	$41.60	$44.47	$47.07	$49.68
$350	$23.78	$26.39	$28.99	$31.60	$34.20	$36.81	$39.41	$42.02	$44.88	$47.49	$50.10
$400	$24.20	$26.80	$29.41	$32.01	$34.62	$37.23	$39.83	$42.44	$45.30	$47.91	$50.51
$450	$24.62	$27.22	$29.83	$32.43	$35.04	$37.64	$40.25	$42.85	$45.72	$48.32	$50.93
$500	$25.03	$27.64	$30.24	$32.85	$35.45	$38.06	$40.67	$43.27	$46.14	$48.74	$51.35
$550	$25.45	$28.06	$30.66	$33.27	$35.87	$38.48	$41.08	$43.69	$46.55	$49.16	$51.77
$600	$25.87	$28.47	$31.08	$33.68	$36.29	$38.90	$41.50	$44.11	$46.97	$49.58	$52.18

*Cull potato prices derived from FeedVal-2012 (http://dairymgt.info/tools/feedval_12/index.php)
[Z]Soybean meal – 89% dry matter (DM), 54% crude protein (cp), and 1.00 Mcals/lb. Net Energy Lactation, 3X (Nel3
[Y]Shelled corn – 89% DM, 9% cp, and 0.91 Mcals/lb. Nel3x
[X]Cull potatoes – 15% DM, 10.5% cp, and 0.84 Mcals/lb. Nel3x

What about moisture content when figuring a price for cull potatoes?

As mentioned, potato moisture content can vary from 75 to 85% moisture or more depending on potato variety, storage conditions, and length of time in storage. In order to establish a comparable price across different moisture levels we need to work from a DM basis. For example: If a price of $40 per ton of 85% moisture potatoes is established, each ton will contain 300 lbs. DM (2000 x 0.15). The value per pound of DM = $0.133 ($40/300). If moisture content is only 80%, then a ton will contain 400 lbs. DM and a comparable price would be $53.33 per ton (400 x $0.133). See Table 2 for price adjustments.

Table 2. Price adjustments for cull potato moisture.

Moisture	Base price per ton of cull potatoes at 85% moisture							
	$20	$25	$30	$35	$40	$45	$50	$55
87%	$17.33	$21.67	$26.00	$30.33	$34.67	$39.00	$43.33	$47.67
86%	$18.67	$23.33	$28.00	$32.67	$37.33	$42.00	$46.67	$51.33
85%	**$20.00**	**$25.00**	**$30.00**	**$35.00**	**$40.00**	**$45.00**	**$50.00**	**$55.00**
84%	$21.33	$26.67	$32.00	$37.33	$42.67	$48.00	$53.33	$58.67
83%	$22.67	$28.33	$34.00	$39.67	$45.33	$51.00	$56.67	$62.33
82%	$24.00	$30.00	$36.00	$42.00	$48.00	$54.00	$60.00	$66.00
81%	$25.33	$31.67	$38.00	$44.33	$50.67	$57.00	$63.33	$69.67
80%	$26.67	$33.33	$40.00	$46.67	$53.33	$60.00	$66.67	$73.33
75%	$33.33	$41.67	$50.00	$58.33	$66.67	$75.00	$83.33	$91.67

Factors to consider:

- Quality and moisture content of the potatoes must be monitored.
- Dry matter intake needs to be managed for maximum dairy and beef production.
- Potatoes are a high energy feed that must compete with more traditional feed grains.
- Price paid should allow for additional expenses of hauling, storage, and feeding.
- Account for potential shrinkage during storage and handling.
- Consistency of supply is also important to avoid abrupt ration changes.

Conclusion: Potatoes can be an economical substitute for grains. If fed at moderate levels animal performance should be similar to cattle fed equivalent amounts of dry grains. Check with your local potato grower for packing sheds interested in selling cull potatoes. For best results always feed a balanced ration.

Acknowledgements: Thanks to Randy D. Shaver, Professor and Extension Dairy Nutritionist, University of Wisconsin-Madison/Extension and Patrick C. Hoffman, University of Wisconsin-Extension, Specialist in Dairy Management for reviewing this paper and providing editorial suggestions.

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Appendix 3

Feeding Cabbage Waste

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Introduction

One way farmers can feed quality ingredients at bargain prices is to use food waste in the ration. During sauerkraut production, leftover cabbage leaves and cores (called cabbage waste) can be fed in dairy cow and heifer diets.

What is cabbage waste?

Cabbage waste is a wet product (93% moisture) with nutrient composition (Table 1) similar in energy, lower in fiber and higher in protein contents than corn silage on a dry matter (DM) basis. Cabbage waste might best be used to replace some of the corn silage in the ration.

Table 1. Nutrient composition of waste cabbage and corn silage.

Nutrient (% DM)	Waste cabbage	Corn silage
Dry matter	7.0%	35.0%
Crude protein	16.6%	8.5%
ADF	15.8%	24.0%
NDF	20.0%	43.0%
Sulfur	0.70%	0.13%
TDN	74.0%	72.0%
Net energy lactation (Mcal/lb)	0.77	0.74

How much should I feed?

Feeding too much too quickly may cause digestive upsets. It is recommended to start with one pound DM per cow per day and gradually increase until reaching the upper recommended limits provided in Table 2. For bred heifers, the feeding recommendation is 4 to 6 pounds DM per head per day. For dairy cows, the feeding recommendation is 2 to 3 pounds DM per cow per day.

Table 2. Recommended step-up program for feeding cabbage waste.

	Day 1	Day 4	Day 7
Cows	1 lb. DM	2 lb. DM	3 lb. DM
Bred heifers	1 lb. DM	4 lb. DM	6 lb. DM

How much does it cost?

The cost of cabbage waste depends on how far away the farm is from the plant. Trucking costs are currently $4/mile. Currently, a 25-ton load of cabbage waste costs $75. For example, if you live 20 miles from the plant, your total cost would be $80 (trucking) plus $75 (25 ton load of cabbage waste). This comes to $6.20 per ton as fed or $0.04 per pound dry matter (Table 3). A 12 ton straight truck load of cabbage waste is also available. **For more information, contact Jeff Handschke owner of North Point Transport at 920-810-1363.**

Table 3. Cost of cabbage waste.

Miles from plant	Cost/pound DM
20	$0.04
40	$0.06
60	$0.08
80	$0.10
90	$0.11
100	$0.12

When is it economical to feed?

It is economical to feed cabbage waste when the market price for corn silage is high. Currently, corn silage costs $60-80 per ton as fed or $0.09-0.11 per pound dry matter. This means that it is economical to feed cabbage waste if the farm is located 90 miles or less from the plant (Table 3).

Keep in mind that there are other potential savings when replacing corn silage with cabbage waste. For example, the higher nutritional value of cabbage waste may allow farmers to reduce or eliminate the use of some feed supplements. Consult with your nutritionist to see if this is the case for you.

Since bred heifers can be fed twice as much as cows, multiply Table 4 by two to calculate annual savings.

Table 4. Annual savings under current economic conditions when replacing 3 pounds corn silage with cabbage waste (dry matter basis) for cow rations.				
Miles from plant	150 cows	500 cows	1000 cows	5000 cows
20	$2,835	$9,450	$18,900	$94,500
40	$2,025	$6,750	$13,500	$67,500
60	$1,215	$4,050	$8,100	$40,500
80	$405	$1,350	$2,700	$13,500
90	$0	$0	$0	$0
100	-$405	-$1,350	-$2,700	-$13,500

What else should I know about feeding waste cabbage to dairy cattle?

Availability. Cabbage waste is only available from the end of July through Thanksgiving. If there is a problem at the plant, cabbage waste may not be available that day. A back-up ration must always be available in this case.

With over 27,000 tons of cabbage waste produced at Great Lakes Kraut each year, there is an abundant supply to feed to dairy cattle. This makes it unlikely that extra charges would be applied since the supply far exceeds the current demand.

Agronomic benefits. Spreading cabbage waste on fields can cause diseases such as white mold and black rot. Feeding cabbage waste to dairy cattle decreases the amount spread on fields which could help manage these diseases.

Sulfur content. Cabbage waste is high in sulfur. It is not recommended to feed cabbage waste if there are other high sulfur ingredients in the diet (i.e. corn gluten feed or distillers grains), as this will increase the risk of sulfur toxicity. The NRC recommends feeding no more than 0.4% dietary sulfur (dry matter basis) to dairy cows. When feeding sulfur in excess, dietary additives may be included or increased (i.e. thiamine, molybdenum, 9-10, anthraquinone) to help manage this issue. However, the best way to manage hydrogen sulfide production is a good step-up program and feeding no more than the recommended limit.

Leachate. Due to the high moisture content of cabbage waste, leachate can occur. Therefore, cabbage waste must be fed up in 3 days. It is recommended to store cabbage waste where leachate can be gathered in the bunker silo.

Mixing and moving. Large quantities of cabbage waste in the mixer can cause "leaking". Also, if you have to travel down public roads with the mixer, leaking from the wagon can occur. Lastly, farmers must be careful about heating and over-mixing the TMR.

Cheese-making/Off-flavors in milk.
Certain bulk roughages consumed by cows prior to milking (within 4-5 hrs) tend to impart a flavor to milk characteristic of the feed. Cabbage is high in sulfur content and high consumption of these products is expected to give milk a sulfury or eggy flavor. Indeed any cabbage left to rot or decompose will intensify the off-flavor imparted to milk as these flavors are volatile and are easily detected in the milk by smell. Milk products including cheese made from tainted milk may exhibit these off-flavors. However, in recent experiments with feeding low level (2-3 pounds dry matter) of cabbage waste (non-fermented cores and outer leaves) did not give milk or Cheddar cheese (at least through 6 months of aging) any off-flavors derived from the cabbage.

Acknowledgements: Thanks to Randy D. Shaver, Professor and Extension Dairy Nutritionist, University of Wisconsin-Madison/Extension, Patrick C. Hoffman, University of Wisconsin-Extension, Specialist in Dairy Management, and Mark Johnson, Assistant Director, Center for Dairy Research for reviewing this paper and providing editorial suggestions.

UW Extension
Cooperative Extension

Appendix 4

National Swine
Nutrition Guide

By-Product Feed Ingredients for Use in Swine Diets

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Introduction

Feed costs comprise approximately 65-70% of the cost of pork production. While most U.S. producers think of strictly corn and soybean meal (SBM) when feeding pigs, they need to realize that pigs require amino acids, energy, vitamins and minerals, and not any particular feedstuff for normal growth. In most regions of the U.S., a corn–SBM combination is usually the least expensive ingredient combination that meets the pig's nutrient requirements. However, in times of higher corn and SBM prices or in regions of the U.S. that are removed from the Corn Belt, producers need to look at alternative feedstuffs in order to keep diet costs down.

Objectives

- To identify by-products that are useful in swine diets
- To describe how these by-products result from processing
- Present nutrient value of by-products
- Show how they may be utilized in swine feeding

Questions to Consider Before Utilizing By-products

A number of questions should be asked and answered satisfactorily before by-products are incorporated into swine diets.

1. Are there animal and human health hazards associated with the by-products? The presence of toxic substances, disease organisms, molds, mycotoxins, and growth inhibiting factors in a by-product should be checked. If present, the by-product should not be considered unless these deleterious factors can be inexpensively eliminated or neutralized.
2. Is the nutrient composition suited to swine feeding? Check the nutrient composition from feed composition tables and laboratory analyses. The by-product must be an effective source of available nutrients or energy to be considered as a substitute for conventional ingredients. Even if a by-product has an acceptable total nutrient concentration, if that nutrient is poorly digested or absorbed, it's not available for growth and therefore of little benefit to the pig. Therefore, by-products with low nutrient density and/or availability should generally be avoided, except, perhaps for gestating or open sows. Also, palatability of feedstuffs is an issue to consider. If a feedstuff is not palatable, feed consumption and subsequently growth performance/production, will be reduced. Special caution must be taken when considering using by-products in nursery and lactation diets, where feed/energy intake is a critical issue.
3. Are there added costs of utilizing the by-product? By-products can directly increase costs because of added transportation, storage, processing equipment, facility modifications, or labor required for their use. Additional costs can result indirectly from reduced facility and equipment life, extra management time, feed wastage, manure disposal complications, increased risk of animal health problems,

and reduced performance caused from by-product variability. Total feed consumption can be affected by ingredients utilized, and would therefore impact the economic benefit of a by-product. If a product is high in fiber, animals will consume more of that diet than they would of a corn-SBM diet, so total feed consumption would be higher. Also, certain by-products may have a short shelf life (ex. high fat products) so they must be purchased in smaller amounts, thereby reducing the potential cost savings of buying in bulk. The other option would be to add a preservative or antioxidant to increase shelf life. Another cost of a by-product would be the potential for a nutrient imbalance. If a product contains a high concentration of one nutrient, it may cause a deficiency in another nutrient (ex. Ca-P or Ca-Zn) that normally would not occur. Therefore, experience of others and accurate "cost of production" records for the existing feeding program are valuable tools when projecting real costs.

4. Who is in charge of quality control, and how much will that cost in time and money? By-product composition can vary greatly depending on raw ingredients, processing method, drying temperature, etc; and for producers to properly incorporate a by-product into swine diets, they need to know the actual nutrient content of the product purchased. Values from reference tables provide a good starting point, but by-products should be routinely analyzed for nutrient content for the producer to get the maximum nutritional value of the product without affecting pig performance. It takes time and money to sample and analyze ingredients, and those costs must be incorporated into the actual cost of the ingredient for the producer.
5. Do by-products reduce the cost of production most of the time? The financial commitment necessary to feed by-products requires a cost-benefit advantage a high percentage of the time, not just during periods of high prices of conventional ingredients. A study of conventional ingredients' pricing history and cycles is necessary for making any long term decisions.
6. Is by-product availability and quality sufficiently consistent to support longtime use? A steady supply of the byproduct, a reliable price, and uniform quality are essential to consistent cost savings. If a by-product is produced nearby and at a price that will be competitive long-term, it may be feasible to build equipment to specifically handle it. Examples may be dairy processing facilities, hatcheries, or corn processing plants.

Potential By-products for Swine Diets

Potential by-products which may be considered for swine diets may be classified from their primary product origin as follows:

1. Grain
    a. Distilling by-products/co-products
    b. Brewing by-products
    c. Milling by-products
    d. Baking by-products
2. Animal
    a. Milk by-products
    b. Meat by-products
    c. Egg by-products
3. Vegetable
    a. Potato by-products
    b. Cull beans
    c. Field peas
4. Sugar and starch production
    a. Cane, beet and corn molasses
    b. Salvage candy

In the following pages, each of the by-products in this classification system will be discussed. The discussion will provide information on the by-product including definition, how it is produced, nutritive value, palatability, availability, how it may be used, level of use in swine diets, management considerations, effect of level of use on pig performance, and problems related to its usage.

Grain Fermentation By-products

The principal by-products/co-products of the brewing and distilling industries that are useful in swine diets are brewers dried grains from the beer brewing industry, distillers dried grains from the commercial ethanol industry, and stillage from on-the-farm alcohol production.

Distillers dried grains is the residue remaining after the removal of alcohol and water from a yeast fermented grain mash. Distillers co-products are primarily from corn but may also be from barley or other grains. Corn is 2/3 starch and during the fermentation and distillation processes, the starch is converted to ethanol. One bushel of corn produces approximately 2.6 gallons of ethanol, 17 lbs of CO2, and a wet spent mash. This wet mash goes through a series of centrifuges, evaporators, and presses to produce Solubles (liquid) and Distillers Grains (semi-dry). The Solubles and Distillers Grains are then blended and dried to produce 17 lbs of Distillers Dried Grains with Solubles (DDGS) from the same bushel of corn. DDGS provides lysine, phosphorus, and energy, and replaces soybean meal, dicalcium phosphate, and corn in swine diets. It is approximately equal to corn as an energy source (1,552 kcal/lb), and although DDGS is quite high in protein (27%) it retains the poor amino acid balance of grains and is particularly limiting in lysine (0.7%; Table 1). Also, it appears that the amino acids in DDGS are less available than those from SBM. However, by supplementing swine diets with synthetic amino acids, DDGS can work well in swine diets. Also, DDGS does contain a relatively large amount of available phosphorus (0.78%) so inorganic phosphorus supplementation can be reduced. Therefore, diets need to be balanced on available amino acids and available phosphorus to ensure proper performance.

