UNIVERSITY OF MINNESOTA

Dairy Extension
Department of Animal Science
101 Haecker Hall
1364 Eckles Ave.
St. Paul, Minnesota 55108
(612) 373-1014

Dairy Update

ALTERNATIVE FEEDSTUFFS FOR DAIRY CATTLE

James G. Linn
Extension Animal Scientist, Dairy Nutrition

July, 1985
Issue 72

The increased availability and competitive cost of alternative or byproduct feedstuffs requires they be considered for use in livestock feeding. In this paper, three categories of byproduct feedstuffs are considered: 1) liquids, 2) energy, and 3) protein. Liquid byproducts from cheese, cereal grain and wood processing may be utilized as a supplementary water source or as liquid supplement ingredients. The energy byproducts have a unique characteristic of being high in fiber compared to traditional energy feedstuffs. Therefore, fiber utilization must be considered in order to maximize their utilization. Protein bypass is of most interest with protein byproduct feeding.

Availability and cost are the primary factors to consider in feeding alternative feedstuffs. However, they are not the only factors. Nutrient content and variability, palatability, possible contaminants or residues in the byproducts along with the effects upon overall ration digestibility, utilization, handling and feeding ease need to be considered. Storage facilities and methods also need consideration, especially when high moisture byproduct feedstuffs are being considered.

TABLE 1. Composition of some common byproduct feedstuffs.[1]

Feed	DM (%)	NE_L (Mcal/lb)	TDN (%)	CP (%)	NDF (%)	ADF (%)	Lignin (%)	Ca (%)	P (%)
Brewers grains, dry	92	.68	66	26	42	23	5	.29	.54
Brewers grains, wet	28	.69	67	26	42	23	5	.29	.54
Corn gluten feed, dry	90	.82	82	17		10		.33	.86
Corn gluten feed, wet	45	.86	86	17	38	14		.10	.60
Corn gluten meal	90	.88	84	66				.18	.51
Corn steep liquor	50	.80	82	46	0	0	0	.28	3.60
Distillers grains, dry	92	.87	84	29	43	16		.10	.40
Distillers grains with solubles, dry	92	.92	88	30				.16	.79
Molasses fermentation products, condensed	60		85	20					
Soybean hulls or soybran flakes	91	.81	78	12	67	46	2	.45	.17
Sulfite liquor	50		55	15					
Sunflower meal, 28%	90	.72	70	33		26		.4	1.1
Thin stillage	3			27.5				1.07	1.51
Whey, liquid	6	.81	75	16	0	0	0	.98	.81
Whey, condensed	40		92	13	0	0	0		

[1]All analyses except DM are a 100% dry basis.

LIQUID BYPRODUCTS

Corn steep liquor. Corn steep liquor is a high protein liquid consisting of corn kernel solubles removed during the wet milling of corn. Corn steep liquor may be sold as is (less than 10 percent dry matter) but is usually sold as condensed corn fermented extractives (40 to 50 percent solids). Most often these products are added to corn gluten feed at plants to attain a guaranteed protein content.

Thin stillage. Thin stillage is an alcohol fermentation byproduct. It is the liquid portion of the grain mash separated from the solids and de-alcoholized by distillation. Thin stillage contains small grain particles, yeast cells and other soluble nutrients. Mineral concentrations also are quite high in thin stillage, especially trace minerals.

Thin stillage, like corn steep liquor, can be condensed (30 to 40 percent solids) or dried completely. The major use of thin stillage or condensed solubles is for adding to pressed grains for increased protein content.

A University of Minnesota study concluded thin stillage could substitute for water and a supplemental protein source for feedlot steers. Cattle fed thin stillage had slightly higher daily gains (3.51 vs 3.37 pounds per day) and were slightly more efficient than cattle receiving water.

Whey. The primary form in which whey is fed to dairy cows is liquid (six percent dry matter). However, dry whey and more recently condensed whey has been fed.

Whey is a good source of calcium and phosphorus, and total mineral content may be eight percent of the dry matter. Lactose content of whey is 75 to 80 percent of the dry matter. The mineral and other nutrient contents may vary from values shown in Table 1 due to processing and type of cheese being manufactured.

The amount of whey which can be fed is determined by the form being fed. Up to 200 pounds of liquid whey daily have been consumed by mature lactating cows. Dry whey is usually added at 10 to 20 percent of the grain mix as an aid in maintaining milk fat tests. In general, the guideline is cows should not consume over four pounds of lactose per day.

