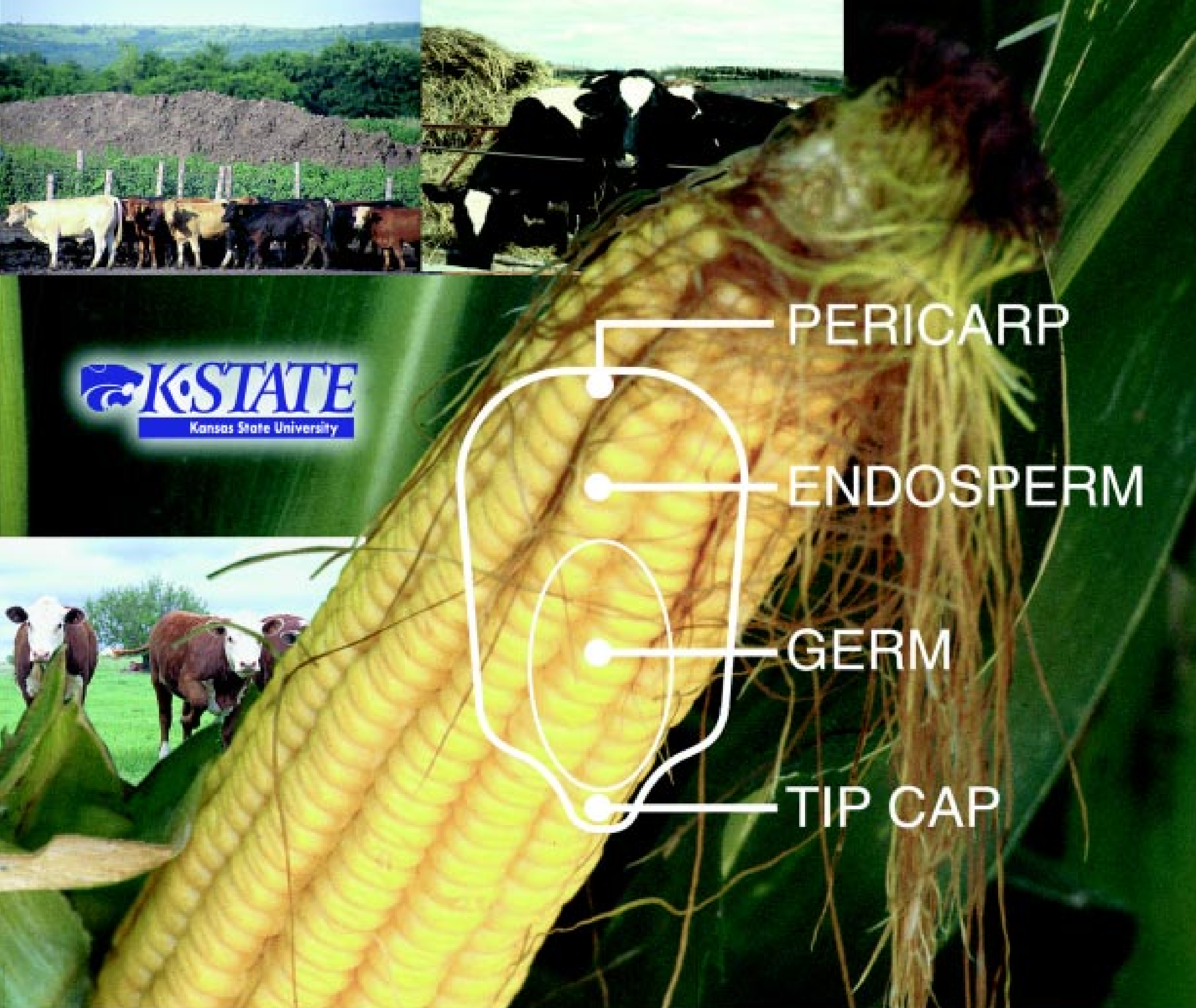


Corn Gluten Feed

Composition and Feeding Value for Beef and Dairy Cattle

Corn gluten feed (CGF) is a by-product of the wet milling process. Wet CGF or dry CGF represents an excellent feedstuff that has broad feeding applications in the beef and dairy cattle industries. It contains significant amounts of energy, crude protein, digestible fiber, and minerals. Sample analysis should be conducted regularly to account for manufacturing plant or batch variations in nutrient composition of CGF. Wet CGF is more digestible than dry CGF and can replace up to 50% of dry rolled corn or 30% steam-flaked corn in beef finishing diets without negatively affecting performance. Dry CGF can replace up to 25% of dry rolled corn in beef finishing diets before reductions in cattle performance begin to occur. However, the relative feeding values of both wet CGF and dry CGF compared to corn depend on the roughage level of the diet. This is due to the inherent ability of CGF to reduce negative associative effects on fiber digestion induced by starch. In general, most studies show that either wet CGF or dry CGF can be utilized in dairy heifer and cow diets without negatively impacting performance.

Although wet CGF is nutritionally superior compared to dry CGF, least cost ration formulation may dictate the use of the dry form as the distance between the milling plant and the livestock operation increases. This is because transportation costs on a dry matter basis are generally less for dry CGF. Thus, inclusion of CGF in diets must be evaluated on an individual operation basis.

Introduction

The stature of Kansas as a significant agricultural state can be attributed heavily to its ranking as a producer of livestock and crops. Because Kansas often is referred to as the Wheat State, few realize the significant effects of other crops such as corn on the state's economy. Although Kansas is located on the fringes of the corn belt, its 1998 annual production ranked 8th in the United States. For the third consecutive year, 1999 corn production in Kansas set a new record with almost 419 million bushels on 3.14 million acres (Kansas Department of Agriculture, 1999). Based upon the average marketing price ($1.90/bushel), the value of the 1999 Kansas corn crop was almost $800 million (Hartwig, 2000).