In general, there are 2 broad categories of DDGS: DDGS from "Old Generation" plants and DDGS from "New Generation" plants. The "New Generation" plants are relatively new (less than 10 years old) and utilize new technologies such as batch fermentation and improved quality control procedures to produce a higher quality DDGS compared to some older, larger ethanol plants. As a "Rule of Thumb", 200 lbs of DDGS and 3 lbs of limestone can replace 178 lbs of corn, 19 lbs of 46% protein soybean meal, and 6 lbs of dicalcium phosphate in a ton of complete feed. Therefore, if 200 lbs of DDGS and 3 lbs of limestone are less expensive than 178 lbs of corn, 19 lbs of 46% protein soybean meal, and 6 lbs of dicalcium phosphate, it is economical to use DDGS.

Traditionally, DDGS has been included in swine diets up to 10%. However, the higher quality, New Generation DDGS can be added at higher amounts (see PIG Factsheet 07-07-09 Composition and Usage Rate of Feed Ingredients for Swine Diets). Occasionally, there may an initial reduction in feed intake if DDGS is added to diets at a higher level. Therefore it is recommended to start at a lower level and then increase DDGS additions up to the maximum inclusion level to avoid this problem. Grow-finish pigs can perform normally on diets containing 30% DDGS. However, at this level, the bellies become "soft" due to the increase in unsaturated fats coming from the DDGS. Therefore, grow-finish diets should not exceed 20% DDGS if pork quality is a concern. There have been numerous field reports and observations that 10-20% DDGS in growing-finishing diets reduces the incidence/severity of ileitis and Hemorrhagic Bowel Syndrome (HBS). However, controlled research trials have not been able to consistently demonstrate this effect. Therefore, caution should be used when applying any economic value to DDGS' health effects unless it is known to work in a specific operation.

Brewers dried grains is the dried residue of barley malting and often contains other grains in the brewing of beer. It is a low energy feed (ME = 1,000 kcal/lb.) containing 13 to 16% crude fiber. Brewers dried grains has a fairly high protein level (25%), but the quality is low because of low levels of lysine (0.9%) and tryptophan (0.3%). Because of its low energy value, this ingredient is not very useful in growing-finishing or lactation diets but could be used in gestation diets with grain to meet the lysine requirements.
Stillage is the wet mash resulting from either on-farm alcohol production from corn or from the New Generation plants. It is usually fed wet, which limits the pig's ability to consume large quantities. On an air-dried basis (90% dry matter), protein level ranges from 11 to 27% and lysine from 0.2 to 0.6%. Dry matter content of the wet product varies from 7 to 20% depending upon the thoroughness of separation of liquids from solids. Liquid stillage may be offered free choice along with a typical growing diet to growing-finishing pigs. A management concern for stillage when feeding to swine is that it must be picked up daily and can not be used in a "dry" feeding system. Stillage is better utilized by ruminants than by swine because of the poor protein quality and the high fiber and water content.

Grain Milling By-products

Corn dry milling is the method of producing cornmeal, hominy, and corn grits for human consumption, and by-products such as hominy feed and corn bran for consumption by animals. Corn bran is the outer coating of the corn kernel including the hull and small amounts of the underlying gluten. It contains 5 to 10% crude fiber, and consequently, is lower in energy (1,200 kcal ME/lb) than the whole corn grain. It is similar to whole corn grain in protein, lysine, calcium, and phosphorus, and its energy value is similar to that of oats and may be used like oats in swine diets.

Hominy feed is a mixture of corn bran, corn germ and part of the starchy portion of the kernel. Hominy feed is similar in analysis to corn, being higher in fat (6.7%) and fiber (5%) than corn but similar in energy (1,459 kcal ME/lb), protein (8.0), lysine (0.2%), and tryptophan (0.1%) concentrations. It can replace corn in swine diets on an equivalent basis.

Corn wet milling is the process of producing cornstarch and corn oil for human consumption. In the wet milling process, a bushel (56 lbs) of No. 2 yellow corn yields 31.5 lbs of starch, 3.5 lbs of germ, 9.2 lbs of gluten feed, and 2.7 lbs of gluten meal. Corn oil is extracted from the germ, and the residue is added to the gluten feed.

Corn gluten feed is a mixture of gluten meal and bran and may contain some solubles and part of the germ. On an air-dried basis, corn gluten feed contains about 21.5% protein but is low in lysine (0.63%), tryptophan (0.07%), and energy (1,184 kcal ME/lb). On an energy basis, corn gluten feed is worth about 70% of that of corn. Because of its high fiber (6.8%) and low energy value for swine, corn gluten feed is better utilized by cattle.

Corn gluten meal may be either a 40% or a 60% protein by-product of wet milling. Its value as a replacement (60% CGM) for soybean meal in swine diets is limited because of its low lysine (1.02%) and tryptophan (0.31%) values. Because of its cryptoxanthine (yellow) content, corn gluten meal is used primarily for poultry in layer diets for egg yolk color and in broiler diets for skin color.

By-products of milling wheat for flour consist primarily of the bran and aleurone layers of the kernel and the germ. Wheat flour by-products are generally identified by their fiber level. A wheat milling byproduct with more than 9.5% fiber is wheat bran; that with less than 9.5% fiber may be classified as wheat middlings; if fiber is less than 7%, it's wheat shorts; and that with less than 4% fiber is red dog. Wheat bran typically contains about 15% protein, 0.6% lysine, 0.22% tryptophan, and 1.2% phosphorus. The phosphorus in bran is poorly available, and because of the high fiber content (10%) the energy value (1,034 kcal ME/ lb) is low. Wheat bran may be used as a laxative agent in sow diets around farrowing, but because of its low ME value, it is not recommended for growing pig or lactation diets.

Wheat middlings and wheat shorts are similar in nutritional value. They both consist of portions of flour, bran, aleurone layer, and germ from the flour milling process. Both are considerably higher in energy value (1,300 to 1,400 kcal ME/lb) than bran. They contain about 16% protein, 0.6% lysine, and 0.20% tryptophan. They have about 0.9% phosphorus, which is poorly available. Middlings and shorts may constitute up to 10% of corn-soybean meal growing-finishing pig diets if in the meal form, and up to 35% of the diet if it is pelleted. Middlings and shorts replace portions of the corn and soybean meal on an equal lysine basis. These by-products have good pellet binding properties and are used extensively in commercially-pelleted swine feeds.

There are three by-products of processing rice grain for human consumption. These are rice bran, fat extracted rice bran, and rice polishings. Rice bran is very palatable and readily consumed when fresh. However, because of its high unsaturated fat content (13%), rancidity occurs, causing objectionable odor and taste. The quality and value of rice bran (1,350 kcal ME/lb) also varies depending upon the amount of rice hulls included in the bran. The high fiber of hulls and poor digestibility rapidly reduces the energy value of rice bran. The phosphorus is largely unavailable. Fat extracted rice bran has a lower energy value (1,200 kcal ME /lb), but the problem of rancidity in storage is eliminated. Rice polishings is the by-product of polished rice for human consumption. It does not vary as much in nutritional value as rice bran and can be a useful diet ingredient for swine. The combination of rice polishings and rice bran may be included in growing-finishing diets at levels of 20 to 30% with satisfactory performance. The cost of transporting these rice by-products from the source of production and processing (Arkansas, Texas, and Louisiana in the U.S.A.) virtually eliminates them from consideration by swine producers in the upper Midwest.

Bakery By-products

Dried bakery product is a mixture of bread, cookies, cake, crackers, and dough. It is similar to corn in protein and amino acid composition (10.8% protein, 0.27% lysine, and 0.10% tryptophan) but higher in fat (11%) and energy (1,682 kcal ME /lb). Dried bakery product may replace up to one-half of the corn in corn soybean meal growing-finishing and sow diets and up to 20% in starter diets. The salt content may be fairly high, and the standard salt supplementation could be deleted. Keep water available for the pigs at all times.

Milk By-products

Milk by-products have a concentration and balance of nutrients that make them desirable as swine feeds (Table 1). They are very palatable and highly digestible but usually are not economical for extensive use in swine feeds. Liquid by-products like sweet or acid whey and salvaged whole or skim milk are less costly than dried by-products, but their high water content limits the distance that these materials may be transported economically.

Liquid milk from surplus production or that which has not been sold within a prescribed time after processing may be available for swine feeding. Whole milk contains about twice the energy density but about the same lysine level as skim milk (Table 1). Milk may be fed to all classes of swine but is best suited for pigs from weaning through market weight. About 9.5 lbs of liquid skim milk is equivalent to 1 lb of soybean meal (44%) on an energy and lysine basis.

Milk that has soured under sanitary conditions may be fed. However, fresh milk is best for young pigs. Care should be taken to feed either sweet (fresh) or sour milk rather than changing from one to another because such changes may cause scouring. Avoid storing unprocessed milk under unsanitary conditions to reduce the growth of organisms that could threaten swine health. Milk packaged for human consumption may require special equipment or additional labor to remove it from cartons.
Liquid buttermilk is produced from the manufacture of butter and has about the same feeding value as skim milk if it has not been diluted by churn washings. Condensed buttermilk (semi-solid) is made by evaporating buttermilk to about one-third of its original weight. Thus, 1 lb of condensed buttermilk is equivalent to 3 lb of liquid buttermilk.

Dried buttermilk contains less than 8% moisture, 32 to 35% crude protein, and 6% fat. One pound of dried buttermilk is equivalent to about 10 lbs of liquid buttermilk or 3 lbs of condensed buttermilk. Dried buttermilk is an excellent feed but is generally too expensive to be used in swine diets except for starter diets. Feeding guidelines that apply to dried skim milk also apply to dried buttermilk.

Dried skim milk (DSM), produced from roller-drying or spray-drying of low fat milk, contains about 50% lactose and 34.6% of a very high quality protein (Table 1). This by-product is very palatable and highly digestible, and on an available lysine basis, it is equal to soybean meal (44%). Because dried skim milk is usually expensive compared to other feed ingredients, its use should be limited to pre-starter diets fed during the first 2 weeks after early weaning (less than 3 weeks of age). Dried skim milk is commonly included at 10 to 20% of pre-starter diets. However, if economics change (ex: reduced cost due to government programs) it can be fed in all phases of swine production.

Liquid sweet whey is the by-product from making hard cheeses (Cheddar, Munster, and Monterey Jack). When the cheese curds are separated, the liquid whey has a temperature of about 100° F, is slightly acidic (pH 6.0 to 6.5), and contains about 5% lactose, 1% high quality protein, and 0.05% high available phosphorus. Liquid sweet whey is best suited for pigs from 50 lbs to market weight. While it may be fed to gestating sows, it should not be fed to lactating sows because consumption of a large volume of liquid during lactation may reduce total energy intake.

The greatest economic benefit occurs when liquid sweet whey replaces soybean meal or other supplemental protein ingredients used in growing-finishing pig diets. To achieve these savings, liquid sweet whey should be available continuously and be provided free choice with ground corn (or sorghum, wheat, or barley) fortified with vitamins and minerals. Drinking water should be withheld so that pigs consume ample whey to meet their need for supplemental lysine, the first limiting amino acid. Daily whey intake will increase until pigs reach 130 lbs when it will average 3.5 gallons per head per day. When fed in this manner, liquid sweet whey can replace 100 lbs of soybean meal (44% crude protein) per pig from 40 lbs to market weight. Nipple drinkers with strainers removed or troughs have been used in free choice feeding. To assure adequate access of pigs to liquid whey, the amount of drinking space or nipple drinkers should be doubled over that used for water. Although liquid sweet whey has the greatest economic benefit when substituted for supplemental protein, it can be partially substituted for complete feed by mixing the dry diet in a 5:1 ratio with whey to form a slurry. This method will reduce dry feed use 25 to 30%. The slurry distribution system should have main lines that continuously recycle the slurry back to the mixing tank and add new feed and whey as needed. Dry feed must be finely ground so that it will pass through a 0.1-in. opening to prevent blockage of distribution lines. Lines should be dropped from the main line to each pen and should be fitted with a valve to control feed delivery to coincide with the pig's needs. The entire system should be cleaned frequently to prevent yeast growth and reduced palatability.

Fresh liquid sweet whey must be delivered daily. Up to 40% of the nutrients can be lost during a 48-hour storage period, and the acid produced will decrease intake. High quality sweet whey that has a consistent pH and temperature is important to minimize digestive upsets. Liquid whey is corrosive and reduces the life of facilities and equipment. Storage tanks, troughs and distribution equipment should be made of plastic, porcelain, or stainless steel. Storage tanks should be cleaned at least once a week to inhibit yeast growth that causes off-flavor and reduces palatability. Liquid whey, especially acid whey, corrodes concrete slats and solid floors. Feeding liquid whey will increase manure volume by twofold to threefold and can produce a wet environment. Manure handling systems should be designed to handle liquid manure and have sufficient capacity to store manure during periods when spreading on the field is not possible. Liquid acid whey is the by-product from cottage cheese production. Acid whey nutrient composition is similar to that of sweet whey (Table 1). The principle difference is the greater acidity (pH 4.0) of acid whey. Acid whey is not as palatable as sweet whey, and voluntary intake is not sufficient to adequately supply the lysine needed to supplement a ground corn diet fortified with vitamins and minerals. Management of liquid acid whey is similar to that for sweet liquid whey except that acid whey can be stored up to a week without deterioration, while sweet whey must be freshly supplied and consumed daily.

Dried whey is produced by spray-drying or roller-drying liquid whey. The dried product contains 65 to 70% lactose, 12.1% crude protein, 0.9% lysine, 0.75% calcium, 0.72% phosphorus, and about 5% salts of sodium and potassium. Dried whey contains high quality protein and nutrients that are readily digested by the young pig. Because dried whey is much less expensive than dried skim milk and has many of the benefits of milk, it is an attractive substitute for DSM in starter feeds. Dried whey can be included at 20 to 30% of the starter diet and should be substituted on a lysine equivalent basis. The greatest benefit from dried whey occurs the first week after weaning. The benefit may last for only the first week for pigs weighing over 13 lbs at weaning, while pigs weighing less than 13 lbs may benefit from dried whey in the diet for 2 to 3 weeks post-weaning. These benefits in starter diets will be consistently observed only when an "edible" grade of whey is used. When the cost of dried whey exceeds that of conventional ingredients, judgment should be used as to how long whey-fortified diets are fed. Dried whey may be included in diets of growing-finishing pigs and breeding animals when substitution is economical. Dried whey should be limited to 10% of the diet of older pigs, even when it enters the least cost formula at greater levels, because lactase activity diminishes with age, and older pigs are unable to properly digest higher levels. Dried whey does not increase feed intake of either growing-finishing pigs or sows in lactation. Dried whey can cause pelleting difficulty and can increase pellet hardness which reduces palatability. Dried whey diets may also attract moisture, causing feeds to bridge in feeders. Dried whey should be free of brown or tan color which indicates overheating. This may cause decreased amino acid availability. Food grade (edible) dried whey contains less ash and has less variation in protein content and greater lysine content than feed grade whey. Food grade whey tends to support better performance of weanling pigs than feed grade whey. Dried whey product or low lactose dried whey is produced by removing some of the lactose prior to drying. Dried whey product contains 40 to 50% lactose, 16% protein, 1.4% lysine, 1.7% calcium, and 1.0% phosphorus. It can be used in starter feeds with performance similar to that of dried whole whey. Up to 20% may be included in starter diets when substituted on a lysine equivalent basis.

Meat By-products

Animal harvesting and processing generally have three main by-products: animal fat (tallow and lard), blood meal (cooker-dried or flash-dried), and meat meal or meat and bone meal. Currently, while ruminant diets can not legally contain beef or poultry by-products, there is no such restriction for swine diets. Pigs can be fed diets containing meat by-products from pigs, cattle, poultry, etc.

Animal fat is obtained from the tissues of harvested animals by commercial processes of rendering or extracting. Animal fat consists primarily of true fats (triglycerides) and can be classified into four types: choice white grease, tallow, yellow grease, and hydrolyzed animal fat. Lard is rendered from swine, and tallow is rendered from cattle, sheep, and goats. Yellow grease is predominantly tallow but may also include restaurant greases. Hydrolyzed animal fat is obtained from fat processing procedures commonly used in edible fat processing or soap making. It consists predominantly of fatty acids. All of these fats have a metabolizable energy (ME) value of about 3,550 kcal/lb. They contain virtually no nutrients other than fat. Fat quality can be an issue. If there is a quality concern for a certain fat source, it should be analyzed for moisture, impurities, and unsaponifiable matter (MIU), as well as free fatty acids. Moisture should not exceed 1%, free fatty acids 15%, impurities 0.5%, unsaponifiable material 1%, and total MIU of 2.5%. Full-fed growing-finishing pigs will generally consume a fairly constant daily ME caloric intake regardless of the energy density of the diet. Thus, as fat is incorporated into the diet, the energy density (kcal/lb) increases, and the pig consumes fewer pounds daily to maintain an equal intake of ME (calories). Rate of gain in growing-finishing pigs is maximized by incorporating 5 to 8% of animal fat into a corn-soybean meal diet. Consequently, feed efficiency is considerably improved as animal fat is incorporated into the diet. The relative cost of ME from fat vs. grain essentially determines its use in growing-finishing diets. However, fat additions greater than 6% can cause feed to bridge in feeders or storage bins. Animal fat may be added to the diet by melting and then dripping or spraying into the feed mixer when the diet is being prepared. Some dry-fat products on the market have good mixing and flow characteristics but are quite expensive.