Others. Condensed molasses fermentation solubles and sulfite liquors are two other liquid byproducts available for feeding to ruminants. These products are most commonly used in liquid supplement manufacturing and not direct feeding.

Sulfite liquor is a byproduct of the wood pulp industry. Its composition is quite variable among pulp plants and depends upon the process they're using. The major ingredients in sulfite liquor are soluble hemicellulose, lignin and minerals (calcium, sodium, magnesium or ammonia and sulfur). The quantity of any particular mineral will depend on the process used. Lignin, which is indigestible, will be 40 to 45 percent of the dry matter and can be considered a detriment.

Research at Nebraska has shown sulfite liquor to have a dry matter digestibility of 50 percent and an energy value less than molasses. Mineral availabilities of sulfur, calcium, sodium and magnesium were not directly determined but are apparently quite good. It was concluded sulfite liquor is worth about one-half as much as molasses on a dry matter basis.

In general, most of the liquid byproducts are good sources of energy and nitrogen. They appear to enhance nonprotein nitrogen utilization in ruminant rations. Thus, the interest is in their usage as liquid protein supplements.

Corn gluten feed. A relatively higher fiber, medium energy, medium protein byproduct of the corn wet milling process. Approximately nine to 12 pounds of corn gluten feed are produced for every bushel of corn wet milled. Corn gluten feed is what remains after the starch, germ and gluten have been removed. It is composed primarily of bran which is the fiber fraction of the kernel. Corn steep liquor may or may not be added before being sold in either a dry (90 percent dry matter) or wet (40 to 44 percent dry matter) form. The usual combination of wet corn gluten feed is two-thirds gluten feed and one-third steep liquor.

The average nutrient content of corn gluten feed dry matter is listed in Table 1, however, composition can vary widely between processing plants. In general, corn gluten is a medium protein feed high in fiber, phosphorus and potassium. The net energy content of wet corn gluten feed is considered to be higher than that of the dried (.86 vs .82 Mcal per pound of dry matter). Protein degradation of corn gluten feed is similar to that of soybean meal (about 75 percent).

Some concern has been raised about the sulfuric acid content of the steep liquor and its destruction of thiamine. This should not be a problem when recommended feeding amounts are followed but if it is necessary, 100 milligrams of thiamine per cow per day can be supplemented.

Dairy nutrition research on corn gluten feed is limited. Canadian researchers have reported two studies, one with wet and the other with wet and dry corn gluten feed. In the first study, wet gluten feed was included in the ration at 0, 18.6 and 37.1 percent of the total dry matter. Gluten feed replaced corn and soybean meal in rations of 40 percent corn silage, 10 percent haylage and 50 percent concentrate. Early lactation cows fed the rations containing wet gluten feed produced less milk and ate less dry matter than cows fed the control corn and soybean meal ration (Table 2). The second study involved feeding of wet or dry corn gluten feed at 26 percent of the ration dry matter. Alfalfa hay (17 percent of the dry matter), corn silage (33 percent of the dry matter) and a corn soybean meal grain mix (24 percent of the dry matter) were included in the ration also. Cows fed the ration containing dry gluten feed ate the most daily dry matter (42.2 pounds vs 38.3 for controls vs 36.3 for cows fed wet gluten feed). Solids corrected milk (pounds per day) was highest for cows fed dry gluten feed (55.0) and similar for cows fed the control (51.5) and wet gluten feed rations (51.0).

TABLE 2. Feeding value of wet corn gluten feed for cows in early lactation (5 to 14 weeks).

	Wet corn gluten feed (% of ration dry matter)		
Item	0	18.6	37.1
Ration dry matter, %	49.2	45.0	41.0
Dry matter intake, lb/day			
First lactation cows	33.9	35.4	34.8
Older cows	44.2	41.6	40.0
Milk, lb/day			
First lactation cows	47.1	46.6	45.3
Older cows	72.2	66.4	64.5

SOURCE: University of Guelph.

University of Illinois researchers incorporated wet corn gluten feed into lactating cow rations at 0, 20, 30 or 40 percent of the dry matter. All rations contained 50 percent of the dry matter as corn silage. Feed intake and milk production declined with increasing percentages of wet gluten feed (Table 3). Milk fat percentages increased slightly with increasing wet gluten feed percentages. This data indicate wet gluten feed should be limited to about 25 percent of the ration dry matter or less.

TABLE 3. Feeding value of wet corn gluten feed for dairy cows.