The beef industry is dominant in Kansas. A combination of more than 4 million stockers and feeders imported into the state and the calves derived from the 1.5 million-head resident population of beef cows contribute to the demand created by the 5-million head capacity of the state's feedlot industry. Additionally, the Kansas dairy industry includes about 90,000 cows that produce approximately 1.6 billion pounds of milk each year. Feed costs, which account for approximately 50% of total costs, are major considerations for efficient production of beef and milk. Because of the large volumes of feed grains that are grown and processed in the Midwest, Kansas beef and dairy producers have tremendous opportunities to significantly reduce feed costs through the use of by-products such as CGF.

Although approximately 60% of the U.S. corn crop is destined for direct utilization by livestock, milling operations that refine corn into food and industrial products represent a second growing, robust market. The refining process that removes the starch fraction from the parent grain results in numerous by-products, such as corn gluten feed (CGF), corn gluten meal, and corn steep liquor that have potential feeding value for beef and dairy cattle. If readily accessible and priced competitively with other feedstuffs, by-products such as CGF, can assist in reducing feed costs. The estimated yield of CGF from a 56-pound bushel of corn is about 6 pounds, or approximately 11% of the original corn weight. Although no in-state corn milling facility is available, Kansas livestock producers have obtained CGF from refinery facilities located in Nebraska and Iowa. This publication contains information about the nutrient composition and feeding management of CGF, which will help Kansas livestock producers effectively reduce feed costs.

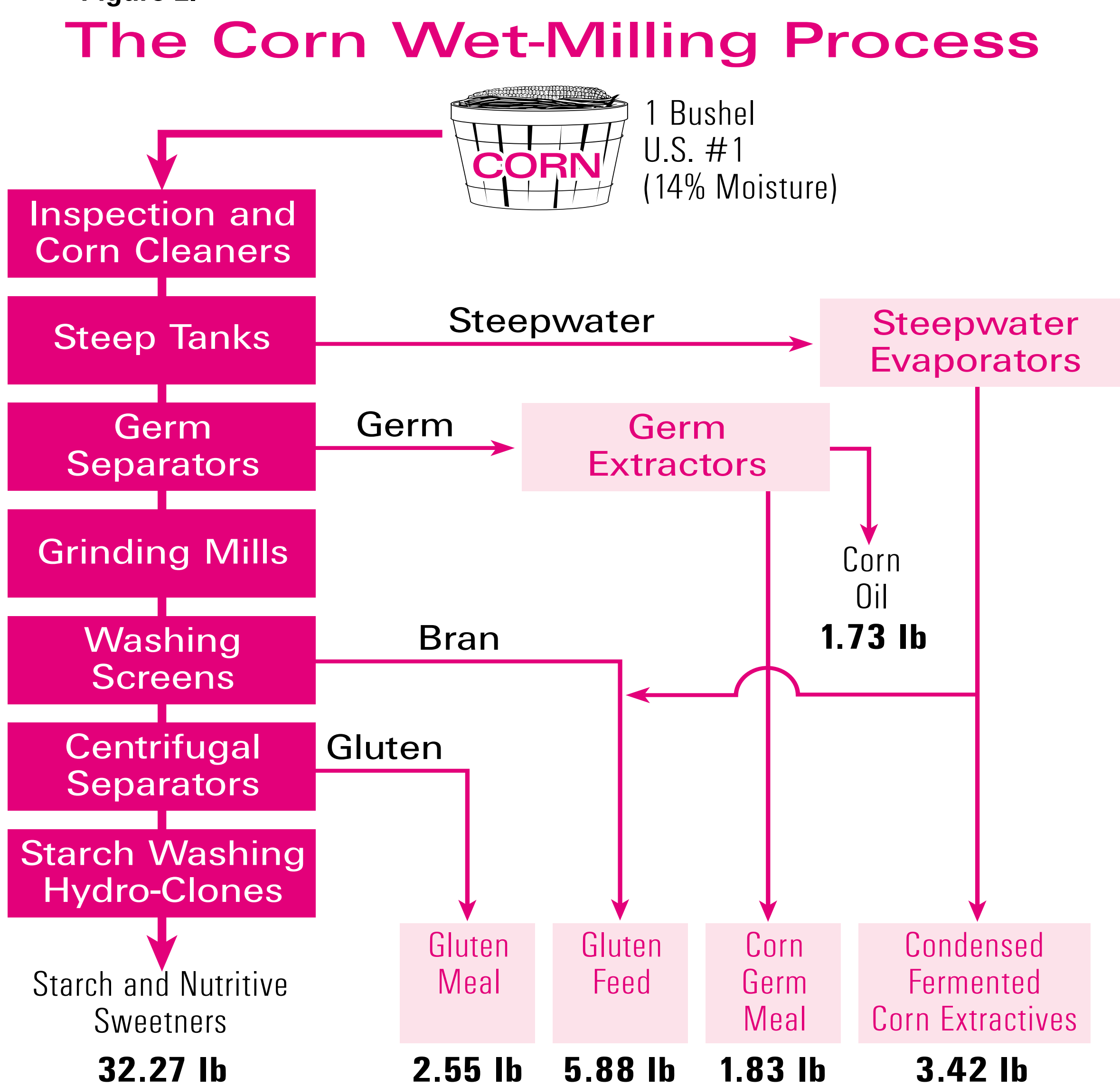
The Corn Wet-Milling Process

Depending upon the desired end products, corn can be refined by either a dry- or a wet-milling process. In contrast to the corn wet-milling process that will be described in greater detail (Figure 1), the dry-milling process involves grinding, cooking, and fermenting for production of alcohol.

Stage 1. Preparation and Steeping—After removal of cobs, dust, chaff, and foreign material, the corn is soaked (steeped) in water and sulfur dioxide in order to swell the kernels. During this process, many essential nutrients are absorbed into the steep water. After several hours, the water (or liquor) is drawn off and concentrated (condensed corn steep water).

Stage 2. Germ Separation—Cyclone separators spin the low-density corn germ out of the slurry that results from the steeping process. The germs, containing approximately 85% of the corn's oil, are pumped onto screens and repeatedly washed to remove any starch from the mixture. A combination of mechanical and solvent processes removes the oil from the germ where it is further refined and filtered into finished corn oil. The germ residue represents another useful component for animal feeds.