There are several commercially available fat "blends" that contain one or more of the following: pork choice white grease, beef tallow, poultry fat, soybean oil, corn oil, and restaurant grease. Some are formulated on a "least cost" blend while others are a standard blend tailored to a specific market. Most often they are sold for less than straight choice white grease or vegetable oils and claim to have higher caloric content. From a production perspective, the ability of these blends to replace other energy sources appears to depend upon the ingredient quality, the blend of the particular load, and the type of diet being fed. For example, some blends perform well with finishing swine but are refused by lactating sows. If two fat sources are being blended together, moisture should not exceed 1%, free fatty acids 30%, impurities 0.5%, unsaponifiable material 3.5%, and total MIU 5% (moisture, impurities & unsaponifiable materials). Meat meal and meat and bone meal are made from the trimmings at harvest. These include bone, tendons, ligaments, inedible organs, cleaned entrails, and some carcass trimmings. These differ from tankage in that they do not include dried blood and are produced by a different cooking method. If the meat meal contains more than 4.0% phosphorus, it is designated meat and bone meal. Meat meal typically contains about 6.6% calcium (Ca) and 3.2% phosphorus (P) and meat and bone meal contains about 10% Ca and 5% P. In both meat meal and meat and bone meal, the official specifications state that Ca shall not exceed 2.2 times the actual P level. Both Ca and P of these products are highly available. Meat meal contains about 56% protein, 3.3% lysine, and 0.43% tryptophan. Meat and bone meal contains about 53% protein, 2.8% lysine, and 0.36% tryptophan (Table 1). The digestibility of protein and availability of amino acids in these products are not as high as that of soybean meal. In a corn-meat and bone meal diet, tryptophan is the first limiting amino acid. Because of this, the high ash content and palatability, it is advisable to limit these products to 5% of the diet.

Blood meal is produced by drying the blood collected at slaughter by one of several drying processes. The old drying procedure was by a vat cooker process. This was a slow drying process, and much of the lysine in blood meal was poorly available. Blood meals contain 80 to 90% protein and 7 to 9% lysine. However, with the cooker drying process, less than 20% of the lysine is available to the pig. The newer drying processes include spray drying, ring drying, or steam drum drying. All of them are rapid drying procedures and result in a product called 'flash dried" blood meal. The lysine of flash dried blood meals is about 80% available. The first limiting amino acid in flash dried blood meal is isoleucine and limits the use of flash dried blood meals to 5% of the diet of growing pigs. A value of 7% lysine assigned to flash dried blood meal is a safe, conservative value to use in least cost formulation of swine rations. However, there is still variation in blood meal content between plants as well as between different batches at the same plant. Color can be used as a general indicator of blood meal quality. Light or tan-colored blood meal has a much higher feeding value than black or dark blood meal (over-heating in the drying process can decrease nutrient availability).

Hydrolyzed hog hair is prepared from cleaned hair of slaughtered animals by heat and pressure to produce a byproduct suitable for animal feeding. It contains 94% crude protein (which is about 75% digestible) and 3.5% lysine (Table 1) of lower availability than the lysine of soybean meal. Its use should be limited to 2% or 3% in diets of growing-finishing pigs and sows and may replace an equal amount of soybean meal.

Feather meal is a by-product resulting from the hydrolysis under pressure of cleaned feathers from slaughtered poultry. The lysine level in feather meal is quite low (about 1.5% available lysine). Most of this product is used in feeding poultry. Its use in swine diets should be limited to 3% for growing-finishing pigs and sows.

Poultry by-product meal consists of the viscera, head, and feet from poultry harvest. These are dry or wet rendered, dried, and ground into a meal. The meal is 93% dry matter, 1% crude fiber, 12% crude fat, 55% crude protein, 3.7% lysine, 0.45% tryptophan, 4.4% calcium, 2.5% phosphorus, and has an ME value of 1,300 kcal/lb (Table 1). Poultry by-product meal may be utilized similarly to meat meal in swine rations.

Egg By-products

Discarded eggs from candling stations and cull eggs and chicks from hatcheries are by-products of the egg industry. Bloodspot eggs from egg candling stations are often available at little or no cost. Eggs, including the shell, contain 60% moisture, 10% protein, 9% fat, 6% calcium, 0.2% phosphorus, and 0.7% lysine (Table 1). Finishing pig studies in which one-third of the dietary energy was from eggs showed satisfactory performance. This would indicate that growing-finishing pigs could safely consume a dozen eggs in the shell daily, eliminating the need for supplemental calcium and reduce the supplemental protein need. Raw eggs in the shell are best utilized by growing-finishing pigs and are not recommended for young weanling pigs or sows. Raw egg white contains a protein (avidin) which binds the vitamin biotin, making it unavailable. Biotin deficiency has been observed in weanling pigs and sows but is seldom seen in growing-finishing pigs. Nevertheless, pigs fed raw eggs should be observed for signs of biotin deficiency, including cracked hoof pads and poor growth. This may be prevented by incorporating biotin into the vitamin-trace mineral premix to supply 100 mg to 200 mg of biotin per ton of feed.

Hatchery by-product meal is hatchery waste consisting of a mixture of egg shells, infertile and unhatched eggs, and cull chicks. This is cooked, dried, and ground with or without removal of part of the fat. Hatchery by-product meal from layer type chick hatcheries has a higher protein level than that from broiler chick hatcheries (Table 1) because males are culled from layer type chicks and go into the by-product. Because of the high calcium content, hatchery by-product meal should be limited to no more than 3% of the diet of growing-finishing pigs and sows. At this level it will replace the lysine in 2% of soybean meal and also replace the supplemental calcium.

Vegetable By-products

Cull potatoes are available in large quantities each fall after harvest and in lesser amounts at other times of the year. Raw potatoes have 22% dry matter, which is primarily starch. Raw potatoes are unpalatable to the pig and poorly digested, but cooking improves both the palatability and digestibility. Cooking can be accomplished by boiling in water or by steaming. Potatoes contain 2% protein and have an ME value of 370 kcal/lb on a freshly cooked basis. Because of the energy value, cooked potatoes may replace about one-half of the corn in growing-finishing diets.

Several dried processed potato products are sometimes available for feeding to swine or other livestock. These include potato meal, potato flakes, potato slices, and potato pulp. Potato meal is from cull potatoes that are sliced, dried, and then ground to a meal consistency. This dried raw potato meal is not well-digested by the pig and even when limited to 30% of the diet, there is often diarrhea and reduced performance.

This product is uncooked, and both starch and protein are poorly digested. This product is better utilized by cattle than by pigs.

Potato flakes are prepared by steaming clean washed potatoes for 30 minutes in a tank in which pressure rises to 10 to 15 lbs/in2. After they are steam-cooked, they are mashed, passed over drying rollers, and finally removed as thin flakes. Digestibility is good. Best performance is obtained when potato flakes are limited to 30 to 40% of the diet, but satisfactory performance has been obtained when potato flakes replace up to 50 to 60% of the cereals in the diets of starting, growing, and finishing pigs. Potato flakes contain 8 to 9% protein, 2 to 3% fiber, and about 75% starch. Metabolizable energy (about 1,600 kcal/lb) is equal to or higher than that of corn.

Potato slices are prepared by passing raw potato slices through a hot air rotating drier at 175° F for about 2 hours. This allows for both cooking and drying. Inadequate cooking could reduce their nutritive value. Potato slices may replace barley and corn in growing-finishing diets. Use up to 20% cooked-dried potato slices in the grower-diet and 40% in the finisher diet. Potato pulp is a by-product of the starch industry and is the residue obtained after starch is extracted. Since potato pulp is uncooked, its palatability and digestibility are poor. It is better utilized by cattle.

Potato chips and French fries contain considerable vegetable fat taken up in deep frying. They consist of about 50% starch, 35% fat, 5% protein, and 3% minerals, mainly potassium and sodium salts. They have a high energy value (2,000 kcal ME/lb.) but little else of nutritional value.

Cull beans from the dry navy bean (Phaseolus vulgaris) crop are available in considerable quantities at the fall harvest, and lesser amounts are available at other times during the year. Navy beans, like potatoes, must be cooked to obtain good performance of growing-finishing pigs. Navy beans contain factors such as trypsin inhibitor and hemaglutinin, which reduce digestibility and palatability. These factors are inactivated in the cooking process (steam cooking for 30 min.). Cooking also improves the utilization of the complex carbohydrates in beans. If the cull beans are not cooked, they will be better utilized by ruminants than by swine. Cooked, air-dried (90% dry matter) cull navy beans are 57% digestible carbohydrates, 23% protein, 4% fiber, 4% minerals, and 1% fat. They contain about 1.5% lysine.

Field peas are used for human consumption, but can be also both an amino acid and energy source for pigs. A major benefit of field peas is that they can be fed raw. Since most varieties contain no antinutritional factors, they do not have to be heat-treated. Field peas' amino acid content is intermediate between corn and soybeans, and depending on variety, can have an energy concentration similar to that found in corn. They are low in the sulfur amino acids methionine and cysteine, and marginal in tryptophan, but supplementation of synthetic amino acids alleviates this problem. When formulating diets containing field peas, they should first be balanced on lysine concentration, and then analyzed for concentrations of methionine, tryptophan, and threonine. Nursery pigs can be fed diets containing up to 18% peas, while growing-finishing diets can contain up to 40% field peas. Gestating and lactating sows can be fed 16 and 24% field peas, respectively.

Sugar and Starch By-products

Cane molasses and bagasse are by-products of cane sugar refining. Bagasse is the material left after the juice has been squeezed from the plant. Molasses is that portion of the juice remaining after further refining in the production of sugar. These by-products are economically utilized only in areas producing and refining sugar cane. Cane molasses and bagasse in a 4:1 ratio can be incorporated into growing finishing diets at 10 to 30% if the diet is properly balanced with soybean meal, minerals, and vitamins; near maximal growth rate can still be attained. Excessive use of molasses can induce scouring. Adding bagasse at one-fourth of the molasses level will aid in reducing this problem. However, because of the high fiber concentration (45%) of bagasse, growth rate of growing-finishing pigs will not be optimum. Molasses and bagasse may be used as a laxative much as wheat bran to prevent constipation of sows.

Beet molasses and beet pulp are by-products of the production and refining of beet sugar. The high fiber content of beet pulp, much like that of bagasse in sugar cane, limits its use to that of lactating sows as a laxative feed. However, this practice is not commonly recommended. Dried beet molasses may be used to a level of 10% (replacing corn) in the growing-finishing diet for good performance.

Table 1. Nutrient composition of by-products, as-fed basis.								
By-product	**ME (kcal/ lb)**	**Dry Matter (%)**	**Crude Fiber (%)**	**Crude Protein (%)**	**Lys (%)**	**Trp (%)**	**Ca (%)**	**P (%)**
Milk by-products								
Liquid whole milk	290	12.8	0.0	3.4	0.25	0.05	0.12	0.09
Dried whole milk	2,200	97.0	0.1	26.0	2.09	0.37	0.91	0.75
Liquid skim milk	160	9.5	0.0	3.4	0.30	0.05	0.12	0.10
Dried skim milk	1,689	96.0	0.2	34.6	2.86	0.51	1.31	1.00
Liquid buttermilk	155	9.7	0.0	3.3	0.26	0.04	0.13	0.09
Condensed buttermilk	493	29.1	0.1	10.8	0.78	0.12	0.44	0.26
Dried buttermilk	1,380	93.0	0.4	32.0	2.20	0.47	1.32	0.93
Liquid sweet whey	103	7.1	0.0	0.9	0.07	0.01	0.05	0.05
Liquid acid whey	95	6.6	0.0	0.8	0.07	0.02	0.10	0.08
Dried whey	1,450	96.0	0.0	12.1	0.90	0.18	0.75	0.72
Dried whey product	1,240	92.0	0.2	16.0	1.40	0.22	1.69	1.13
Meat by-products								
Animal fat	3,550	99.0	0.0	0.0	0.0	0.0	0.0	0.0
Meat meal (<4% P)	1,328	96.0	2.4	56.4	3.29	0.43	6.60	3.17
Meat and bone meal (≥4.0% P)	1,249	96.0	2.4	52.8	2.76	0.36	9.87	4.63
Flash dried blood meal	886	92.0	1.0	87.6	7.56	1.06	0.21	0.21
Hydrolyzed hog hair	1,000	95.0	1.0	94.0	3.50	0.50	0.20	0.80
Hydrolyzed feather meal	1,000	94.6	1.0	85.0	1.94	0.50	0.20	0.80
Poultry by-product meal	1,300	93.0	1.0	55.0	3.70	0.45	4.40	2.50
Egg by-products								
Bloodspot eggs	500	40.0	0.0	10.0	0.50	0.10	6.00	0.20
Hatchery by-product meal-broiler chick	800	90.0	0.0	22.2	1.16	0.22	24.60	0.33
Hatchery by-product meal-egg chick	1,000	90.0	0.0	32.3	1.83	0.30	17.20	0.60
Grain by-products								
Corn bran	1,200	89.0	8.5	8.0	0.20	0.10	0.03	0.20
Hominy feed	1,459	90.0	5.0	10.3	0.38	0.10	0.05	0.43
Corn gluten feed	1,184	90.0	6.8	21.5	0.63	0.07	0.22	0.83
Corn gluten meal, 60% CP	1,741	90.0	1.1	60.2	1.02	0.31	0.05	0.44
Wheat bran	1,034	89.0	10.0	15.7	0.64	0.22	0.16	1.20
Wheat middlings, <9.5% fiber	1,375	89.0	7.8	15.9	0.57	0.20	0.12	0.93
Rice bran	1,350	91.0	12.0	13.0	0.60	0.10	0.10	1.30
Rice bran, fat extracted	1,200	91.0	11.4	16.0	0.60	0.18	0.13	1.32
Rice polishings	1,500	90.0	4.0	12.0	0.50	0.10	0.05	1.20
Brewers dried grains	1,000	92.0	13.0	25.0	0.90	0.30	0.25	0.50
Distillers dried grains w/ solubles	1,552	88.0	7.7	27.4	0.78	0.20	0.06	0.69
Stillage	150	10.0	1.0	3.0	0.08	0.02	0.02	0.10
Bakery waste, dehydrated	1,682	91.0	1.2	10.8	0.27	0.10	0.13	0.25

By-product	ME (kcal/ lb)	Dry Matter (%)	Crude Fiber (%)	Crude Protein (%)	Lys (%)	Trp (%)	Ca (%)	P (%)
Vegetable and fruit by-products								
Cooked cull potatoes	370	22.0	0.7	2.2	0.06	0.02	0.02	0.06
Potato meal	1,100	90.0	2.0	9.0	0.25	0.10	0.10	0.30
Potato flakes	1,600	90.0	2.0	9.0	0.25	0.10	0.10	0.30
Potato slices	1,500	90.0	2.0	9.0	0.25	0.10	0.10	0.30
Potato pulp	1,000	90.0	6.0	7.7	0.20	0.10	0.10	0.30
Potato chips and fries	2,000	90.0	2.0	5.0	0.20	0.10	0.10	0.30
Cooked cull dry beans	1,400	90.0	4.0	23.0	1.50	0.20	0.20	0.40
Field peas	1,500	88.0	5.5	22.0	1.60	0.19	0.10	0.44
Starch and sugar by-products								
Cane molasses	1,011	74.0	0.0	4.0	0.01	0.01	0.74	0.06
Dried cane bagasse	500	91.5	44.5	2.0	0.10	0.05	0.60	0.20
Beet molasses	1,060	76.0	0.0	11.0	0.16	0.08	0.10	0.02
Dried beet pulp	1,134	91.0	18.2	8.6	0.52	0.10	0.70	0.10
Corn molasses	1,200	73.0	0.0	0.4	0.00	0.00	0.04	0.04
Salvage candy	1,600	93.5	0.0	3.0	0.00	0.00	0.06	0.06

Table 1. Nutrient composition of by-products, as-fed basis. *(continued)*

Corn molasses is a by-product of corn sugar (dextrose) manufacture from corn starch. Corn, cane, and beet molasses all have similar nutrient analyses, except that corn molasses contains practically no protein or calcium.