	Wet corn gluten feed (% of ration dry matter)			
Item	0	20	30	40
Dry matter intake, lb/day	52.8	51.3	48.9	47.3
Milk, lb/day	67.1	65.7	61.7	61.9
Fat, %	2.9	3.0	3.1	3.2
4% fat milk, lb/day	55.8	55.5	53.9	54.6

SOURCE: University of Illinois.

Both wet and dry corn gluten feed are composed primarily of corn bran (fiber). Corn bran is about 15 percent of the kernel. The digestibility of corn fiber is high (85 plus percent) and also is digested rapidly (six to 10 percent per hour). Wet gluten feed fiber is probably digested faster and to a greater extent than dry gluten fiber. Drying appears to alter fiber structure making it less available to rumen bacteria. Also, drying decreases particle size increasing rate of passage. However, the overall high digestibility of corn fiber offers considerable potential for high grain early lactation rations.

The general recommendations at this time would be for corn gluten feed, wet or dry, not to exceed 30 percent of the total ration dry matter. At this feeding rate, 100 pounds of corn gluten feed replaces about 80 pounds of corn and 20 pounds of soybean meal. The average economic value of corn gluten feed can be determined as follows:

$$\text{Corn gluten feed, dry (\$/cwt)} = .8 \times \text{corn (\$/cwt)} + .2 \times \text{soybean meal (\$/cwt)}$$

$$\text{Corn gluten feed, wet (\$/cwt)} = [.8 \times \text{corn (\$/cwt)} + .2 \times \text{soybean meal (\$/cwt)}] \times \frac{\%DM}{100}$$

Soybean hulls. Soybean hulls, or soyhulls, are a byproduct of soybean oil processing. The soybean contains about eight percent hull which is separated from the meal during the oil extraction process. Soyhulls can be fed ground, whole, or steam treated and rolled for feeding as soybran flakes.

Soyhulls are high in fiber yet highly digestible. Nebraska reports indicate soyhull fiber digestibility is over 90 percent in vitro. Rate of fiber digestion was seven to eight percent per hour, which is very rapid. However, fine ground hulls will have a faster rate of passage than whole or coarse ground hulls and, therefore, be lower in digestibility. Ohio researchers reported cellulose digestibilities of 77 to 79 percent for soybran flakes. They also concluded soybran flakes were equal to starch for supporting rumen nitrogen metabolism in lactating dairy cows. Since soyhulls are low in crude protein (12 percent) but high in digestible fiber, they appear to offer considerable potential for replacing starch in diets of high producing dairy cows.

Reports from Ohio and Nebraska indicate soyhulls can replace up to 50 percent of the grain mix in lactating dairy cow rations without loss of production. Nebraska research evaluated the partial replacement of corn and soybean meal with soyhulls in two early lactation experiments. In experiment one, soyhulls accounted for 21 percent of the grain mix and experiment two, 40 percent of the grain mix. In both experiments the forage to concentrate dry matter ratio was 50:50. The forage portion was approximately two-thirds corn silage and one-third alfalfa. In trial 2 (40 percent soyhulls), soyhull fed cows were superior in milk production to cows fed the control ration (Table 4). Soyhulls were essentially equal to the replaced corn and soybean meal for supporting milk production in trial 1 (Table 4).

TABLE 4. Value of soyhulls in partially replacing corn and soybean meal in rations for cows in early lactation.

	Trial 1[1]		Trial 2[3]	
Item	Control	Soyhulls[2]	Control	Soyhulls[4]
Dry matter intake, lb/day	38.1	40.1	46.9	47.3
Milk, lb/day	58.7	59.8	77.7	82.1
Peak milk, lb/day			94.4	100.8
Milk fat, %	3.87	3.84	3.29	3.19
Milk SNF, %	8.25	8.16	8.60	8.43

SOURCE: University of Nebraska.

[1]First 3 months of lactation.
[2]Soyhulls included at 21% of grain mix.
[3]First 18 weeks of lactation.
[4]Soyhulls included at 40% of grain mix.

The economic value of soyhulls can be determined using the following formula:

Soyhulls ($/cwt) = .82 x corn ($/cwt) + .08 x soybean meal ($/cwt)

However, when feeding or mixing, remember it requires 100 pounds of soyhulls to equal the protein and energy content in 82 pounds of corn and eight pounds of soybean meal.

PROTEIN BYPRODUCTS

Brewers grains. Two forms of brewers grains are available for livestock feeding, wet and dry. The wet form, 22 to 30 percent dry matter, is composed of barley malt and other grains (usually corn and some rice) which remain after steeping in hot water. Dried grains may contain up to three percent hops in addition to the grains in the wet form. The majority of brewers grains fed in the Midwest is in the wet form. Most of the dried grain feeding is as a component in commercial protein supplements.