Figure 1.



Stage 3. Fine Grinding and Screening —The corn and water slurry exits the germ separator for a more concise grinding in an impact or attrition-impact mill to release the starch and gluten from the fiber in the kernel. The fiber fraction is collected, slurried, and rescreened again to reclaim residual starch or protein and passed on to the mill stream destined for animal feeds. The separated starch/gluten suspension (often referred to as mill starch) is transported to the starch separators.

Stage 4. Starch Separation and Conversion—Because of relative differences in density, centrifuging the mill starch readily removes the gluten which eventually is combined with other fractions destined for animal utilization. The remaining starch fraction may contain 1 or 2 % protein and requires a series of dilutions and washing steps to produce a high quality starch that typically is more than 99.5% pure.

Standard Specifications

The following international feed numbers and descriptions of corn by-products were obtained from the Association of American Feed Control Officials (AAFCO, 1996).

48.2 Corn Bran is the outer coating of the corn kernel, with little or none of the starchy part of the germ (Adopted 1931.) IFN 4-02-841 Maize bran.

48.13 Corn Gluten Feed is that part of the 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 one or both of the following: fermented corn extractives, corn germ meal. (Adopted 1936, Amended 1960.) IFN 5-02-903 Maize gluten meal.

48.14 Corn Gluten Meal is the dried residue from corn after the removal of the larger part of the starch and germ, 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 contain fermented corn extractives and/or corn germ meal. (Adopted 1936, Amended 1960.) IFN 5-02-900 Maize gluten meal.

48.23 Corn Germ Meal is ground corn germ from which most of the solubles have been removed by steeping and most of the oil removed by hydraulic, expeller, or solvent extraction processes and is obtained in the wet-milling process of manufacture of corn starch, corn syrup, or other corn products (Proposed 1960, Adopted 1961). IFN 5-02-897 Maize germs without extractives meal wet milled mechanical extracted, IFN 5-02-898 Maize germs without extractives meal wet milled solvent extracted.

48.24 Condensed Fermented Corn Extractives are obtained by the partial removal of water from the liquid resulting from steeping corn in a water and sulphur dioxide solution, which is allowed to ferment by the action of naturally occurring lactic-acid producing microorganisms as practiced in the wet milling of corn. (Proposed 1959, Amended 1960, Adopted 1961.) IFN 4-02-890 Maize extractives fermented condensed.

Factors Affecting the Nutrient Content of Corn Gluten Feed

Dry CGF is manufactured by combining corn bran with steep liquor (and corn germ meal at some facilities) and drying in a rotary drum dryer. After the mixture is ground through a hammer mill, the product is pelleted to increase bulk density, facilitate handling, and enhance storage characteristics. Wet CGF is made by pressing the wet corn bran to approximately 35% dry matter (DM). When combined with corn steep liquor, the final product contains about 40% DM (Corn Refiners Association, Inc., 1989). Various book values reflecting the “average” or guaranteed nutrient contents of corn grain and CGF are shown in Table 1. However, the energy value of CGF is dependent upon the amount of forage fed in the diet (Berger and Willms, 1992; Hussein and Berger, 1995; Whitham et al.,1999); the physical form (wet vs. dry) fed

Table 1. Nutrient comparison of corn and by-products resulting from the wet-milling process.[a]

Nutrient	Corn	Wet CGF	Dry CGF
Dry matter, %	88	42 - 44	90 - 92
Crude protein, %	10.1	14 - 22	21 - 22
NEm, (Mcal/lb)[b]	1.02	.96 - .99	.87
NEg, (Mcal/lb)[b]	.70	.65	.57
TDN %[c]	90	90	78
Fat, %	4.2	3.0 - 5.0	2.0 - 3.3
Crude fiber, %	2.2	7.0 - 8.4	8.0 - 8.4
Total starch, %	72	26	18
Ash, %	1.4	7.2 - 9.0	7 - 7.2
Calcium, %	.02	.10	.1 - .2
Phosphorus, %	.35	.45 - 1.0	.8 - 1.0
Potassium, %	.37	.9 - 1.60	1.3 - 1.5
Magnesium, %	.13	.15 - .50	.42 - .50
Sodium, %	.02	.20	.12
Sulfur, %	.14	.35 - .40	.16 - .30
Cobalt, ppm	.04	-	.09
Copper, ppm	4	6.0	6 - 9.9
Iron, ppm	26	41 - 165	165 - 304
Maganese, ppm	6	12 - 26	22 - 26
Molybdenum, ppm	—	—	—
Selenium, ppm	—	—	
Zinc, ppm	16	45 - 114	88 - 114

[a]NCR-88, Cargill; MCP Factsheet; Hutjens,1991.
[b]NEm & NEg= Net energy, maintenance and growth, respectively.
[c]TDN= Total digestible nutrients.

(Green et al., 1987; NRC-88, 1989); and the ratios of corn bran, solvent-extracted germ meal, and steep liquor blends that are used to create CGF (Herold et al; 1998, 1999).

The ultimate nutrient composition of by-products that result from the corn wet-milling process can vary greatly depending upon the individual market values of the various products that are added and blended in the CGF-destined mill stream. In other words, millers may extract a specific constituent of the corn kernel that is valued higher by itself rather than for its contribution as a portion of CGF. The ratio of bran to steep liquor is normally 2/3 to 1/3 in the final CGF product. However, significant deviations from this oft-quoted range can and do occur quite often among products from different manufacturers. The CGF can vary in color from golden to brown, and the steep liquor adds a pleasant molasses-like or caramel odor. A lighter colored product usually is preferred because a darker color may indicate that heat damage has occurred during the drying process. The product also will become darker as additional steep water is added. In CGF the nutrient variation can be considerable. For example, the crude protein can range from 17 to 26% from 26 to 54% (DiCostanzo et al., 1986; Macleod et al., 1985);

neutral detergent fiber from 26 to 54% (Krishnamoorthy et al., 1982; DiCostanzo et al., 1986); and ether extract from 1 to 7% (Phelps, 1988). These ranges further emphasize that livestock producers who incorporate CGF into diets should accept the challenges of nutrient variation and know the nutrient content of the by-product. Thus, the user must either conduct chemical analyses on each purchased load or purchase product with a guaranteed analysis.