Salvage candy is any candy that is not marketable for human consumption including excess production, out-of-season, misshapen, or stale candy. Stale candy that never reaches the retailers shelf and outdated holiday candy are two major sources. The nutritive value of salvage candy varies greatly. If it contains peanuts or almonds it may contain a fairly high level of protein and would be more valuable than jellybeans, for example, which supply principally energy. Unless protein analyses are performed it would be best to assume no protein value and more soybean meal will need to be used in the diet when candy is substituted for corn. Depending on price, the cost of additional protein may more than offset the value of corn saved. Salvage candy could probably replace up to one-half of the corn in growing-finishing diets if amino acids are properly balanced.

By-product Nutrient Composition

The metabolizable energy density (kcal/lb, as fed) and analyses (%, as fed) of dry matter, fiber, protein, lysine, tryptophan, calcium, and phosphorus of by-products are summarized in Table 1. By-products vary greatly in their nutrient content and also in the availability of the nutrients to swine! Average values are listed. If a by-product is to make up a substantial part of the diet, it would be well to get one or more analyses of dry matter, crude protein, lysine, calcium, and phosphorus. Many of the state Departments of Agriculture have laboratories capable of analyzing feeds or feed ingredients for these components. In addition, there are feed company, university, and independent laboratories. However, make sure any laboratory you use is AOAC certified, or the results may be incorrect.

Summary

Pork producers in the U.S. have many different feedstuffs available, and by-products/co-products are typically used to provide amino acids, one of the most expensive components of a swine diet. Many by-products are available from the industries of grain milling, baking, brewing and distilling, fruit and vegetable processing, and meat, milk, and egg processing. Many of these by-products are utilized regularly in manufactured feeds and supplements because of least cost formula. Other by-products may be major ingredients in unique swine diets because of their abundant supply from nearby sources.

Frequently Asked Questions

Will other ingredients besides corn and soybean meal give me the same performance in my pigs?
Yes. Feedstuffs just supply energy, amino acids, and other nutrients, and pigs don't require corn or soybean meal. Traditionally in the US, corn and soybean meal have been the cheapest combination to meet the pigs' requirements and that's why they've been used extensively. Other areas of the world (Europe, Asia, Australia) have the same or better performance using totally different feed ingredients.

How do I decide which by-products will work in my operations?
First, you need to identify if there are any health factors associated with the product. Secondly, look at its nutrient profile to make sure you know what it ME, SID AA and P so it can be properly evaluated in a ration balancing program. Third, find out how consistent the product is in nutrient content. Fourth, determine how long the product will be available, and at what price.

Are there shipping and storage concerns?
Depending on the by-product, there can be serious limitations regarding storage. Also, it may require additional storage space on-farm, as well as adaptations to the mixing and feeding systems. Also, if the product contains a lot of liquid, you need to calculate the cost of the product delivered to your site since it is very expensive to ship water.

Alternative Feed Ingredients in Swine Diets II:

Use, Advantages and Disadvantages of Common Alternative Feedstuffs

Appendix 5

Use, Advantages and Disadvantages of Common Alternative Feedstuffs

Introduction

Historically, feed costs have represented 65 -75 percent of the variable costs of pork production, but for many producers this figure is now higher. Increased grain and supplement costs have pork producers seeking alternatives to traditional ingredients in swine diets. Feed costs are, and will continue to be, an ever increasing factor in determining the profitability of a swine enterprise.

Adopting ingredient alternatives seems like a logical step for pork producers, however, availability, cost competitiveness, handling, and accurate formulation are often obstacles that must be overcome before an alternative can be utilized successfully. Producers must recognize that alternatives may not be economical or may not complement the goals of their production system when used in the diet. Producers must continually evaluate the economics of using alternative ingredients as they may price into diets when corn or soybean meal are high, but may fail to be economical if demand or other factors change the price significantly. Understanding these factors is critical to determine if the use of alternative ingredients is a long term option for lowering diet costs or simply a short term price advantage.

Historically, corn has been the swine industry standard for supplying energy in a diet. but many other alternatives can easily meet the pigs' dietary nutritional requirements with proper formulation. The most common cereal grain substitutes used are grain sorghum (milo), wheat and barley. Bakery by-product also can serve as a primary energy source in swine diets.

On the protein side, soybean meal has been the standard for supplying amino acids. Ingredients used as alternatives to soybean meal include meat and bone meal and canola meal. The use of synthetic amino acids also can greatly reduce the protein source needed in a diet.

Finally, ingredients that can replace a portion of both corn and soybean meal include distillers grains with solubles, field peas, wheat midds and soybean hulls. These ingredients provide a variety of benefits to a swine ration including energy, protein and fiber.

Important considerations to take into account when using alternative ingredients are determining accurate nutrient values; accounting for ingredient variation; formulating on a digestible amino acid basis; and, valuing the energy impact on the diet. These factors must be accurately determined to predict growth performance changes that may impact the economic analysis.

The feed ingredients suggested in this publication have been used successfully to feed swine and can be used with confidence with proper sourcing and diet formulation. However, locating the right source for the alternative ingredients can be challenging. A basic knowledge and understanding of alternative ingredients and suppliers not only in times of high corn and soybean prices, but on an on-going basis will help to provide current pricing data and identify opportunities to develop long-term pricing advantages.

Contact the Pork Checkoff, your local or state extension specialists for more information.

WHEAT MIDDLINGS

Background

During the wheat milling process, about 70 to 75 percent of the grain becomes flour, leaving 25 to 30 percent as wheat byproducts. The identification of the different wheat byproducts is based on the crude fiber concentration. One of these byproducts is wheat middlings or wheat midds. Wheat midds are relatively higher in fiber than feed grains.

Typical nutrient composition (as-fed)	
Dry matter, %	89.0
Energy, kcal/lb	
Digestible	1,395
Metabolizable	1,372
Net, INRA	849
Net, NRC	708
Crude protein, %	15.9
Calcium, %	0.12
Phosphorus, %	0.93
Available P, %	0.38
Crude fat, %	4.2
Linoleic acid, %	1.74
Crude fiber, %	8.5
Neutral detergent fiber, %	35.6
Acid detergent fiber, %	10.7

Amino acids, %	Total	SID[1]
Lysine	0.57	89%
Isoleucine	0.53	92%
Leucine	1.06	93%
Methionine	0.26	93%
Cysteine	0.32	91%
Threonine	0.51	88%
Tryptophan	0.20	91%
Valine	0.75	90%

[1]Standardized ileal digestibility

Advantages

Wheat midds are valuable to swine diets because of their energy and protein content. Wheat midds are commonly added to pelleted feeds because of their beneficial effects on pellet quality. Because of their low bulk density, it is recommended to use pelleted wheat midds and then regrinding them to incorporate into the diet. Typically, 100 lb of wheat midds will replace 86.5 lb of corn, 12 lb of high protein soybean meal, and 1.5 lb of monocalcium phosphate. This will replace the lysine and phosphorus provided by corn and soybean meal. It will also have little effect on the energy content of the diet and only lower dietary energy content by approximately 15 Kcal metabolizable energy per ton, the equivalent of 0.50 percent added fat.

Disadvantages

Wheat midds contain between 7.0 and 9.5 percent of fiber. In addition to the fiber content, the low bulk density (anywhere from 18 to 24 lb/cubic ft.) increases the volume of the feed unless the wheat midds are pelleted at the flour mill.

Thus, capacity of mixers, trucks, feed bins, and feeders must be considered when adding unpelleted wheat midds to the diet, particularly at relatively high inclusion rates.

Wheat midds should be stored away from contact with cement floors or soil. High relative humidity or water from leaks in the storage bin completely destroy wheat midd pellets. Make sure to level the surface of the midds in storage, this allows for better distribution of air. Lastly the goal of air circulation is to dry the midds, not to cool them. Therefore, air used for aeration should contain less than 65 percent relative humidity.

Feeding and Handling

The low bulk density of wheat midds will decrease the bulk density of the final diet. To increase bulk density, wheat midds are often sold in a pelleted form. When purchasing as a pellet, grinding will reduce handling issues in the mill and sorting in feeders.

Gestating sow feeding levels will need to be increased if high levels of wheat midds are included in the gestation diet without adjusting the energy level of the diet.

KEY CONSIDERATIONS WITH WHEAT MIDDS:

- Need to be pelleted then reground to counteract low bulk density
- Long term storage requires special precautions
- Excellent source of crude fat, crude protein (lysine) and fiber
- Breakeven pricing depends on existing protein source and cereal grain prices

Nutrient Profiles and Feeding Recommendations

Wheat midds can be added up to 5 percent of the diet for nursery pigs and lactating sows. It can be added up 25 percent of the diet for growing and finishing pigs. Studies have shown decreased daily gain and feed conversion if added at levels greater than 25 percent. There is no limit for wheat midds in gestating sow diets as long as the diet is balanced properly.

Availability

Wheat midds are available wherever wheat is ground for flour. The availability of wheat midds is limited to a large degree by the seasonal level of production and demand for flour. The price of wheat midds generally decreases during the spring and early summer, and is highest in the fall and winter months. Its price is also in relationship to demand as a feed ingredient for beef and dairy cattle, where it has a higher value than for swine.

More information on the availability of wheat midds can be found at:

U.S. Wheat Associates: ***www.uswheat.org***

North American Millers Association: ***www.namamillers.org***

References

NRC. 1998. Nutrient Requirements of Swine. 10th ed. Natl. Acad. Press, Washington, DC.

Patience, J.F., P.A. Thacker, and C.F.M. De Lange. 1995. Swine Nutrition Guide, 2nd Edition. Prairie Swine Center, Saskatoon, Saskatchewan, Canada

Tables of Composition and Nutritional Value of Feed Materials. 2004. D. Savant, J.M. Perez, and G. Tran. Wageningen Academic Publishers, the Netherlands and INRA, France.

Wheat middlings, composition, feeding value, and storage guidelines. Contribution no. 99-35-E from the Kansas Agricultural Experiment Station. Kansas State University, Manhattan, KS 66506.

Typical nutrient composition (as-fed)	
Dry matter, %	88.0
Energy, kcal/lb	
Digestible	1,526
Metabolizable	1,456
Net, INRA	1,111
Net, NRC	1,009
Crude protein, %	13.5
Calcium, %	0.06
Phosphorus, %	0.37
Available P, %	0.185
Crude fat, %	2.0
Linoleic acid, %	0.93
Crude fiber, %	2.2
Neutral detergent fiber, %	13.5
Acid detergent fiber, %	4.0

Amino acids, %	Total	SID[1]
Lysine	0.34	81%
Isoleucine	0.41	89%
Leucine	0.86	89%
Methionine	0.20	90%
Cysteine	0.29	90%
Threonine	0.37	84%
Tryptophan	0.15	90%
Valine	0.54	86%

[1]Standardized ileal digestibility

Background

Wheat is grown primarily for human food manufacturing in a variety of regions across the United States and Canada. There are numerous types of wheat and they are generally classified as hard or soft. Also, wheat can be seeded in the fall or spring depending on geographic region. Regardless of planting time and variety, they can be successfully fed to swine as a partial or complete replacement for corn in most swine diets. The keys to successfully feeding wheat to swine are in diet formulation and proper feed processing.

Advantages

Wheat can be an excellent replacement for a portion or all of the corn in most swine diets. Wheat contains approximately 30 percent more lysine and over three times the amount of available phosphorus than corn. Because of the greater lysine and available phosphorus concentration, producers can generally afford to pay a little more for wheat (approximately 107 percent) than corn on a hundred weight (cwt.) basis and still lower diet costs.

Disadvantages

Wheat contains only 95 percent the energy content of corn and as a result, feed efficiency will be slightly poorer compared with pigs fed corn unless an additional energy source, such as fat, is added to the diet. If ground too finely wheat will tend to flour, reducing feed intake, plugging feeders and increasing the potential for ulcers.

Feeding and Handling

Properly adjusting diet formulations to take into account wheat's higher lysine and available phosphorus concentrations is essential to maximize the economic benefit of feeding wheat. It also is important in order to decrease nitrogen and phosphorus excretion into the environment. The amino acid profile of wheat also will allow for higher inclusion of synthetic lysine in diets containing wheat.

Secondly, proper feed processing is necessary so that the wheat will not flour, which reduces feed intake and plugs feeders. Whereas in almost all swine diets we recommend producers grind to a particle size of 700 microns or less, wheat-based diets should be slightly coarser (800 microns) to reduce the risk of it becoming flour. As a rule of thumb, it is recommended that a wheat kernel be broken into four to five pieces as a compromise between optimum consumption, feed efficiency and diet flowability. Because of the shape and uniform distribution of particle size, roller mills are excellent for grinding wheat.

KEY CONSIDERATIONS WITH WHEAT:

- Excellent source of lysine and available phosphorus
- 5 percent less energy than corn
- Be careful grinding so as not to flour
- Breakeven price at approximately 107 percent or lower of corn price

Nutrient Profiles and Feeding Recommendations

An important diet formulation consideration when using wheat-based diets is its low energy content. As a result, when diets are formulated to the same lysine-to-calorie ratio, the actual lysine content of the diet will be slightly less than a corn-based diet.

When adding wheat in place of corn, the amount of supplemental soybean meal and inorganic phosphorus can be reduced. For example, a wheat-based finishing diet will require less soybean meal and only one-third the amount of inorganic phosphorus than a corn-based diet.

While much of the wheat production in the United States is hard red varieties, soft wheat also makes an excellent feed ingredient in swine diets. Studies comparing soft red wheat to hard red winter wheat in finishing pig diets reveal virtually no differences in pig performance. Therefore, soft wheat can be as effectively utilized in swine diets as hard red wheat. There also are no differences among pigs fed spring versus winter wheat and red versus white wheat.

Test weight is not necessarily a good quality indicator for establishing the relative economic value for wheat. Studies evaluating the energy content of wheat showed no differences in digestible energy in wheat having 53 or 62 lb test weight. Digestible energy content of wheat will decrease with test weights below 53 lb. In fact, pigs fed wheat had 6.5 and 8.0 percent poorer feed efficiency as test weight decreased to 51 and 45 lb, respectively. Therefore, when purchasing wheat with test weights below 53 lb, some discount should be anticipated to offset the expected decreases in feed efficiency. If test weight is below normal, another option might be to use the wheat as only a partial substitution for corn. Research demonstrates that sprouted wheat (up to 15 percent of diet) has the same feeding value as regular wheat.

Recent evaluation of the addition of enzymes (Pentosanases) to swine diets failed to show any improvement in growth performance in wheat-based diets.

Cool wet weather conditions during early summer can provide ideal conditions for the development of wheat scab or head blight disease. This disease is caused by the fungus, *Fusarium graminearum*, which can produce vomitoxin. Vomitoxin is a mycotoxin known for dramatically reducing intake of contaminated feeds. Infected grains are generally shrunken or shriveled and have a high percentage of pink kernels. Vomitoxin contamination as low as 0.75 ppm in a complete diet will reduce pig performance. Mycotoxin contamination can be a particular concern with drought stressed, low test weight wheat.

Availability

Wheat is primarily grown for human consumption and therefore it is usually not economically feasible to replace corn in swine diets. An exception is when there is a large wheat harvest coupled with low corn supply. Because wheat is harvested earlier in the summer than corn, wheat may be more economical than corn between wheat and corn harvest in wheat producing areas. Wheat also can be available when it is specifically grown as feed grade wheat or when the wheat is discounted for human consumption due to quality concerns. Wheat that exceeds mycotoxin limits for human consumption can often be used safely for livestock feed.

Information on wheat availability can be found at: ***http://www.ngfa.org/trygrains_wheat.asp***

References

NRC. 1998. Nutrient Requirements of Swine. 10th ed. Natl. Acad. Press, Washington, DC.

Patience, J.F., P.A. Thacker, and C.F.M. De Lange. 1995. Swine Nutrition Guide, 2nd Edition. Prairie Swine Center, Saskatoon, Saskatchewan, Canada

Tables of Composition and Nutritional Value of Feed Materials. 2004. D. Savant, J.M. Perez, and G. Tran. Wageningen Academic Publishers, the Netherlands and INRA, France.

SYNTHETIC AMINO ACIDS

Typical nutrient composition (as-fed)[1]	
L-lysine HCl[2]	78.6% lysine
DL-methionine	99% methionine
Liquid MHA	88% methionine[3]
L-threonine	99% threonine
L-tryptophan	98.5% tryptophan
L-isoleucine	99% isoleucine
L-valine	99% valine

1 All synthetic amino acids are considered to be 100% digestible.

2 Lysine is also available in liquid and dry forms with 50 to 60% lysine.

3 Technically, methionine hydroxy analog (MHA) does not contain methionine but is converted to this amino acid by the pig.