Wet, unpressed brewers grains will range from 22 to 30 percent dry matter and are more variable in moisture content than pressed grains (28 to 30 percent dry matter). Brewers grains are higher in fiber content than most other high protein byproducts or protein supplements (42 percent NDF and 23 percent ADF). The protein content of brewers grains is intermediate in level (27 to 32 percent on a dry matter basis) but considered to be of high rumen escape or resistant to rumen microbial breakdown, approximately 50 percent undegradable. Brewers grains also are a good source of phosphorus and selenium but are relatively low in potassium.

Brewers grains can substitute for soybean meal or other conventional protein sources in rations for lactating dairy cows. Research at Illinois has shown dried brewers or distillers grains were equal in feeding value to soybean meal when incorporated into complete mixed diets on an equal protein basis (Table 5).

TABLE 5. Comparison between soybean meal, dried brewers grains and dried distillers grains with solubles for lactating dairy cows.

Milk production	Soybean meal + wheat bran	Dried brewers grain	Dried distillers grain/solubles
Daily, lb	54.1	54.3	53.2
305-day total, lb	17,501	17,561	17,225
Peak, lb	85.8	84.7	79.2

SOURCE: University of Illinois.

In another study at the University of Illinois, it was concluded wet or pressed brewers grains should not be more than 25 percent of the total ration dry matter for high producing dairy cows (Table 6). Adding wet brewers grains to corn silage-based rations at 30 or 40 percent of the dry matter depressed intakes and reduced milk production compared to rations containing 0 or 20 percent pressed grains. Efficiency of milk production measurements indicated pressed grain nutrients were equal to those in corn and soybean meal for milk production. The problem was cows fed rations high (30 to 40 percent of the total dry matter) in brewers grains could not consume adequate amounts of dry matter to sustain high milk production levels.

TABLE 6. Lactation performance of dairy cows fed rations containing various levels of pressed brewers grains.

	Brewers grains (% of total dry matter)			
Item	0	20	30	40
Dry matter intake, lb/day	43.3	40.0	37.6	32.6
Ration dry matter, %	54.8	44.2	40.3	37.0
Milk, lb/day	56.3	55.0	53.7	48.8
Milk fat, %	3.07	3.32	3.34	3.54
Milk protein, %	3.31	3.21	3.18	3.08
Milk SNF, %	8.11	8.06	8.02	7.93

SOURCE: University of Illinois.

Ohio researchers compared the feeding value of wet versus dry brewers grains for lactating cows. With average producing cows, wet grains and dry grains were equal in supporting milk production when fed on an equal dry matter basis (20 percent of the total ration). This is in agreement with the Illinois research and, thus, inclusion of brewers grains up to 25 percent of the total ration dry matter should not reduce dry matter intakes or milk production. For wet or pressed grains, a maximum of 35 pounds per day per cow appears advisable in most feeding programs.

One of the major decisions regarding useage of brewers grains is their relative cost compared to corn and soybean meal. The following equation can be used to compute a relative dollar value for brewers grains based on energy and protein content:

Wet brewers grain ($/cwt) = .121 x corn ($/cwt) + .081 x soybean meal ($/cwt)
Dry brewers grain ($/cwt) = .374 x corn ($/cwt) + .464 x soybean meal ($/cwt)

Corn gluten meal. Approximately two to three pounds of corn gluten meal are produced per bushel of wet milled corn. Corn gluten is a high protein energy concentrate consisting of insoluble corn protein along with minimal amounts of starch and corn fiber. It may contain condensed fermented corn extractives and/or corn germ meal. Two protein levels are commonly marketed, a 40 or 60 percent.

The major use of corn gluten meal in dairy feeding is as a low rumen degradable protein supplement. Rumen degradability is estimated at 45 percent. Corn gluten meal also is a good source of sulfur amino acids (methionine) and appears to compliment the amino acid content of soybean meal.