Corn Gluten Feed for Beef Cattle Grazing Forages

Corn gluten feed is a viable source of protein and energy for cattle that are grazing low and moderate quality forages (Fleck and Lusby, 1986; Fleck et al., 1987; Willms et al., 1992; Cordes et al., 1988). The crude protein in CGF is of high quality (DeHann et al., 1983; Firkins et al., 1985; Loy et al., 1987) and constitutes about 26% of DM, of which about 75% is ruminally degraded (degradable intake protein = DIP). When cattle graze low-quality forages, feeding corn grain often leads to a reduction in forage intake and decreased fiber digestion. This phenomenon commonly is referred to as a negative associative effect. This presumably is a result of corn grain favoring starch-fermenting microbes over fiber digesters, thereby reducing overall fiber digestion. Alternatively,

Table 2. Performance of mature beef cows and their calves fed dry CGF[a]

	Treatment[b]					
	NC/SBM	PC/SBM	DCGF	DCGF/SBM	DCGF/Urea	Prob.
Supplement composition						
Crude protein, %	37.43	41.11	17.89	25.9	25.71	
Total digestible nutrients (TDN) %	67.92	74.41	73.99	73.94	69.86	
11/20/84 to 01/29/85						
Amount of supplement fed daily	1.10	2.00	4.60	3.20	3.20	
Daily level of crude protein (lbs)	0.41	0.82	0.82	0.83	0.82	
Daily level of TDN (lbs)	0.75	1.49	3.40	2.37	2.24	
1/30/85 to 3/26/85						
Amount of supplement fed daily	1.60	3.00	6.90	4.80	4.80	
Daily level of crude protein (lbs)	0.60	1.23	1.23	1.24	1.23	
Daily level of TDN (lbs)	1.09	2.23	5.11	3.55	3.35	
Cows and Calves						
Number of pairs	18	18	18	17	18	
Initial cow weight, lbs	1041	1047	1048	1044	1040	
Cow weight change						
11/20/84 - precalving	-77[c]	-24[de]	3[e]	1[e]	-56[cd]	P<.01
Conception rate, %	55.5	87.5	83.3	80	88.2	P<.11
Calf birth weight, lbs	75	77	80	80	76	P<.14
Calf daily gain, lb/day	1.25	1.40	1.38	1.27	1.32	NS
Cow weight at weaning (10/17/85)	975	993	1003	999	988	NS
Adjusted weaning weight	346	384	377	359	367	P<.19

[a] Table adapted from Fleck and Lusby, 1986.
[b] NC/SBM = Negative control, 1.1 lb/day soybean meal; PC/SBM = Positive control, 2.0 lb/day soybean meal, DCGF = 4.6 lb/day dry corn gluten feed, DCGF/SBM = 3.2 lb/day of a 2:1 DCGF:SBM mixture, and DCGF/Urea = 3.2 lb/day dry corn gluten feed and urea.
[cde] Means with different superscript letters differ significantly.

including corn grain in the diet also may lead to a deficiency of DIP, which also could limit fiber digestion. In comparison to mixtures of soybean meal (SBM) and corn or SBM alone as a supplement for beef cows fed corn stalklage (Willms et al., 1992) or grazing native grass hay (Fleck and Lusby, 1986;1987), dry CGF was an effective source of energy and protein (Table 2).

Corn Gluten Feed in Diets for Growing Beef Cattle

Corn gluten feed consists mainly of corn bran, which is a source of fermentable fiber in ruminant diets. The energy value of CGF relative to corn increases in high-roughage diets because it supplies additional energy without the negative associative effects on fiber digestion that can occur when high levels of grain are fed. By not retarding fiber digestion, CGF increases total digestibility of these high-roughage diets, thereby increasing cattle performance (Cordes et al., 1988; Kampman and Loerch, 1989; Ham et al., 1995). Research suggests that wet or dry CGF can effectively replace up to 100% of dry-rolled corn on a DM basis in diets containing greater than 50% roughage (DM basis) without compromising growing cattle performance (Trenkle1987a; Ham et al., 1995).

Whitham et al. (1999) conducted a 99-day study in which 216 beef heifers (average 524 lb) were fed traditional roughage-based diets at 2.75% of body weight or limit-fed high-concentrate diets at 2.0% of body weight to determine the effects of diet type on wet CGF feed value. The wet CGF was essentially equal to corn when included in roughage-based diets, but produced lower gains and poor feed efficiencies when used to replace corn in high-concentrate limit-fed diets (Table 3).

Corn Gluten Feed in Diets for Finishing Beef Cattle

Differences between wet CGF and dry CGF and their values relative to corn in diets for finishing cattle have been reported (Table 4). Firkins et al. (1985) conducted a finishing trial in which steers were fed diets consisting of 10% roughage, 37% dry-rolled corn, and 50% wet or dry CGF. They found that steers fed wet CGF responded with a 7.0% reduction in DM intake, but similar weight gains and, consequently, a 9.0% increase in feed efficiency compared to steers fed dry CGF. This reduction in DM intake may have been due to the increased mean particle size of wet CGF (2 mm) compared to dry CGF (.9 mm) (Firkins et al. 1985). Such a difference in particle size may affect the passage rate and digestibility of wet CGF compared to dry CGF.