Background

Synthetic amino acids can be used to replace a portion of the protein in the diet to meet the amino acid needs of the pig. The increasing availability of synthetic amino acids continues to make their use a more economically viable option for swine diets. Prices vary significantly among synthetics.

Advantages

Use of synthetic amino acids lowers the crude protein level of the diet. Synthetic lysine is almost always an economical addition to swine diets, but prices vary between synthetics and one may be economical while another may not at a given price. Nitrogen excretion and ammonia emissions are reduced as greater levels of synthetic amino acids are used in the diet and relative crude protein levels decrease. The net energy level of the diet also increases as grain and synthetic amino acids replace protein sources in the diet.

Disadvantages

Because nutritionists are now formulating to the third, fourth, or fifth limiting amino acids when using synthetic amino acids, there is often less margin for error in diet formulation. For example, if too much crude protein is replaced with synthetic amino acids, pig performance is reduced and feed efficiency increases. This is particularly a problem with late finishing pigs. Due to their rapid absorption, synthetic amino acids are used less efficiently by pigs fed once per day (such as gestating sows).

Feeding and Handling

Most synthetic amino acids are available in dry or liquid forms. In order to use liquid forms, pumps and metering devices are required. The dry forms are free flowing and do not pose great handling concerns and are relatively stable during storage. Because of the precision required with low inclusion rates of some amino acids, accurate scales and mixing equipment are required for their use.

Nutrient Profiles and Feeding Recommendations

The amounts of synthetic amino acids that can be added to the diet depend on the other ingredients included in the diet. For example, 3 lb/ton of L-Lysine HCl can be added to most corn-soybean meal based diets before other synthetic amino acids must be added. If more than 3 lb of lysine is added per ton (and crude protein is reduced accordingly), supplemental threonine and methionine must also be added because crude protein levels will have decreased enough to create additional supplementation. When 10 percent DDGS is added to a corn-soybean meal based diet, the quantity of L-lysine that can be added increases to approximately 5 lb/ton before other amino acids must be added.

As a replacement for soybean meal, lysine, threonine, and methionine are the only amino acids that are typically economical. Thus, the diet is balanced for the fourth limiting amino acid (often tryptophan, valine or isoleucine) and the first three limiting amino acids (lysine, threonine and methionine) are added as synthetics to meet their requirement. An exception to this rule would be in nursery diets where other synthetic amino acids (such as valine and isoleucine) may be added to replace a more expensive protein source, such as fish meal.

KEY CONSIDERATIONS WITH SYNTHETIC AMINO ACIDS:

- Often reduce diet cost by replacing soybean meal in the diet
- Reduce dietary crude protein level
- Increase dietary net energy
- Reduce nitrogen excretion
- Breakeven pricing depends on protein source and cereal grain price

Nutrient Profiles and Feeding Recommendations (continued)

Reliable estimates of the pig's amino acid requirements and the digestible amino acid content in the dietary ingredients are required to properly use synthetic amino acids. Synthetic amino acids are generally considered 100 percent digestible when used in diet formulation. Producers should work closely with a nutritionist to fully utilize synthetic amino acids in the diet.

Availability

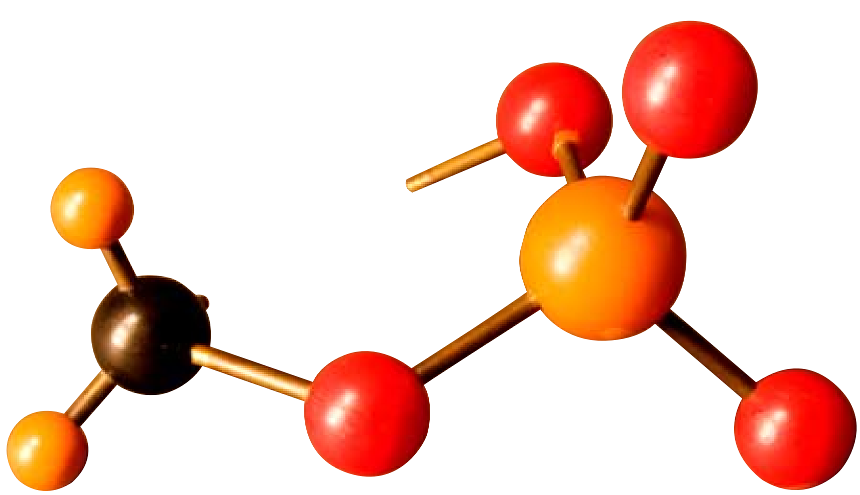
Synthetic amino acids are available from several companies. Lysine can be purchased as L-lysine HCl or as liquid or dry forms containing 50 to 60 percent L-lysine. Methionine can be purchased as either DL-methionine or as a methionine hydroxyl analog. The methionine hydroxyl analog (MHA) is available in a liquid (88 percent dry matter) or dry form. The estimates for efficiency of MHA conversion to methionine ranges from 60 to 100 percent depending on the response criteria and methodology. Threonine, tryptophan, isoleucine and valine are usually purchased as dry concentrated products.

For more information on synthetic amino acid availability, visit:

ADM: ***http://www.admworld.com/naen/ahn/aminoacids.asp***
Ajinomoto Heartland LLC: ***http://www.lysine.com/new/index.html***
Degussa: ***http://www.aminoacidsandmore.com/default.cfm***
Novus International: ***http://www.novusint.com/index.aspx***

References

Tables of Composition and Nutritional Value of Feed Materials. 2004. D. Savant, J.M. Perez, and G. Tran. Wageningen Academic Publishers, The Netherlands and INRA, France.



Typical nutrient composition (as-fed)	
Dry matter, %	93.0
Energy, kcal/lb	
Digestible	1,107
Metabolizable	1,009
Net, INRA	794
Net, NRC	615
Crude protein, %	51.5
Calcium, %	9.99
Phosphorus, %	4.98
Available P, %	4.48
Crude fat, %	10.9
Linoleic acid, %	0.72
Crude fiber, %	2.4
Neutral detergent fiber, %	32.5
Acid detergent fiber, %	5.6

Amino acids, %	Total	SID[1]
Lysine	2.51	80%
Isoleucine	1.34	82%
Leucine	2.98	81%
Methionine	0.68	83%
Cysteine	0.50	63%
Threonine	1.59	80%
Tryptophan	0.28	78%
Valine	2.04	79%

[1]Standardized ileal digestibility

Background

Meat and bone meal is a byproduct of the packing and rendering industry. It is composed of meat trimmings, inedible parts and organs and sometimes whole carcasses that have been mixed and cooked (rendered) to produce a high protein (50 percent) feed ingredient. Meat and bone meal should not be confused with meat meal which contains approximately 55 percent crude protein. Other distinctions are the calcium (Ca) and Phosphorous (P) concentrations, meat and bone meal has greater than 4 percent P, while meat meal contains less than 4 percent.

Advantages

Meat and bone meal is added to the pig ration as a protein source. Meat and bone meal is higher in crude protein than soybean meal. However, the lysine content and digestibility of amino acids are lower than in soybean meal. Meat and bone meal also is an excellent source of Ca and available P which can reduce, or in some cases totally replace, the limestone and inorganic P added to the diet. Because of its high crude protein, Ca and P content, meat and bone meal is worth slightly more than soybean meal (103 to 105 percent).

Disadvantages

Historically, the biggest challenge with using meat and bone meal has been overall quality and product variation. The protein (lysine) content can vary considerably among and within sources. Another limitation to the addition of meat and bone meal in swine diets is its low tryptophan concentration, which can become limiting depending on the product's inclusion level. The low tryptophan content is because collagen –which is nearly devoid of tryptophan- is one of the major proteins in meat and bone meal. Studies have shown that increasing cooking temperatures from 257 to 300º F reduced the digestible lysine content by 50 percent creating variation in quality and underscoring the need to analyze each lot for nutrient composition. In some cases, adding meat and bone meal to the diet might exceed the pig's dietary P requirement which may increase P level in manure and subsequently lead to P accumulation in crop ground and to manure application restrictions.

Feeding and Handling

Meat and bone meal can be a partial replacement for soybean meal and a partial or complete replacement for the limestone and inorganic phosphorus in the diet. The high salt concentration (2.5 percent) also will require recalculating the supplemental salt added to the diet. While it is illegal to feed ruminant meat and bone meal back to ruminants, this is not a restriction on swine. However if a feed mill handles both swine and cattle feeds, ruminant meat and bone meal cannot come in contact with any feed processing or transportation equipment used for cattle feed.

KEY CONSIDERATIONS WITH MEAT AND BONE MEAL:

- Meat and bone meal can be highly variable in composition
- Good source of lysine
- Good source of calcium and phosphorous
- Can be used up to 5 percent of the diet.
- Breakeven pricing depends on both existing protein source and supplemental phosphorus price

Nutrient Profiles and Feeding Recommendations

Studies have shown that meat and bone meal can be used up to 5 percent of the diet without negatively affecting pig performance. Meat and bone meal can be added at higher levels if tryptophan concentrations are adjusted accordingly.

Despite its high fat content (approximately 10 percent), meat and bone meal contains slightly less metabolizable energy than soybean meal. Therefore, feed efficiency may be slightly poorer when adding meat and bone meal to the diet unless the energy level is maintained in the diet. At the 5 percent inclusion level it will replace approximately 25 to 30 percent of the soybean meal and nearly all of the supplemental inorganic P in the diet. In some cases, the amount of P contributed by meat and bone meal may exceed the pig's requirement leading to greater P concentrations in swine waste.

Availability

Meat and bone meal can be purchased from packing plants, renderers or ingredient suppliers. Finding a source of consistent product greatly increases the value of meat and bone meal.

Meat and bone meal suppliers can be found at:
http://www.ingredients101.com/meatbm.htm
http://www.griffinind.com/FPS-Bone.html
http://www.rendermagazine.com

References

NRC. 1998. Nutrient Requirements of Swine. 10th ed. Natl. Acad. Press, Washington, DC.

Patience, J.F., P.A. Thacker, and C.F.M. De Lange. 1995. Swine Nutrition Guide, 2nd Edition. Prairie Swine Center, Saskatoon, Saskatchewan, Canada.

Renderer Magazine, ***http://www.rendermagazine.com/***

Cromwell, G.L., Rendered Products in Swine Nutrition, ***http://nationalrenderers.org/nutrition/swine***

Typical nutrient composition (as-fed)	
Dry matter, %	90.0
Energy, kcal/lb	
Digestible	1,309
Metabolizable	1,197
Net, INRA	559
Net, NRC	730
Crude protein, %	35.6
Calcium, %	0.63
Phosphorus, %	1.01
Available P, %	0.212
Crude fat, %	3.5
Linoleic acid, %	0.42
Crude fiber, %	11.8
Neutral detergent fiber, %	21.2
Acid detergent fiber, %	17.2

Amino acids, %	Total	SID[1]
Lysine	2.08	78%
Isoleucine	1.43	78%
Leucine	2.58	81%
Methionine	0.74	86%
Cysteine	0.91	83%
Threonine	1.59	76%
Tryptophan	0.45	75%
Valine	1.82	77%

[1]Standardized ileal digestibility

Background

Canola meal is the by-product of canola processing to produce vegetable oil. Canola meal is not the same as rapeseed meal that is high in glucosinolates that reduce palatability and feed intake. Because it is well adapted to cool season growing conditions, canola is produced primarily in Canada and the northern United States. In these areas, canola meal, when economical (65-75 percent price of soybean meal), is used as a major protein source in swine diets. While canola meal has a relatively balanced amino acid profile, it has a lower energy value than soybean meal. Thus dietary adjustments need to be considered when utilizing canola meal as a major protein source in the diet.

Advantages

Canola meal is relatively high in crude protein and some essential amino acids. One distinct advantage is that canola meal contains approximately 17 percent more total sulfur amino acids (methionine and cysteine) than soybean meal. Therefore, increased amounts of synthetic lysine can be used with canola meal while maintaining similar dietary amino acid ratios. In addition, canola meal contains more available phosphorus than soybean meal, lowering the need for inorganic phosphorus in the diet.

Disadvantages

Due to its higher fiber content, canola meal has approximately 22 percent less energy than soybean meal. The lower energy will cause poorer feed efficiency and a decrease in average daily gain (ADG) if other energy sources are not added to the formulation. While canola meal contains higher levels of certain amino acids than soybean meal, the digestibility of essential amino acids is 4 to 15 percent lower. However, research has shown that if the diet is formulated on an equal digestible nutrient basis, pigs fed diets containing canola meal will have equal performance compared to those consuming only soybean meal as the primary amino acid source.

Feeding and Handling

Properly adjusting diet formulations to take into account canola meal's amino acid profile, lower amino acid digestibility, energy content and higher available phosphorus concentration than soybean meal is essential to maximize the economic benefit of feeding canola meal.

Canola meal is a free flowing ingredient that does not require further processing once purchased. Also, because it contains a low level of fat, its stability in storage is similar to that of corn.

KEY CONSIDERATIONS WITH CANOLA MEAL:

- Formulate diets on a digestible amino acid basis
- Low energy ingredient
- High available phosphorus content
- Breakeven price at approximately 77 percent of soybean meal price

Nutrient Profiles and Feeding Recommendations

Canola meal can be used to replace up to 25 percent of the protein from soybean meal in nursery diets; 50 percent of the soybean meal in growing pigs and lactation diets; and the entire protein source in gestation and finishing diets. The main limitation of full replacement with canola meal in lactation, nursery and early grower diets is the lower energy content. Higher levels than those recommended can be fed, but limitations on practical fat inclusion levels in these diets may limit performance due to not achieving equal dietary energy concentrations. Choline also is very low in canola meal relative to soybean meal and supplemental choline may be needed with sow and weanling pig diets.

A laboratory analysis should be conducted for estimating canola meal's amino acid and energy content for diet formulation. ,. The amino acid profile of canola meal also will allow for higher inclusion of synthetic amino acids in diets containing canola meal. Digestibility of amino acids is lower in canola meal than in soybean meal. Thus, diets should be formulated on digestible amino acid basis when canola meal is used in the diet. Canola meal can be price competitive at approximately 77 percent or less of soybean meal price when accounting for the lower energy content and subsequent higher feed to gain ratio. However, when balanced for energy content by adding dietary fat to maintain equal growth performance, the breakeven price of canola meal should be less than 66 percent of that of soybean meal.

Although canola is derived from rapeseed, it does not have the same limitations as rapeseed meal. Rapeseed meal has a poor reputation due to its high levels of eruic acid and glucosinolates which are unpalatable and lead to low feed intake. Due to advancements in canola varieties, the levels of eruic acid and glucosinolates have been greatly reduced. Thus, palatability is not an issue with canola meal.

Availability

Canola meal is available extensively throughout Canada and in the northern United States. It is marketed by canola oil extraction processing facilities as their primary coproduct.

Some suppliers of canola meal include:
http://www.canola-council.org/suppliers_and_contacts.aspx#supply_meal
http://pacificcoastcanola.com/canola_meal.php

References

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Canola Council of Canada. 2001. Canola Meal Feed industry Guide. 3rd edition.
http://www.canola-council.org/uploads/feedguide/canolamealpigs.pdf

U.S. Canola Association, ***http://www.uscanola.com/***

Typical nutrient composition (as-fed)	
Dry matter, %	89.4
Energy, kcal/lb	
Digestible	911
Metabolizable	846
Net, INRA	455
Crude protein, %	12.0
Calcium, %	0.49
Phosphorus, %	0.14
Available P, %	0.04
Crude fat, %	2.2
Linoleic acid, %	1.1
Crude fiber, %	34.2
Neutral detergent fiber, %	56.4
Acid detergent fiber, %	40.4

Amino acids, %	Total	SID[1]
Lysine	0.71	60%
Isoleucine	0.44	68%
Leucine	0.74	70%
Methionine	0.14	71%
Cysteine	0.19	63%
Threonine	0.43	61%
Tryptophan	0.14	63%
Valine	0.51	61%

[1]Standardized ileal digestibility

Background

Soybean hulls are byproducts of soybean processing. Hulls are separated from the soybean during the oil extraction process. Soybean hulls represent 5 percent of the original weight of the raw soybean. Soybean hulls are often added to sow diets as a relatively digestible source of non-starch polysaccharides to increase the fiber content and to grow-finish diets to reduce ammonia emissions.