Recent research at Minnesota indicates combinations of extruded soybeans and corn gluten meal, two low degradable protein sources, were no better than soybean meal in supporting milk production of cows in early lactation (Table 7). Thus, the relative value of corn gluten meal should be based on energy and cost per protein equivalency to soybean meal and not on its undegradable protein potential. The following formula can be used as a guideline in pricing corn gluten meal (60 percent):

Corn gluten meal ($/cwt) = (11.4 - 1.4 x corn ($/cwt)) + .65
x soybean meal ($/cwt)

TABLE 7. Dry matter intake and milk production of cows fed corn gluten meal and extruded soybeans as supplemental protein sources.[a]

	Protein source[b]			
Item	Soybean meal	75% ES: 25% CGM	50% ES: 50% CGM	25% ES: 75% CGM
Dry matter intake, lb/day	51.2	49.2	47.8	48.7
Milk, lb/day	87.1	78.8	78.1	79.8
Milk fat, %	4.1	3.8	3.8	4.1
Milk solids, %	13.1	13.0	12.3	13.0

SOURCE: University of Minnesota.

[a]Data is for first 150 days of lactation and from cows in second lactation or greater.

[b]ES - extruded soybeans, CGM - corn gluten meal.

Distillers grains. There are several types and forms of byproducts produced from fermenting grains into ethyl alcohol. The major type of byproduct is corn distillers grains with or without solubles (liquid fraction after distilling containing soluble nutrients not fermented). Distillers grains, in general, include the unfermented carbohydrates, fiber and insoluble proteins of any grain (usually corn) fermented for alcohol production. Grains can be sold in the dry, partially dried, or wet forms.

The nutrient content of dried corn distillers grain with and without solubles is shown in Table 1. However, composition of any distillers grains will vary depending on grain(s) used, completeness of fermentation and quantity of solubles added to or remaining in grains after processing. In general, distillers grains should be considered a good source of protein and energy.

The major use of dried distillers grains or dried distillers grains with solubles in dairy cattle rations has been as a low rumen degradable protein supplement. Dried distillers grains has a protein degradability of about 46 percent and dried distillers grains with solubles about 51 percent. Conclusions from bypass protein studies confirm the high bypass protein effect of distillers grains with or without solubles but milk production advantages are not always shown. Distillers grains contain higher amounts of fiber than corn or unfermented cereal grains which also may be beneficial in supporting higher milk fat percentages. Recommended feeding levels for dried distillers grains or dried distillers grains with solubles are a maximum of 30 percent of the grain mix or no more than 14 percent of the total ration.

Limited feeding information is available on distillers wet grains and whole stillage (liquid). The composition of these products will vary with suppliers. Nutrient analyses, especially dry matter, will be needed on these products. In general, wet grains should not exceed 20 percent of the ration dry matter and whole stillage should be limited to 150 pounds or less per cow per day.

Equations to calculate an approximate feeding value of dried and wet distillers grains are:

$$\text{Dried distillers grains (\$/cwt)} = .138 + .505 \times \text{corn (\$/cwt)} + .503 \times \text{soybean meal (\$/cwt)}$$

$$\text{Wet distillers grains (\$/cwt)} = \frac{\text{dried distillers grain (\$/cwt)} \times \text{wet grain DM \%}}{90}$$

Sunflower meal. Sunflower meal, which is the material after extracting the oil from the seed, may provide an economical protein supplement for dairy animals. Two types of sunflower meal may be available, a dehulled meal (45 percent crude protein) and a partially dehulled meal (28 percent crude protein). The latter is the most commonly used in Minnesota.

The protein and energy content of sunflower meal vary with the amount of hull removed during processing. Dehulled sunflower meal will contain as much protein as soybean meal but be slightly lower in energy (70 percent TDN vs 82 percent in soybean meal). The with hulls or partially dehulled sunflower meal will be lower in protein and energy, and higher in fiber than dehulled (Table 1). Sunflower meals also are good sources of calcium and phosphorus.

Sunflower hulls contain 55 percent acid detergent fiber and are low in digestibility. The additional fiber from sunflower hulls may be beneficial in rations containing minimal fiber amounts, but may be a disadvantage when sunflower meal is the only protein supplement fed with low quality forages.

Sunflower meal appears to be palatable to cows. South Dakota researchers observed no problems when partially dehulled sunflower meal replaced soybean meal on an equal protein basis in rations for lactating cows. Thus, it appears sunflower meal can be fed as the sole source of supplemental protein for dairy cows. Cost per pound of protein should be the deciding factor.

SUMMARY

Overviews of nutrient content, feeding research studies, and feeding management strategies, along with general pricing schemes, have been presented for various alternative feedstuffs. All of the byproducts discussed are currently more or less available in Minnesota. Most can be used, at least to some extent, in dairy feeding enterprises. However, byproduct feeding requires more attention to and better feeding management than with conventional feedstuffs if optimal animal performance is to be maintained.