Table 3. Performance of beef cattle fed corn- and wet CGF-based diets[a]

	Day 0 to 99 Performance		
Treatment[b]	**Intake, lb/d**	**Daily Gain, lb/d**	**Feed:Gain**
CORN (2.0%)	13.73[e]	2.54[c]	5.42[d]
CORN (2.75%)	18.96[c]	2.52[c]	7.52[c]
WCGF (2.0%)	13.69[e]	2.27[d]	6.02[e]
WCGF (2.75%)	19.81[d]	2.57[c]	7.72[c]
SEM[f]	.18	.08	.60

[a] Whitham et al., 1999.
[b] CORN 2.0% = corn-based diet fed at 2.0% of body weight (BW); CORN 2.75% = corn-based diet with roughage fed at 2.75% BW; WCGF 2.0% = wet CGF-based diet fed at 2.0% of BW; WCGF 2.75% = wet CGF-based diet with roughage fed at 2.75% BW.
[cde] Means in a column with different superscripts are different ($P<.05$).
[f] SEM = standard error of the mean

Table 4. Evaluation of wet CGF and dry CGF in diets for growing and finishing beef cattle.

Reference	Form of CGF	% of Corn DM Replaced	Diet	Average Daily Gain lb	Change from Control %	Feed: Gain	Change from Control %
Green et al. (1987)	Wet	23	Finishing	3.23	+3.5	6.2	3.1
Green et al. (1987)	Dry	23	Finishing	3.04	-4.3	6.1	-1
Ham et al. (1995)	Wet	100	Growing	2.62	+16.0	6.9	+13.3
Ham et al. (1995)	Wet	40	Finishing	3.74	+8.3	6.4	+3.3
Firkens et al. (1985)	Wet	54	Finishing	3.04	+3.8	6.4	-3.9
Firkens et al. (1985)	Dry	54	Finishing	2.97	+1.5	7.0	-14.4
Richards et al. (1998)	Wet	50	Finishing	3.76	+9.6	6.3	+12.0
Sindt et al. (2000)	Wet	30	Finishing	3.22	+2.5	6.0	+1.8
Trenkle (1987a)	Wet	56	Finishing	3.09	-4.0	6.4	0.0
Trenkle (1987a)	Dry	56	Finishing	3.13	-2.2	6.9	-8.9

Other researchers also have observed reduced DM intakes of cattle fed wet CGF. Staples et al. (1984) reported a linear decrease in DM intake with increasing levels of wet CGF fed to cows, and Milton et al. (2000) reported decreased DM intakes for steers consuming wet or rehydrated corn bran as opposed to dry corn bran.

However, Green et al. (1987), who fed finishing steers a diet containing 10% roughage and replaced 23 or 46% of dry-rolled corn with wet or dry CGF found a tendency for increased DM intakes by steers fed both wet CGF treatments. The 23 and 46 % levels of wet CGF increased average daily gains by 7.0 and 12% respectively, compared to dry CGF. Feed efficiencies were similar when both wet and dry CGF replaced 23% of dry-rolled corn; however, wet CGF increased feed efficiency 10% more than dry CGF when they replaced 46% of dry-rolled corn. The increased DM intakes of the wet CGF treatments help explain the similar feed efficiencies of steers fed the 23% level of wet and dry CGF. The authors concluded that wet CGF has 97% the value of dry-rolled corn at replacement levels of 23 or 46% (DM basis), and that dry CGF has 97% the value of dry-rolled corn at a replacement level of 23% but only 87% the value of dry-rolled corn at a replacement level of 46%.

In another study of corn-based finishing diets, replacing up to 50% of dry-rolled corn with WCGF on a DM basis improved average daily gain and feed efficiency by 9.6 and 12% respectively, compared to dry-rolled corn alone (Richards et al., 1998).

Although most studies investigating the effects of CGF on cattle performance have been conducted with diets consisting of dry-rolled corn, Sindt et al. (2000) evaluated the effects of wet CGF in finishing diets containing steam-flaked corn on steer performance. They replaced 30 or 60% of steam-flaked corn with CGF on a DM basis and reported reduced feed efficiencies for steers fed the 60% wet CGF treatment. Furthermore, average daily gains were reduced for the 60% wet CGF compared to the 30% wet CGF treatment. However, average daily gain and feed:gain were not different between steers fed the control diet (no CGF) or the 30% wet CGF treatment.

Because finishing diets contain low amounts of roughage, the mechanism for maintaining or improving cattle performance with the addition of CGF remains unclear. However, because CGF provides dietary energy in the form of fermentable fiber and not grain, its addition may lessen the severity of acidosis in feedlot cattle, thus improving performance.

Finishing diets consist mainly of grain, which is low in degradable intake protein, on which the rumen microflora depends for nitrogen in order to synthesize microbial protein. To meet these nitrogen requirements a ruminally degradable nitrogen source such as soybean meal or urea commonly is fed to finishing cattle. Research has demonstrated that CGF possesses a ruminally degradable protein fraction similar to that of SBM (Firkens et al., 1984). In fact, CGF alone can meet the increased requirements for degradable intake protein of cattle consuming corn-based finishing diets when it replaces 50% of dry-rolled corn on a DM basis (Trenkle, 1987b; Bowman and Paterson, 1988; Richards et al., 1998). Reports regarding the effects of feeding CGF on carcass quality are inconsistent. Some studies have demonstrated no effect (Trenkle, 1987a; Kampman and Loerch, 1989; Hussein and Berger, 1995; McCoy et al., 1998; Richards et al., 1998) whereas other studies have documented a reduction in carcass quality with increasing levels of CGF (Firkens et al., 1985; Green et al., 1987; Ham et al., 1995; Sindt et al., 2000).

Corn Gluten Feed as a Source of Roughage in Beef Cattle Diets

Because of its high fiber content CGF has successfully replaced the roughage portion in limit-fed growing diets when fed at 40% of DM (Montgomery et al., 2000), and in finishing diets when fed at 40, 50 or 60% of DM (Trenkle, 1987a). This implies that CGF can serve as a roughage source when traditional sources of roughage such as hay become scarce.

Corn Gluten Feed in Diets for Lactating Dairy Cows

Corn gluten feed generally is included in rations for lactating dairy cows as a source of energy, protein and fiber. Its energy value is similar to that of corn, and it contains three times as much crude protein. When used as a replacement for corn, it effectively reduces the nonstructural carbohydrate level of the diet with minimal impacts upon the energy content. When fed at higher levels, it reduces the supplemental phosphorous requirements.