Advantages

Soybean hulls are a potentially valuable source of fiber, protein and energy, particularly in sow diets. When added at low levels to the diet, soybean hulls shift urinary nitrogen production to fecal nitrogen. Thus, ammonia levels in the barn are reduced by including soybean hulls in the diet. Adding low levels (less than 5 percent) to the diet doesn't appear to impact growth performance as much as expected by the lower energy content. The lower bulk density and high fiber helps increase satiety and acts as a laxative for gestating sows.

Disadvantages

Soybean hulls are low in energy (55 percent of the metabolizable energy of corn). Unless diets are balanced for energy, growing pig performance will be reduced if high levels (of more than 5 percent) of soybean hulls are included in the diet. Low bulk density of soybean hulls can increase transportation costs when compared to cereal grains.

Feeding and Handling

The low bulk density of soybean hulls will decrease the bulk density of the final diet. Thus, capacity of mixers, trucks, feed bins and feeders must be considered when adding soybean hulls or any other low density ingredient to a diet. To increase bulk density, soybean hulls are often sold in pelleted form. When purchasing as either pellet or as whole soybean hulls, grinding will reduce handling issues in the mill and sorting in feeders.

Daily sow feed levels need to be increased if high levels of soybean hulls are included in the gestation diet unless the dietary energy level of the diet is adjusted accordingly.

KEY CONSIDERATIONS WITH SOYBEAN HULLS:

- Source of non-starch polysaccharides (soluble fiber)
- Low energy ingredient
- Low bulk density
- Reduces pig ammonia emissions when included in diet
- Breakeven pricing depends on existing protein source and cereal grain prices

Nutrient Profiles and Feeding Recommendations

If the energy density of the diet is not adjusted by adding a high energy ingredient such as fat, performance of growing pigs will be reduced. Because sows utilize fiber more effectively than growing pigs, the energy value of soybean hulls for sows can be as much as 40 percent higher than the energy values for growing pigs.

Feeding levels for sows should be increased if the energy content of the diet is not adjusted when soybean hulls are added to gestation diets. Also, due to changes in the bulk density of the diet when hulls are used at high levels, gestation feeding boxes should be measured for drop accuracy and adjusted accordingly. Amino acid concentrations in soybean hulls are highly correlated to the crude protein level. Digestibility of amino acids is lower in soybean hulls than in soybean meal. Thus, diets should be formulated on digestible amino acid basis when soybean hulls are used in the diet.

Availability

Soybean hulls are available from most soybean processors throughout the United States. The amount of soybean hulls available depends on: 1) whether the soybean crusher is operating at full or partial capacity; 2) whether the processor is adding them back to the soybean meal; and, 3) on demand as a feed ingredient for beef and dairy cattle, where they have a higher feed value. The value of soybean hulls for swine varies with price, but they can be an economical alternative particularly in sow diets.

More information on availability of soybean hulls can be found from;
U.S. soybean processors: ***http://www.soymeal.org/map/newmap.html***

References

Tables of Composition and Nutritional Value of Feed Materials. 2004. D. Savant, J.M. Perez, and G. Tran. Wageningen Academic Publishers, The Netherlands and INRA, France.

National Oilseed Processors Organization Web site at ***http://www.nopa.org***

United Soybean Board Web site at ***http://www.unitedsoybean.org/***

Background

Field peas are grown for human and livestock consumption primarily in Canada. In the United States, field pea production is grown as a complement in various crop rotations. Peas can be either green or yellow in color, and seed size depends on the variety. Field peas do not require special equipment to grow, handle, grind or feed. Field peas can be used as a protein source or to replace a portion of the cereal grain when used at high levels in the diet.

Advantages

Peas are a good source of lysine and have essential amino acid digestibility similar to soybean meal. However, peas have approximately 50 percent of total crude protein compared to soybean meal. When peas also replace a portion of corn, peas contribute a greater level of calcium and available phosphorus.

Some varieties of peas have energy content similar to corn, but generally the energy value is slightly lower than corn. Also, the net energy content of peas is higher than soybean meal and higher on a both a net and metabolizable basis than most other protein alternatives such as canola meal.

Disadvantages

Peas contain low levels of sulfur amino acids (methionine and cysteine) and tryptophan relative to lysine. Thus, formulating on a digestible amino acid basis is critical when using peas. While increases in synthetic methionine use can overcome the low sulfur amino acid content, limitations can occur with synthetic lysine use due to minimum required tryptophan levels. Also, due to a lower energy content compared to corn, adjustment in the energy content of the diet is needed to maintain pig performance.

The nutrient content of peas can vary widely depending on the variety. Therefore, chemical analysis of nutrient content and availability is suggested to determine the ratio to be used in diet formulation. Many peas are available as screenings or "low germination" lots. Producers should inspect screenings and conduct a nutrient analysis before using in swine rations.

Typical nutrient composition (as-fed)	
Dry matter, %	89.0
Energy, kcal/lb	
Digestible	1,558
Metabolizable	1,456
Net, INRA	1,069
Net, NRC	996
Crude protein, %	22.8
Calcium, %	0.11
Phosphorus, %	0.39
Available P, %	0.15
Crude fat, %	1.2
Linoleic acid, %	0.47
Crude fiber, %	5.5
Neutral detergent fiber, %	12.7
Acid detergent fiber, %	7.2

Amino acids, %	Total	SID[1]
Lysine	1.50	88%
Isoleucine	0.86	85%
Leucine	1.51	86%
Methionine	0.21	84%
Cysteine	0.31	79%
Threonine	0.78	83%
Tryptophan	0.19	81%
Valine	0.98	83%

[1]Standardized ileal digestibility

Feeding and Handling

Like raw soybeans, field peas contain the anti-nutritional factor trypsin inhibitor. The trypsin inhibitor concentration can be deactivated by heating, but levels are usually low enough in field peas that they do not cause problems in diet formulation. Thus, peas are fed raw without heat treatment in most situations. There are no concerns of reduced palatability with feeding raw peas in diets for swine.

Peas are a free-flowing ingredient, similar in seed size to whole soybeans and are stored similar to other cereal grains. Because the crude fat level of peas is low (1.2 percent), rancidity is of little concern during storage. Before mixing peas into the complete diet, they should be ground similarly to other cereal grains, targeting a mean particle size of 650 to 750 microns.

Peas work well in diets containing canola meal because canola meal is high in sulfur amino acids which compensates for the low level found in peas. When these two ingredients are used in combination, they can serve as total replacements for soybean meal in growing and finishing pig diets.

KEY CONSIDERATIONS WITH FIELD PEAS:

- Formulate on a digestible amino acid basis
- Low in methionine and tryptophan
- Grind to 650 to 750 microns
- Variation in nutrient content based on variety
- Breakeven price at approximately 75 percent of soybean meal price

Nutrient Profiles and Feeding Recommendations

Field peas can be added up to 15 percent in nursery and 40 percent in growing and finishing pigs without affecting growth performance when fed in balanced diets. Much less research has been conducted with breeding animals, but recommendations of up to 15 percent in gestation and 25 percent in lactation are generally accepted.

Because of the varied nutrient content of different varieties planted in different geographic areas, chemical analysis should be conducted to determine the nutrient content and the economics of using peas as a replacement for soybean meal and cereal grains. As a general guideline, peas can replace soybean meal once they can be procured at approximately 74 percent of soybean meal price.

Availability

Peas are available extensively throughout Canada and in the northern United States. Geographic region influence the varieties that are planted and are available for purchase. Peas can be purchased directly from producers as well as through typical grain marketing channels. In some areas, peas are available at cost effective prices as low germination or as screenings. Low germination peas will typically be of very high quality, while screening lots may contain dirt and weed seeds, among other things, and should be tested for nutrient content before use.

More information on availability of field peas can be found at: ***http://www.pea-lentil.com/home.htm***

References

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Thaler, R. and H. Stein. 2003. Using South Dakota Grown Field Peas In Swine Diets. South Dakota State University Extension Extra 2041.

Anderson, V. R. Harrold, D. Landblom, G. Lardy, B. Schatz, and J.W. Schroeder. 2002. A Guide to Feeding Field Peas to Livestock. North Dakota State University, AS-1224.

Background

Barley is typically produced in regions where corn production is not agronomically feasible. Barley is well adapted to areas with shorter growing seasons and lower rainfall. For these reasons, barley is a major feed ingredient in Western Canada and the upper Great Plains where it is often used as the sole grain source. Barley is also available as a byproduct of malt barley production in some regions when protein levels are too high for malting. Barley can be either a partial or complete replacement for corn in most swine diets. The keys to successfully feeding barley to swine are in diet formulation and feed processing.

Typical nutrient composition (as-fed)	
Dry matter, %	89.0
Energy, kcal/lb	
Digestible	1,383
Metabolizable	1,320
Net, INRA	1047
Net, NRC	1,048
Crude protein, %	10.5
Calcium, %	0.06
Phosphorus, %	0.36
Available P, %	0.11
Crude fat, %	1.9
Linoleic acid, %	0.91
Crude fiber, %	4.6
Neutral detergent fiber, %	18.6
Acid detergent fiber, %	7.0

Amino acids, %	Total	SID[1]
Lysine	0.36	79%
Isoleucine	0.37	84%
Leucine	0.68	86%
Methionine	0.17	86%
Cysteine	0.20	86%
Threonine	0.34	81%
Tryptophan	0.13	80%
Valine	0.49	82%

[1]Standardized ileal digestibility

Advantages

Barley contains more crude protein, lysine and available phosphorus than corn. Because of the greater lysine and available phosphorus concentration, less soybean meal and inorganic phosphorus will be needed in the diet. Hulless varieties of barley have approximately 8 percent greater energy and, therefore, greater economic value than hulled barley. Hulless barley contains 1,475 Kcal of digestible energy and 0.54 percent lysine.

Disadvantages

Barley is generally limited in its uses for swine diets by its high fiber content (4.5 to 7 percent) and relatively light test weights of 46 to 48 pounds per bushel. The high fiber content reduces the energy content of the diet and therefore decreases average daily gain and worsens the feed to gain ratio compared with pigs fed corn. Methods to reduce the impact of barley's low energy content would be to seek out low fiber varieties of barley, add fat or pellet the diet. Despite the high lysine and phosphorus content, the low energy content limits barley's value to approximately 85 percent the feeding value of corn. Barley also contains less biotin than corn and may need extra supplementation when used, especially in sow diets. Some varieties, such as brewers' barleys can vary widely with test weights as heavy as 54 lb /bushel and protein levels as high as 14 percent when produced under irrigation. Production with these varieties can approach that of corn- based rations, increasing the relative value accordingly.

Variability among the different types of barley grown also can be a problem when evaluating it for swine diets. There are two- and six-row barley varieties which have slightly different nutrient values (six-row composition shown), spring and winter barley, and hulled and hulless barley. Differences in nutrient composition can vary dramatically and are based primarily on cultivar, growing conditions and fiber content.

KEY CONSIDERATIONS WITH BARLEY:

- Average of 15 percent less energy than corn
- Greater concentrations of crude protein, lysine and available phosphorus than corn
- Fine grinding (700 microns or less) can improve feeding value
- Nutrient profile varies widely by cultivar and growing conditions
- Breakeven price at approximately 85 percent or lower of corn price

Feeding and Handling

Properly adjusting diets to take into account barley's higher lysine and available phosphorus concentrations and lower energy content than corn is essential to maximize the economic benefit of feeding barley. Accurate nutrient profiles are needed when considering barley for swine rations.

Processing methods used with barley can have a significant impact on its relative feeding value. Pelleting of barley-based diets increases the bulk density of the diet and increases feed consumption. Pigs fed pelleted barley-based diets can have similar growth performance to those fed corn-based diets. Fine grinding (600 to 700 microns or less) also increases digestibility of barley-based diets and improved average daily gain and feed conversion, compared with pigs fed coarsely ground barley. Therefore, fine grinding with a hammer mill is the preferred feed processing method.

Nutrient Profiles and Feeding Recommendations

Because of its high fiber content, barley may not be suitable as the sole energy source in starter pig and sow lactation diets – depending on test weight. On the other hand, it makes an excellent feed for gestating sows as long as daily feed amounts are adjusted to account for the lower energy content. A tool that may be useful to calculate the energy content of barley is a formula developed by nutritionists in Canada and that calculates the digestible energy content of barley based on its fiber content.

$$\text{DE (Kcal/kg dry matter)} = 4228 - 140 \times \text{Crude fiber content (percent in dry matter)}$$

A proximate analysis should be conducted for estimating barley's energy content for diet formulation and economic value. The amino acid profile of barley also will allow for higher inclusion of synthetic amino acids in diets containing barley.

Availability

Although a majority of barley grown is malted for human consumption, barley is available for feed in areas where it is grown (Northern Great Plains, Pacific Northwest and Canada). Because barley has a relatively short growing season and requires less moisture, it is ideally suited for these locations. Some swine producers grow barley because its early harvest time, approximately three weeks earlier than wheat, allows for earlier manure application than late summer or fall crops.

More information on the availability of barley can be found at:
National Grain and Feed Association Web site at ***http://www.ngfa.org/trygrains_barley.asp***
National Barley Growers Association Web site at ***http://www.nationalbarley.org***

References

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GRAIN SORGHUM (MILO)

Typical nutrient composition (as-fed)	
Dry matter, %	89.0
Energy, kcal/lb	
Digestible	1,533
Metabolizable	1,515
Net, INRA	1,213
Net, NRC	1,023
Crude protein, %	9.2
Calcium, %	0.03
Phosphorus, %	0.29
Available P, %	0.058
Crude fat, %	2.9
Linoleic acid, %	1.13
Crude fiber, %	2.4
Neutral detergent fiber, %	18.0
Acid detergent fiber, %	8.3

Amino acids, %	Total	SID[1]
Lysine	0.22	81%
Isoleucine	0.37	87%
Leucine	1.21	90%
Methionine	0.17	89%
Cysteine	0.17	83%
Threonine	0.31	84%
Tryptophan	0.10	83%
Valine	0.46	87%

[1]Standardized ileal digestibility

Background

Grain sorghum (milo) is well suited to be grown in drought-prone regions of the United States, such as in the Central and Southern Plains States. Sorghum grain is an excellent energy source and can completely replace the corn in swine diets. The key to using grain sorghum in swine diets is recognizing its slightly lower energy value compared with corn and to ensure proper feed processing.

Advantages

Sorghum grain is often a cheaper source of energy than corn in the more semi-arid states. Because the energy content of grain sorghum is slightly less than corn, feed efficiency of pigs fed grain sorghum diets will be slightly poorer than that of pigs fed corn, but average daily gains will be similar. A general recommendation for swine diets is that grain sorghum should cost 96 percent of the cost of corn on an equal weight basis to be an economical substitute.

Disadvantages

One disadvantage of grain sorghum is that it can be more variable in nutrient content than corn because of growing conditions. In addition, because a grain sorghum kernel is smaller and harder than a corn kernel, fine grinding (1/8 or 5/32-inch screen) or rolling is suggested for best utilization.

Feeding and Handling

Grain sorghum can replace all or part of the corn without affecting growth rate. Because grain sorghum has slightly less lysine than corn, slight adjustments in the amount of synthetic lysine or soybean meal should be made in diet formulation.

Proper feed processing is necessary so that grain sorghum is fully utilized by the pig. Disrupting the intact kernel and exposing a greater surface area is essential for improved digestibility of milo by the pig. Reducing particle size of grain sorghum has been shown to improve feed utilization. When processing grain sorghum, particle size of the grain should be tested frequently to ensure optimum feed utilization. Optimal particle size for grain sorghum is similar to the optimal particle size of corn at 600 to 700 microns for meal diets.

KEY CONSIDERATIONS WITH SORGHUM GRAIN:

- Excellent energy source for all phases of swine production
- Grain sorghum has 96 percent the value of corn
- Nutrient content can be more variable than corn
- Be careful to properly process to an optimum particle size
- Breakeven price at approximately 96 percent or lower of corn price

Nutrient Profiles and Feeding Recommendations

Grain sorghum can totally replace the corn in all swine diets. An important diet formulation consideration when using grain sorghum-based diets is its slightly lower energy and lysine content relative to corn. While grain sorghum is frequently substituted on an equal weight basis with corn, slight adjustment of the soybean meal or synthetic amino acids can be made to take full advantage of grain sorghum's nutrient composition. Grain sorghum has a small kernel and is very hard relative to corn. Thus, proper processing is essential to obtain optimum particle size. Roller mills are preferred to achieve the particle size target of 600 to 700 microns for meal diets. There appears to be no differences in nutritional value to the pig for grain sorghum varieties of various colors (ex. red, yellow or white).