Several studies have evaluated the use of CGF in diets for lactating dairy cows (Table 5). In general, it has been shown to be an effective replacement for concentrate alone or forage and concentrate without significant impacts upon DM intake or fat-corrected milk production. Fellner and Belyea (1991) used dry CFG to replace up to 60% of the DM in diets containing alfalfa hay and corn silage without reducing intake or milk production. Dry CGF fed at 20 or 26 % of the diet DM increased milk production in two studies (Firkins et al., 1991 and Macleod et al.,1985).

Research at Kansas State University (KSU) (Van Baale et al.,1999) showed increases in intake and milk production for cows fed a diet with wet CGF compared to those fed a control diet containing both alfalfa hay and corn silage. In contrast, Staples and coworkers (1984) reported a linear decrease in intake but no impact on milk production for cows fed a corn silage-based diet with wet CGF replacing concentrate at 20, 30, or 40% of DM. Two additional studies (Bernard and McNeill, 1991 and Bernard et al.,1991) utilizing a corn silage-based diet showed no change in DM intake or milk production when wet or dry CGF was fed as a replacement for forage and concentrate.

Results of such studies have shown that feeding CGF to lactating dairy cattle as a replacement for a portion of the concentrate alone or forage and concentrate in diets containing alfalfa silage, corn silage, alfalfa hay, or a combination of forages either has no effect upon intake and milk production or increases one or both. The only negative impacts upon intake or milk production in a corn silage-based diet were reported when CGF replaced only the concentrate. Either wet CGF or dry CGF can be an effective and efficient feedstuff for lactating dairy cows. It usually is priced lower than corn grain and reduces the amount of supplemental protein required. Thus, it generally will reduce the ration cost. Although CGF has been fed at levels up to 60% of the diet DM, lactation diets usually contain 10-20%. Bernard and coworkers (1991) reported significant variation in nutrient composition of CGF. Thus, limiting the amount of CGF to 10-20% of the diet will minimize the impact of these variations upon the total diet. In addition, changes in DM content and spoilage should be considered when wet CGF is fed.

Corn Gluten Feed in Diets for Dry Dairy Cows

Corn gluten feed can enhance diets for dry dairy cows by providing significant amounts of energy and crude protein. Because CGF is low in nonstructural carbohydrates, it can be effective in reducing the potential for acidosis during the critical transition period 21 days prior to calving. A KSU study (Park, et al. 2000) reported that transition cows fed a diet containing 20% wet CGF consumed similar amounts of dry matter as the control cows. After calving, cows fed wet CGF during the transition period produced similar amounts of milk and milk components. This study demonstrated that dry cows within 3 weeks of calving can be fed wet CGF without negative impacts upon performance. Depending upon feedstuff prices, utilizing wet CGF may reduce the cost of transition diets.

Corn Gluten Feed in Diets for Replacement Dairy Heifers

Wet CGF is also an excellent feedstuff for replacement heifer diets. Armentano and Dentine (1988) used wet CGF as a replacement for concentrate in a diet containing corn silage fed to one group of 700-pound heifers. When heifers reached 900 pounds, both groups were placed on a similar diet and monitored until the end of lactation. Gain, age at first calving, and first lactation milk production were similar for both groups. In another study, (Jaster et al. 1984), 700-pound replacement heifers were fed diets of alfalfa haylage, oatlage, sorghum-soybean silage or wet CGF for 83 days. Heifers fed wet CGF consumed more feed; gained faster; and developed more frame based on heart girth, wither height, body length and depth of chest measurements compared to cows on the other three treatments. In addition, the wet CGF resulted in the greatest feed efficiency. Researchers concluded that wet CGF should be mixed with roughage rather than fed free-choice because of the excessive weight gain observed and a few cases of mild diarrhea.

These studies demonstrate that wet CGF is an efficient substitute for concentrate in replacement heifer diets. Heifers fed wet CGF at 30% of the diet performed similarly to those fed concentrate, and performance remained similar throughout the first lactation. We recommend that supplemental forage be fed along with wet CGF to avoid the excessive body weight gain observed in one study.

Storage Issues for Corn Gluten Feed

The handling characteristics of wet CGF are somewhat similar to those of silage (Hutjens, 1991). If a producer has no provision for long-term storage, wet CGF can be stored for 12 to 14 days in cold weather and up to 7 days in hot weather before the appearance of an apparently harmless white mold and the onset of spoilage. Wet CGF can be stored on the ground or in a pit or even mixed with forages or grain and blown into a silo for fermentation. Relative to pelleted wheat middlings, dry CGF appears to store well. However, producers have reported that settling during transit can cause difficulty in unloading.

Table 5. Responses of lactating dairy cows fed corn gluten feed.

Reference	Feed[b]	Level	Forage Type[c]	Diet Component Replaced	Change from Control[a] DMI[d]	Change from Control[a] FCM[e]
	% of DM				(lb/c/d)	
Allen and Grant (2000)	WCGF	24	AS	Forage & Concentrate	NS	NS
Armentano and Dentine (1988)	WCGF	12 24 36	AS:CS 1:2	Concentrate	NS	NS
Bernard and McNeill (1991)	DCGF	22	CS	Forage & Concentrate	NS	NS
Bernard et al. (1991)	WCGF DCGF	27 27	CS	Forage & Concentrate	NS	NS
Fellner and Belyea (1991)	DCGF	20 40 60	AH:CS 1:1.7	Forage & Concentrate	NS	NS
Firkins et al. (1991)	DCGF	20	AS:CS 1:1.3	Concentrate	NS	+6.6
Gunderson et al. (1988)	WCGF	10 20 30	AH:CS 1:1	Concentrate	NS	NS
Macleod et al. (1985)	WCGF	19	HS:CS	Concentrate	NS	NS
		37	1:4		+5.6	+5.8
	DCGF	26	CS			
	WCGF	26		Concentrate	NS	NS
Staples et al. (1984)	WCGF	20	CS	Concentrate	-1.8	NS
		30				
		40			-4.6	-6.4
Van Baale, et al. (1999)	WCGF	20	AH:CS 2:1	Forage & Concentrate	+4.4	+4.7
Zhu, et al. (1997)	DCGF	33	AH:CS 1:1.2	Forage & Concentrate	NS	NS

[a]NS = no significant difference from control
[b]DCGF = wet corn gluten feed; DCGF = dry corn gluten feed
[c]AH = alfalfa hay; AS = alfalfa silage; CS = corn silage; HS = haycrop silage; 1:1 = dry matter (DM) ratio of forages
[d] DMI = dry matter intake
[e] FCM = 4% fat-corrected milk

References

Association of American Feed Control Officials. 1996. Official Publication. Atlanta, GA.

Allen, D.M. and R.J. Grant. 2000. Interactions between forage and wet corn gluten feed as sources of fiber in diets for lactating cows. J. Dairy Sci. 83:322.

Armentano, L.E. and M.R. Dentine. 1988. Wet corn gluten feed as a supplement for lactating dairy cattle and growing heifers. J. Dairy Sci. 71:990.

Berger, L.L. and C.L. Willms. 1992. Energy value of wet corn gluten feed in a restricted feeding program for feedlot cattle. In: Univ. of Ilinois Beef Rep., p. 3.

Bernard, J.K. and W.W. McNeill. 1991. Effect of high fiber energy supplements on nutrient digestibility and milk production of lactating dairy cows. J. Dairy Sci. 74:991.

Bernard, J.K., R.C. Delost, F.J. Mueller, J.K. Miller and W.M. Miller. 1991. Effect of wet or dry corn gluten feed on nutrient digestibility and milk yield and composition. J. Dairy Sci. 74:3913.

Bowman, J.G.P. and J.A. Paterson. 1988. Evaluation of corn gluten feed in high energy diets for sheep and cattle. J. Anim. Sci. 66:2057.

Cordes, C.S., K.E. Turner, J.A. Paterson, J.G.P. Bowman, and J.R. Forwood. 1988. Corn gluten feed supplementation of grass hay diets for beef cows and yearling heifers. J. Anim. Sci. 66:522.

Corn Refiners Association, Inc. 1989. Corn Wet Milled Feed Products, 3rd Ed., Washington, DC.

DeHaan, K, T. Klopfenstein, and R. Stock. 1983. Corn gluten feed. Protein and energy source for ruminants. In: Univ. Neb. Beef Cattle Rep., MP-44., p.19.

DiCostanzo, A, S.D. Plegge, T.M. Peters, and J.C. Meiske. 1986. Dry corn gluten feed as a replacement for corn grain and corn silage in corn silage based diets. In: Univ. Minn. Beef Rep., B-345, p. 9.

Fellner, V. and R.L. Belyea. 1991. Maximizing gluten feed in corn silage diets for dairy cows. J. Dairy Sci. 74:996.

Firkins, J.L., L.L. Berger, G.C. Fahey, Jr., and N.R. Merchen. 1984. Ruminal nitrogen degradability and escape of wet and dry distillers grains and wet and dry corn gluten feeds. J. Dairy Sci. 67:1936.

Firkins, J.L., L.L. Berger, and G.C. Fahey, Jr. 1985. Evaluation of wet and dry distillers grains and wet and dry corn gluten feeds for ruminants. J. Anim. Sci. 60:847.

Firkins, J.L., M.L. Eastridge, and D.L. Palmquist. 1991. Replacement of corn silage with corn gluten feed and sodium bicarbonate for lactating dairy cows. J. Dairy Sci. 74:1944.

Fleck, A.T., K.S. Lusby, and F.T. McCollum. 1987. The value of corn gluten feed as a supplement for beef cattle grazing native range. In: Okla. State Univ. Anim. Sci. Res. Rep., MP-119, p. 256.

Fleck, A.T. and K.S. Lusby. 1986. Corn gluten feed or soybean meal as winter supplements for pregnant beef cows grazing native range. In: Anim. Sci. Res. Rep., MP-118, p. 196.

Green, D.A., R.A. Stock, F.K. Goedeken, and T.J. Klopfenstein. 1987. Energy value of corn wet milling by product feeds for finishing ruminants. J. Anim. Sci. 65:1655.

Gunderson, S.L., A.A. Aguilar, D.E. Johnson, and J.D. Olson. 1988. Nutritional value of wet corn gluten feed for sheep and lactating dairy cows. J. Dairy Sci. 71:1204.

Ham, G.A., R.A. Stock, T.J. Klopfenstein, and R.P. Huffman. 1995. Determining the net energy value of wet and dry corn gluten feed in beef growing and finishing diets. J. Anim. Sci. 73:353.

Hartwig, 2000. Personal communication. Statistics Division, Kansas Department of Agriculture, Topeka.

Herold, D., M. Klemesrud, T. Klopfenstein, T. Milton, and R. Stock. 1998. Solvent-extracted germ meal, corn bran and steep liquor blends for finishing steers. In: Univ. Neb. Beef Cattle Rep., MP 69-A, p. 50.

Herold, D., R. Cooper, T. Klopfenstein, T. Milton, and R. Stock. 1999. Corn bran, solvent-extracted germ meal, and steep liquor blends for finishing yearlings. In: Univ. Neb. Beef Cattle Rep., MP 71-A, p. 29.

Hutjens, M.F. 1991. Feeding corn gluten feed and corn gluten meal alternative feeds for beef and dairy cattle. In: Pub No. C02665, Nat. Invitational Symp., St. Louis, MO., p. 4.

Hussein, H.S. and L.L. Berger. 1995. Effects of feed intake and dietary level of wet corn gluten feed on feedlot performance, digestibility of nutrients, and carcass characteristics of growing-finishing beef heifers. J. Anim. Sci. 73:3246.