Availability

Grain sorghum is frequently grown in drought-prone states in the south central part of the United States. In these states, grain sorghum is frequently available through grain brokers or elevators.

Information on availability of grain sorghum can be found at:
http://www.sorghumgrowers.com
http://www.ksgrains.com/sorghum
http://www.texassorghum.com

References

Tables of Composition and Nutritional Value of Feed Materials. 2004. D. Savant, J.M. Perez, and G. Tran. Wageningen Academic Publishers, The Netherlands and INRA, France.

NRC. 1998. Nutrient Requirements of Swine. 10th ed. Natl. Acad. Press, Washington, DC.

DRIED DISTILLERS GRAINS WITH SOLUBLES (CORN)

Background

Dried distillers grains with solubles (DDGS) is a byproduct of ethanol fermentation. As fuel ethanol production has dramatically increased, DDGS availability has become widespread in the United States. The primary nutrients in corn are starch, fat, fiber and protein (amino acids). Fermentation removes most of the starch and the other nutrients remain in DDGS. Since corn is approximately 2/3 starch and 1/3 other nutrients, the other nutrients are concentrated by approximately three times through fermentation. The fermentation process also releases a large proportion of the phytic acid bound phosphorus, which greatly increases the concentration of phosphorus available to the pig. DDGS also can be derived from other grains such as milo and wheat. Milo DDGS has a slightly lower energy value compared to corn DDGS. Since wheat has low fat content, wheat DDGS will also have a lower energy value compared to corn DDGS.

Typical nutrient composition (as-fed)	
Dry matter, %	88.0
Energy, kcal/lb	
Digestible	1,602
Metabolizable	1,554
Net, INRA	1,090
Net, NRC	937
Crude protein, %	26.5
Calcium, %	0.13
Phosphorus, %	0.71
Available P, %	0.55
Crude fat, %	10.0
Linoleic acid, %	6.3
Crude fiber, %	6.5
Ash, %	5.2
Neutral detergent fiber, %	25.3
Acid detergent fiber, %	9.9

Amino acids, %	Total	SID[1]
Lysine	.78	62%
Isoleucine	1.01	75%
Leucine	3.17	83%
Methionine	.55	82%
Cysteine	.53	74%
Threonine	1.06	71%
Tryptophan	.21	70%
Valine	1.35	75%

[1]Standardized ileal digestibility

Advantages

Distillers grains with solubles can replace a substantial portion of the corn in swine diets as an energy source. They also partially replace soybean meal due to a higher protein content compared to corn. Due to the excellent phosphorus digestibility, DDGS can replace a significant portion of inorganic phosphorus in the diet.

Disadvantages

The major disadvantage of using DDGS is that it leads to lower feed intake and reduced growth rate in growing/finishing pigs when fed at high levels (greater than 20 percent). Carcass yield and fat quality also can be decreased when feeding DDGS. Nutrient content, especially lysine digestibility can be variable. Finally, mycotoxins are unaffected by the fermentation process and are concentrated if originally present in the corn used for fermentation.

Feeding and Handling

Compared to corn, bulk density is lower in DDGS. Thus, trucks and bins will need to be larger to contain a similar weight of feed. Also, flowability in transport and through feed manufacturing systems will be reduced and may require equipment modifications such as bin agitators. Flowability is reduced when DDGS has higher moisture content or has not been adequately cooled at the processing plant.

KEY CONSIDERATIONS WITH DDGS:

- Energy value is similar to corn
- Formulate on a digestible amino acid basis and maximize use of synthetic lysine
- Formulate on an available or digestible phosphorus basis
- High levels can lead to decreased finishing pig growth rate and reduced carcass quality
- Mycotoxins are unaffected by the fermentation process and may be more concentrated
- Breakeven pricing depends on existing protein source, cereal grain and supplemental phosphorus prices and potential yield reduction

Nutrient Profiles and Feeding Recommendations

Based on recent research, the digestible and metabolizable energy value of typical DDGS available in the Midwest of the United States is similar to that of corn and higher than listed in the current NRC, 1998. Because the digestibility of lysine and other amino acids is lower for DDGS compared to soybean meal, diets utilizing DDGS should be formulated on a digestible amino acid basis. Of the digestibility values, the most variable is lysine. Lysine is the amino acid most easily damaged by the drying process. The digestibility of the other amino acids is higher and more consistent. It has been suggested that one criterion that indicates good lysine digestibility is to ensure that the amount of total lysine is at least 2.8 percent of the crude protein. To minimize excess crude protein, diets containing DDGS should be supplemented with more synthetic lysine. Additionally, due to the increased concentration and digestibility of phosphorus in DDGS, diets utilizing DDGS should be formulated on an available phosphorus basis.

Feeding DDGS throughout the entire finishing phase has been shown to reduce carcass yield by approximately 0.4 to 0.5 percent for each 10 percent increase in inclusion rate. Due to the decrease in yield, pigs will need to be fed to a heavier live weight to obtain the same carcass weight. The decrease in carcass weight needs to be considered when evaluating the economic feasibility of using DDGS. Concerns over changes in pork quality (soft fat) may limit the inclusion of DDGS in swine diets or at least limit its inclusion in the diets fed right before marketing. The concern for impact on fat quality depends on the product mix of the pork processor. Thus, it is important to know the requirements of the pork processor to determine the timing and optimum level of DDGS to feed in the finishing period.

The final challenge with DDGS is how to economically evaluate it. Since DDGS provides energy, amino acids and phosphorus, the economics of DDGS will depend on the cost of alternatives for all three of these nutrient sources. A spreadsheet to calculate the economics of feeding DDGS to pigs is located at *http://www.ksuswine.org*.

For gestating and lactating sows and nursery pigs, using high quality DDGS does not appear to affect productive performance. Thus, reducing diet costs with DDGS inclusion will reduce feed cost per pig. Recommendations are for maximum inclusions of DDGS of up to 50 percent in gestation diets and 30 percent in lactation and nursery pig diets. It is difficult, however, to evaluate the use of DDGS in growing pig diets. Assuming DDGS will result in a reduction in average daily gain and thus a lighter pig at market, the price of DDGS should be no more than approximately 90 percent the value of corn. Assuming no differences in pig performance, DDGS value is approximately 120 percent the value of corn. Therefore, typical inclusion rates vary from 10 to 35 percent of the diet.

Some of the ethanol dry milling plants are beginning to produce other coproducts such as high protein DDGS, deoiled DDGS and or distillers grains without solubles. Also, some plants add soy hulls or other products to improve flowability. These modified products will have different nutrient profiles and require appropriate diet modifications to capture their economic value. Producers should obtain an accurate nutrient profile and consult a professional nutritionist when considering the use of these products in swine rations.

Availability

DDGS are available through a number of sources. Individual ethanol plants or DDGS marketing groups sell directly to producers and also to feed manufacturers. Ethanol plants can be contacted directly for pricing and availability. Also, most regional and local feed mills now have DDGS available for use in swine diets.

Information on sources of DDGS is available at:
Renewal Fuels Association: ***http://www.ethanolrfa.org/industry/locations/***

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University of Minnesota DDGS Web site, ***www.ddgs.umn.edu***

BAKERY BYPRODUCTS

Background

Bakery byproducts are derived from the baking and cereal industries. Dried bakery byproducts are composed of a variety of commodities, including hard and soft wheat products, pasta, potato chip waste, cakes, crackers, breakfast cereals and other food products. Bakery byproduct varies in nutrient profile depending on its source products. It is used primarily as an energy source to replace corn in the diet.

Typical nutrient composition (as-fed)	
Dry matter, %	91.0
Energy, kcal/lb	
Digestible	1,787
Metabolizable	1,678
Net, NRC	1,095
Crude protein, %	10.8
Calcium, %	0.13
Phosphorus, %	0.25
Available P, %	0.07
Crude fat, %	11.3
Linoleic acid, %	5.70
Crude fiber, %	1.2
Neutral detergent fiber, %	2.0
Acid detergent fiber, %	1.3

Amino acids, %	Total	SID[1]
Lysine	0.27	--
Isoleucine	0.38	--
Leucine	0.80	--
Methionine	0.18	--
Cysteine	0.23	--
Threonine	0.33	--
Tryptophan	0.10	--
Valine	0.46	--

[1]Standardized ileal digestibility

Advantages

Bakery products are high in fat and carbohydrates and are an excellent source of energy in swine diets. Bakery byproducts are one of the few alternative ingredients that can increase the energy content of the diet when compared to corn with energy profiles as much as 15 percent higher. Also, because most bakery products contain high amounts of sugar, it is usually highly palatable and can therefore be an excellent alternative in nursery pig and lactation diets.

Disadvantages

As with many byproducts, if the source of materials used to make the product varies, the bakery product will lack uniformity in nutrient content. Also, because the salt content of many bakery products is quite high, it can contribute significantly to the salt content of the diet. This should not pose any major challenge to feeding bakery products as long as the amount of added salt is adjusted and adequate water is available.

Feeding and Handling

The typical process to make bakery byproducts is to combine the various available byproducts and further process the mix by grinding, extruding and drying. Due to the relatively high fat content and low particle size, the flowability may be reduced in diets that include bakery byproducts.

KEY CONSIDERATIONS WITH BAKERY BYPRODUCTS:

- Excellent energy source
- Variability in nutrient content because of variable source products
- Laboratory analysis is needed to establish nutrient levels and feeding value
- Maintain adequate safety margin levels of salt in the diets
- Breakeven price relative to corn depends on actual nutrient content

Nutrient Profiles and Feeding Recommendations

Due to the variability in potential source products, it is essential that laboratory analysis of bakery products is performed routinely. The most critical components to monitor are the dry matter and fat content. If the product is not dried adequately, high moisture content can lead to rapid mold formation.

Due to potential variability in nutrient content and high salt levels, the recommended inclusion limit of bakery byproducts in nursery pig diets is 30 percent of the diet. However, in diets for grow-finish pigs or gestating and lactating sows, there should not be any nutritional inclusion limit for bakery byproducts when the variability in nutrient content is accounted for in diet formulation.

Limitations to the amount of bakery byproducts in diets generally depend upon feed handling and availability. Because of the relatively high amount of unsaturated fatty acids in dried bakery byproducts, caution must be used in order to prevent carcasses with soft fat (high iodine values). Combining bakery products with other unsaturated fat sources like dried distillers grains with solubles (DDGS) can further increase the potential for carcasses with soft fat.

To address the salt content, some nutritionists reduce the amount of added salt in diets containing dried bakery byproduct. Caution should be taken to not reduce the supplemental salt too much. Salt levels may be reduced in the bakery product if the product stream changes. Inadequate salt in diets will dramatically affect growth performance. Excess salt levels are not a major problem as long as adequate access to water is maintained. Thus, nutritionists often maintain a minimum level of supplemental salt (such as 3.5 to 5 lb/ton) in the diet when adding bakery byproducts.

Availability

The availability of bakery byproducts will be determined by manufacturing location of companies that blend or process bakery for feed use. Examples of major bakery byproduct suppliers include:

Endres Processing: ***http://www.endresprocessing.com***

Griffin Industries: ***http://www.griffinind.com/Feeds.html***

References

NRC. 1998. Nutrient Requirements of Swine. 10th ed. Natl. Acad. Press, Washington, DC.

Patience, J.F, P.A. Thacker, and C.F.M. De Lange. 1995. Swine Nutrition Guide, 2nd Edition. Prairie Swine Center, Saskatoon, Saskatchewan, Canada

For more information visit pork.org
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Appendix 6

Washington State Department of Agriculture

Animal Proteins Prohibited in Ruminant Feed & Cattle Materials Prohibited in All Animal Feed

Table 1

Nonprohibited Materials: These feed materials CAN be fed to ruminants.	
A. The following protein products derived from mammals, including ruminants, are exempt from the Ruminant Feed Ban rule and CAN be fed to ruminants:	
Blood and blood products	Inspected meat products, such as plate waste, which have been cooked and offered for human food and further heat processed for animal feed.
Milk products (milk and milk protein)	
Pure porcine (pork) protein	
Pure equine (horse) protein	
Gelatin	
B. The following non-mammalian protein products are not included in from the Ruminant Feed Ban rule and CAN be fed to ruminants:	
Poultry protein	Vegetable protein
Marine (fish) protein	
C. The following materials CAN be fed to ruminants because they are not protein or tissue:	
Recovered cooking oils from restaurants and food processors	Oil
	Amino Acids
**Tallow ** and Tallow Derivatives	Dicalcium Phosphate

** SEE Table 3 TALLOW STANDARDS**

Table 2

Prohibited Materials: The products listed below, unless from the materials in Table 1, CANNOT be fed to ruminants because they may carry the BSE infective agent. *(*See exceptions on page 3*)	
Animal By-Product Meal	Leather Hydrolysate
Animal Digest	Meat
Animal Liver	Meat and Bone Meal
Bone Meal, Cooked	Meat and Bone Meal Tankage
Bone Meal, Steamed	Meat Meal
Cooked Bone Marrow	Meat Meal Tankage
Dehydrated Food Waste	Meat By-Prodcuts
Dehydrated Garbage	Meat Protein Isolate
Distressed Pet Food	Mechanically Separated Bone Marrow
Dried Meat Solubles	Restaurant Food Waste
Fleshings Hydrolysate	Salvage Pet Food
Food Processing Waste	Stock / Broth
Glandular Meal and Extracted Glandular Meal	Tallow exceeding 0.15% Insoluble Impurities
Hydrolyzed Hair	Unborn calf Carcasses
Hydrolyzed Leather Meal	

****Table 3****

TALLOW STANDARDS	
Tallow with Insoluble Impurities level of 0.15% or LESS	CAN be used in Ruminant and Non-Ruminant Feed
Tallow with MORE than 0.15% Insoluble Impurities <u>AND</u> labeled "Do Not Feed To Cattle Or Other Ruminants".	CANNOT be used in Ruminant Feed <u>but</u> Can be used in Non-Ruminant Feed
Tallow with MORE than 0.15% Insoluble Impurities <u>AND</u> labeled "Do Not Feed To Animals".	CANNOT be used in any animal feed.

Table 4

Cattle Materials Prohibited in Animal Feed (CMPAF)
1. The entire carcass of BSE-positive cattle.
2. The brains and spinal cords of cattle 30 months of age and older.
3. The entire carcass of cattle that are 30 months of age or older from which brains and spinal cords were not effectively removed or excluded from animal feed.
4. Mechanically separated beef derived from materials described in 2 and 3 above.
5. Tallow that exceeds 0.15% insoluble impurities derived from materials described in 2 and 3 above.

Rule Overview:

Title 21 CFR 589.2000 BSE - Feed Rule prohibits feeding most mammalian protein to all ruminants.

Title 21 CFR 589.2001 - Enhanced BSE Feed Rule prohibits feeding certain materials from cattle (CMPAF) to all animals.

LABELING – Cautionary Statement:

<u>Non-Prohibited Materials</u>: No cautionary label requirements.
<u>Prohibited Materials</u>: Must be labeled "Do Not Feed To Cattle Or Other Ruminants".
<u>CMPAF</u>: Must be labeled "Do Not Feed To Animals".

MARKING

<u>CMPAF</u>: In addition to labeling, CMPAF must be marked with an agent that can be readily detected on visual inspection.

**Exceptions:*

1) Table 2 lists feed ingredient terms that frequently, or by definition, contain Prohibited Materials. However, most of the terms can also be used for feed ingredients made exclusively from Nonprohibited Materials. For example, if Meat and Bone Meal is made from pure porcine (pork) raw material (see Table 1) then it is a Nonprohibited Material. The way to tell is to look for the BSE Cautionary Statement on the label. Whenever the label says "Do Not Feed To Cattle Or Other Ruminants" then it is a Prohibited Material.
2) Occasionally the statement "Do Not Feed To Cattle Or Other Ruminants" is on the label of a Nonprohibited Material such as Fish Meal. This means that the Fish Meal may contain trace amounts of a Prohibited Material due to processing or handling conditions.
3) Pet Food often contains one or more of the Prohibited Materials listed in Table 2 but the Ruminant Feed Ban rule does not require pet food for retail sale to have the BSE Cautionary Statement on the label. Never feed pet food to ruminants – on purpose or accidentally.
4) If you are not sure if a certain ingredient can be fed to ruminants call WSDA at (360) 902-2025. Also, you can request the manufacturer to verify that the feed does not contain any prohibited materials.

Ruminants are any animals with a four-chambered stomach including cattle, sheep, goats, buffalo, elk, and deer. Alpacas and Llamas are camelids, not ruminants, and therefore not covered by the Ruminant Feed Ban rule.