Jaster, E.H., C.R. Staples, G.C. McCoy, and C.L. Davis. 1984. Evaluation of wet corn gluten feed, oatlage, sorghum-soybean silage and alfalfa haylage for dairy heifers. J. Dairy Sci. 67:1976-1982.

Kampman, K.A. and S.C. Loerch. 1989. Effects of dry corn gluten feed on feedlot cattle performance and fiber digestibility. J. Anim. Sci. 67:501-512.

Kansas Department of Agriculture. 1999. Farm Facts for Kansas. KDA, Division of Statistics, Topeka.

Krishnamoorthy, U., T.V. Muscato, C.J. Sniffen, and P.J. Van Soest. 1982. Nitrogen fractions in selected feedstuffs. J. Dairy Sci. 65:217.

Loy, D., G.H. Rouse, D. Loll, D. Strohbehn, and R. Willham. 1987. Dry corn gluten feed as a major source of energy and protein in starting diets for beef calves. In: Iowa State University Anim. Sci. Leaflet R444, p. 73.

Macleod, G.K., T.E. Droppo, D.G. Grieve, D.J. Barney, and W. Rafalowski. 1985. Feeding value of wet corn gluten feed for lactating dairy cows. Can. J. Anim. Sci. 65:125.

McCoy, R.A., R.A. Stock, T.J. Klopfenstein, D.H. Shain, and M.J. Klemesrud. 1998. Effect of energy source and escape protein on receiving and finishing performance and health of calves. J. Anim. Sci. 76:1488.

Milton, T., T. Klopfenstein, D. Jordon, R. Cooper, and R. Stock. 2000. Effect of dry, wet, or rehydrated corn bran on performance of finishing yearling steers. In: Univ. Neb. Beef Cattle Rep. MP 73, p. 61.

Montgomery, S.P., J.S. Drouillard, J.J. Sindt, T.B. Farran, H.J. LaBrune, R.D. Hunter, J.J. Higgins, T.A. Nutsch, and R.A. Stock. 2000. Alfalfa hay levels in limit-fed, high-energy growing diets for beef steers. In: Cattleman's Day, Kansas State Univ. Res. and Ext. Rep. Prog. 850, p. 29.

North Central Regional Committee 88 on Growing-Finishing Systems. 1989. Corn gluten feed in beef cattle diets. North Cen. Reg. Res. Publ. No. 319.

Park, A.F., M.J. Meyer, J.M. DeFrain, J.E. Shirely, E.C. Titgemeyer, T.T. Marston, J.F. Gleghorn, and L.E. Wankel. 2000. Effect of wet corn gluten feed on intake and performance during the periparturient period. J. Anim. Sci 78 Supplement.

Phelps, A. Variability of corn gluten should be a feeding concern. 1988. Feedstuffs 60(8):10.

Richards, C.J., R.A. Stock, T.J. Klopfenstein, and D.H. Shain. 1998. Effect of wet corn gluten feed, supplemental protein and tallow on steer finishing performance. J. Anim. Sci. 76:421.

Sindt, J.J, J.S. Drouillard, S.P. Montgomery, T.B. Farran, H.J. LaBrune, R.D. Hunter, J.J. Higgins, R.T. Ethington, R.U. Lindquist. 2000. Combinations of wet corn gluten feed and steam-flaked corn in finishing cattle diets. In: Cattlemen's Day, Kansas State Univ. Res. and Ext. Rep. Prog 850, p. 48.

Staples, C.R., C.L. Davis, G.C. McCoy, and J.H. Clark. 1984. Feeding value of wet corn gluten feed for lactating dairy cows. J. Dairy Sci. 67:1214.

Trenkle, A.H. 1987a. Use of wet corn gluten feed in no roughage diets for finishing cattle. In: Iowa State Univ. Anim. Sci. Leaflet R442, p. 61.

Trenkle, A.H. 1987b. Utilization of corn gluten feed in growing and finishing diets for cattle. In: Iowa State Univ. Anim. Sci. Leaflet R443, p. 65.

Van Baale, M.J., J.E. Shirley, M.V. Scheffel and E.C. Titgemeyer. 1999. Evaluation of wet corn gluten feed as an ingredient in diets for lactating dairy cows. In: Dairy Day, Kansas State Univ. Res. and Ext. Rep. of Prog. 842, p. 17.

Whitham, N.G., J.S. Drouillard, D.A. Blasi, E.C. Titgemeyer, C.M. Coetzer, and R.D. Hunter. 1999. Evaluating corn and corn gluten feed in growing cattle diets as a replacement for roughage. In: Cattlemen's Day, Kansas State Univ. Res. and Ext. Rep. of Prog. 831, p.Alan Stevens is the Kansas State Extension Specialist for Commercial Floriculture

Willms, C.L., D.B. Faulkner, D.F. Parrett, L.L. Berger, and P.D. George. 1992. Effect of supplementing corn stalkage diets with dried corn gluten feed or soybean meal-corn fed to gestating cows and heifers. In: Univ. Illinois Beef Rep., p. 55.

Zhu, J.S., S.R. Stokes, and M.R. Murphy. 1997. Substitution of neutral detergent fiber from forage with neutral detergent fiber from by-products in diets of lactating cows. J. Dairy Sci. 80:2901.

Authors

Dale A. Blasi
Extension Specialist
Stockers and Forages, Nutrition and Management
Animal Sciences and Industry
Kansas State University

Jim Drouillard
Professor
Feedlot Nutrition
Animal Sciences and Industry
Kansas State University

Michael J. Brouk
Extension Specialist
Dairy Science
Animal Sciences and Industry
Kansas State University

Sean P. Montgomery
Graduate Research Assistant
Ruminant Nutrition
Animal Sciences and Industry
Kansas State University

Contribution No. 01-101-E from the Kansas Agricultural Experiment Station

Kansas State University Agricultural Experiment Station and Cooperative Extension Service

MF-2488 February 2001

Kansas State University Agricultural Experiment Station
and Cooperative Extension Service

Appreciation is expressed to the following for their assistance

Kansas Corn Commission