Definitions of terms used in the rules

Cattle means bos taurus, bos indicus, and bison bison (American Buffalo).

CMPAF means **C**attle **M**aterial **P**rohibited in **A**nimal **F**eed

Mechanically separated beef means a finely comminuted meat food product, resulting from the mechanical separation and removal of most of the bone from attached skeletal muscle of cattle carcasses and parts of carcasses.

Tallow means the rendered fat of cattle obtained by pressing or by applying any other extraction process to tissues derived directly from discrete adipose tissue masses or to other carcass parts and tissues.

Definitions of Prohibited Materials

Below is an alphabetical list of fully defined feed ingredient terms identified as prohibited materials. Use of the ingredients listed below, from mammalian origins except pure porcine or pure equine, is restricted to non-ruminant feeds. This list may not be all inclusive.

Animal By-Product Meal – is the rendered product from animal tissues, exclusive of any added hair, hoof, horn, hide trimmings, manure, stomach and rumen contents except in such amounts as may occur unavoidably in good processing practices. It shall not contain added extraneous materials not provided for by this definition. This ingredient definition is intended to cover those individual rendered animal tissue products that cannot meet the criteria as set forth elsewhere in this section. This ingredient is not intended to be used to label a mixture of animal tissue products.

Animal Digest – is a material which results from chemical and/or enzymatic hydrolysis of clean and undecomposed animal tissue. The animal tissues used shall be exclusive of hair, horns, teeth, hooves and feathers, except in such trace amounts as might occur unavoidably in good factory practice and shall be suitable for animal feed. If it bears the name descriptive of its kind or flavor(s), it must correspond thereto.

Animal Liver – If it bears a name descriptive of its kind, it must correspond thereto. Meal is obtained by drying and grinding liver from slaughtered mammals.

Bone Meal, Cooked – is the dried and ground sterilized product resulting from wet cooking without steam pressure of undecomposed bones. Fat, gelatin, and meat fiber may or may not be removed. When labeled as a commercial feed ingredient, it shall carry guarantees for protein, phosphorus (P), and calcium (Ca). Cooked bone meal shall be used in all labeling.

Bone Meal, Steamed – is the dried and ground product sterilized by cooking undecomposed bones with steam under pressure. Grease, gelatin, and meat fiber may or may not be removed. . It must be labeled with guarantees for protein, phosphorus (P), and calcium (Ca). Steamed bone meal must be used in all labeling.

Cooked Bone Marrow – is the soft material coming from the center of large bones, such as leg bones. This material, which is predominantly fat with some protein, must be separated from the bone material by cooking with steam. It shall not contain added extraneous materials not provided for by this definition except for small amount of tissue, which may adhere to the bone unavoidably in good processing practice. The labeling of this product shall include, but is not limited to, guarantees for minimum crude protein and minimum crude fat.

Dehydrated Garbage – is composed of artificially dried animal and vegetable waste collected sufficiently often that harmful decomposition has not set in, and from which have been separated crockery, glass, metal, string, and similar materials. It must be processed at a temperature sufficient to destroy all organisms capable of producing animal diseases. If part of the grease and fat is removed, it must be designated as "Degreased Dehydrated Garbage."

Dehydrated Food Waste – Any and all animal and vegetable produce picked up from basic food processing sources or institutions where food is processed. The produce shall be picked up daily or sufficiently often so that no decomposition is evident. Any and all undesirable constituents shall be separated from the material. It shall be dehydrated to a moisture content of not more than 12% and be in a state free from all harmful micro-organisms.

Distressed Pet Food – is a product resulting from pet food distribution but which is no longer available for retail sale. This product may pet food in, but not limited to, dented cans, torn bags, product past its sell-by date, or returned product that is suitable for use in feed. It may consist of a single formula, still in the original packaging, or a variety of formulas commingled into one bulk container and containing none of the original packaging or labeling. If it contains, or may contain, any material identified by 21 CFR 589.2000 as prohibited from use in the feed of ruminant animals, or if it is no longer accompanied by a detailed label listing all of the ingredients in the distressed product, the label must contain the precautionary statement "Do Not Feed To Cattle Or Other Ruminants". It shall be free from foreign materials harmful to animals, suitable for the purpose for which it is being marketed, and properly labeled of its intended use.

Dried Meat Solubles – is obtained by drying the defatted water extract of the clean, wholesome parts of slaughtered animals prepared by steaming or hot water extraction. It must be designated according to its crude protein content which shall be no less than 70%.

Fleshings Hydrolysate – is obtained by acid hydrolysis of the flesh from fresh or salted hides. It is defatted, strained, and neutralized. If evaporated to 50% solids, it shall be designated "Condensed Fleshings Hydrolysate". It must have a minimum crude protein and maximum salt guarantee.

Food Processing Waste – is composed of any and all animal and vegetable products from basic food processing. This may include manufacturing or processing waste, cannery residue, production over-run, and otherwise un-saleable material. The guaranteed analysis shall include the maximum moisture, unless the product is dried by artificial means to less than 12% moisture and designated as "Dehydrated Food Processing Waste." If part of the grease and fat is removed, it must be designated as "Degreased".

Glandular Meal and Extracted Glandular Meal – is obtained by drying liver and other glandular tissues from slaughtered mammals. When a significant portion of the water soluble material has been removed, it may be called Extracted Glandular Meal.

Hydrolyzed Hair – is a product prepared from clean, undecomposed hair, by heat and pressure to produce a product suitable for animal feeding. Not less than 80% of its crude protein must be digestible by the pepsin digestibility method.

Hydrolyzed Leather Meal – is produced from leather scrap that is treated with steam for not less than 33 minutes at a pressure not less than 125 pounds per square inch and further processed to contain not more than 10% moisture, not less than 60% crude protein, not more than 6% crude fiber, not more than 2.75% chromium, and with not less than 80% of its crude protein digestible by the pepsin digestibility method. Hydrolyzed leather meal may be utilized in livestock feeds as provided in food additive regulation 573.540

Leather Hydrolysate – is obtained from chromium tanned unfinished leather shavings, trimmings, and/or lime fleshings that may or may not be pressure cooked with the addition of steam, sodium hydroxide, lime or magnesium oxide. Chromium is precipitated and separated so that only trivalent chromium at less than 1000 ppm on a dry matter basis remains in the hydrolysate. This product is available as a liquid ingredient or as a spray-dried powder. In either form, the analysis on a solids basis will not be less than 75% crude protein and not less than 85% of the protein shall be pepsin digestible.

Meat – is the clean flesh derived from slaughtered mammals and is limited to that part of the striate muscle which is skeletal or that which is found in the tongue, in the diaphragm, in the heart, or in the esophagus; with or without the accompanying and overlying fat and the portions of the skin, sinew, nerve, and blood vessels which normally accompany the flesh. It shall be suitable for use in animal food. If it bears a name descriptive of its kind, it must correspond thereto.

Meat and Bone Meal – is the rendered product from mammal tissues, including bone, exclusive of any added 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 not contain added extraneous materials not provided for in this definition. It shall contain a minimum of 4.0% Phosphorus (P) and the Calcium (Ca) level shall not be more than 2.2 times the actual Phosphorus (P) level. It shall not contain more than 12% pepsin indigestible residue and not more than 9% of the crude protein in the product shall be pepsin indigestible. The label shall include guarantees for minimum crude protein, minimum crude fat, maximum crude fiber, minimum Phosphorus (P) and minimum and maximum Calcium (Ca). If it bears a name description of its kind, composition or origin it must correspond thereto.

Meat and Bone Meal Tankage – is the rendered product from mammal tissues, including bone, exclusive of any added hair, hoof, horn, hide trimmings, manure, stomach and rumen contents except in such amounts as may occur unavoidably in good processing practices. It may contain added blood or blood meal; however, it shall not contain any added extraneous materials not provided for in this definition. It shall contain a minimum of 4.0% Phosphorus (P) and the Calcium (Ca) level shall not be more than 2.2 times the actual Phosphorus (P) level. It shall not contain more than 12% pepsin indigestible residue and not more than 9% of the crude protein in the product shall be pepsin indigestible. The label shall include guarantees for minimum crude protein, minimum crude fat, maximum crude fiber, minimum Phosphorus (P) and minimum and maximum Calcium (Ca). If it bears a name description of its kind, composition or origin it must correspond thereto.

Meat By-Products – The non-rendered, clean parts, other than meat, derived from slaughtered mammals. It includes, but is not limited to, lungs, spleen, kidneys, brain, livers, blood, bone, partially defatted low temperature fatty tissue, and stomachs and intestines freed of their contents. It does not include hair, horns, teeth and hoofs. It shall be suitable for use in animal food. If it bears name descriptive of its kind, it must correspond thereto.

Meat Meal – The rendered product from mammal tissues, exclusive of any added 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 not contain added extraneous materials not provided for by this definition. The Calcium (Ca) level shall not exceed the actual level of Phosphorus (P) by more than 2.2 times. It shall not contain more than 12% pepsin indigestible residue and not more than 9% of the crude protein in the product shall be pepsin indigestible. The label shall include guarantees for minimum crude protein, minimum crude fat, maximum crude fiber, minimum Phosphorus (P) and minimum and maximum Calcium (Ca). If the product bears a name description of its kind, composition or origin, it must correspond thereto.

Meat Meal Tankage – The rendered product from mammal tissues, exclusive of any added hair, hoof, horn, hide trimmings, manure, stomach and rumen contents, except in such amounts as may occur unavoidably in processing factory practices. It may contain added blood or blood meal; however, it shall not contain any other added extraneous materials not provided for by this definition. The Calcium (Ca) level shall not exceed the actual level of Phosphorus (P) by more than 2.2 times. It shall not contain more than 12% pepsin indigestible residue and not more than 9% of the crude protein in the product shall be pepsin indigestible. The label shall include guarantees for minimum crude protein, minimum crude fat, maximum crude fiber, minimum Phosphorus (P) and minimum and maximum Calcium (Ca). If the product bears a name description of its kind, composition or origin, it must correspond thereto.

Meat Protein Isolate – is produced by separating meat protein from fresh, clean, unadulterated bones by heat processing followed by low temperature drying to preserve function and nutrition. This product is characterized by a fresh meaty aroma, a 90% minimum protein level, 1% maximum fat and 2% maximum ash.

Mechanically Separated Bone Marrow – The soft material coming from the center of large bones, such as leg bones. This material, which is predominantly fat with some protein, must be separated from the bone material by mechanical separation. It shall not contain added extraneous materials not provided for by this definition except for small amount of tissue which may adhere to the bone unavoidably in good processing practice. The labeling of this product shall include, but is not limited to, guarantees for minimum crude protein and minimum crude fat.

Restaurant Food Waste – is composed of edible food waste collected from restaurants, cafeterias, and other institutes of food preparation. Processing and/or handling must remove any and all undesirable constituents including crockery, glass, metal, string, and similar materials. The guaranteed analysis shall include maximum moisture, unless the product is dried by artificial means to less than 12% moisture and designated as "Dehydrated Restaurant Food Waste". If part of the grease and fat is removed it must be designated as "Degreased".

Salvage Pet Food – is a product resulting from pet food manufacturing. This product may consist of, but is not limited to, start-up and over-run product, unfinished pet food, pet food fines and other product not suitable for packaging for retail sale. If it contains, or may contain, any material identified by 21 CFR 589.2000 as prohibited from use in the feed of ruminant animals, or if it is no longer accompanied by a detailed label listing all of the ingredients in the salvage pet food, the label must contain the precautionary statement "Do Not Feed To Cattle Or Other Ruminants". It shall be free of foreign materials harmful to animals, suitable for the purpose for which it is being marketed, and properly labeled of its intended use.

Stock / Broth– is obtained by cooking mammalian or poultry bones, parts, and/or muscle tissue. The crude protein content of stock/broth must be no less than 90% on a dry matter basis. In order for the stock/broth to be labeled as such, the moisture to crude protein ratio must not exceed 135:1 (135 parts water to 1 part crude protein). The product must bear a name descriptive of its kind, composition or origin, such as but not limited to, meat, beef, pork, poultry, chicken, turkey: and may be called either stock or broth.

Tallow– is the rendered fat of cattle. Tallow that exceeds 0.15% Insoluble Impurities as measured by the method entitled "Insoluble Impurities" (AOCS Method Ca 3a-46), American Oil Chemists' Society (AOCS), 5th Edition, 1997, is a prohibited material. (This definition is not from the AAFCO Official Publication)

Tallow Derivative- is any product obtained through initial hydrolysis, saponification, or trans-esterification of tallow; chemical conversion of material obtained by hydrolysis, saponification, or trans-esterification may be applied to obtain the desired product. (This definition is not from the AAFCO Official Publication)

Unborn Calf Carcasses – is the product obtained from whole unborn carcasses taken from slaughtered cows at government inspected slaughter plants. The product is produced by grinding the whole-unborn carcass, exclusive of calf hides. The product is denatured, fresh frozen and shall be suitable for use as an animal feed.

NOTE: The following items are found on feed labels and may be fed to ruminants because they are not prohibited under the "Ruminant Feed Ban" rule 21CFR 2000.589. These definitions are included because they are of animal origin and questions often arise.

Animal Plasma – is the product obtained by spray drying plasma which has been separated away from the cellular matter (red and white blood cells) of fresh whole blood by chemical and mechanical processing. The protein portion of this product is primarily albumin, globulin, and fibrinogen type proteins. The minimum percent crude protein and the maximum percent ash must be guaranteed on the label. If it bears a name descriptive of its kind, composition, or origin, it must correspond thereto.

Animal Serum – Animal serum is the product obtained by removing the fibrin from liquid animal plasma by chemical and mechanical processes. The serum protein portion of this product is primarily albumin and globulin proteins. The minimum percent crude protein, maximum percent ash, minimum albumin content, and the minimum globulin content must be guaranteed on the label. The minimum albumin content is 42% (as a percent of total protein) determined by colorimetric assay (Doumas, B.T., Watson, W.A., Biggs, H.G., Clin. Chim Acta. 1971) and the minimum globulin content is 20% (As a percent of total protein) as measured by an assay method such as the Becker titer analysis (Becker, W. 1969 Immunochemistry 6: 539-546). If the product bears a name descriptive of its kind, origin or composition, it must correspond thereto.

> **Note:** Since animal plasma and animal serum are blood products, and since blood is exempted from being prohibited by 21 CFR 2000.589, it is legal to feed these to ruminants even though they are mammalian protein products.

Cholecalciferol (D-Activated Animal Sterol) – is obtained by activation of a sterol fraction of animal origin with ultra-violet light or other means. For label identification it may be followed with the parenthetical phrase (Source of Vitamin D3).

> **Note:** The definition of Sterols is – "(Part) Solid cyclic alcohols which are the major constituents of the unsaponfiable portion of animal and vegetable fats and oils." Since alcohols are not proteins, these are not prohibited as ruminant feeds by 21 CFR 2000.589 regardless of species of origin.

All definitions are from the Association of American Feed Control Officials (AAFCO) 2013 Official Publication, except for: a) Tallow which is as defined in 21 CFR 589.2001; b) Tallow Derivative which is defined in 21 CFR589.2001; c) Dehydrated Garbage and Dehydrated Food Waste, which are from the 2000 AAFCO Official Publication;

Appendix 7

Wisconsin Statute 95:

Animal Health 95.10: Feeding of Garbage to Swine

(1) Beginning July 1, 1968, it is unlawful for any person to feed public or commercial garbage to swine, or to deposit or receive such garbage on any premises where swine are kept, and no swine having fed on such garbage may be sold or removed from the premises. (Note: There is no section 2 in statute 95.10.)

(3) "Public or commercial garbage" as used in this section means putrescible animal or vegetable waste containing animal parts, resulting from the handling, preparation, processing, cooking or consumption of food and which is collected from any source, and includes dead animals as defined in s. 95.72 (1) (c). The term does not apply to private household waste not removed from the premises where produced.

(4) No indemnity shall be paid to the owner of any swine condemned or destroyed because of any infectious or communicable disease if such swine were located, at any time, on any premises receiving public or commercial garbage. No person shall fail or refuse to conform with the department order specifying the manner of disposal of such infected swine. The definition of "communicable disease" in s.990.01 (5g) does not apply to this subsection.

(5) No person shall remove or permit the removal of any swine from any premises where public or commercial garbage is received, except to federally inspected slaughtering establishments and other slaughtering establishments approved by the state to receive diseased animals, and only if such swine are accompanied by a certificate of veterinary inspection.

(6) No person shall bring into this state any raw public or commercial garbage for feeding purposes or for deposit on any premises where swine are kept. Any garbage from vehicles serving food to passengers, if deposited in this state, shall be incinerated.

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