Feeding Dairy Cows When Corn Prices are High

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Take Home Messages

- The diversion of corn away from livestock to the production of ethanol is likely to increase in the future, so corn prices at the dairy farm are likely to remain high for the foreseeable future. Corn prices are about 50% greater now compared to 8 months ago.
- Alternative grain sources high in starch are too expensive or unavailable in Florida. Hominy can partially replace corn because it contains about 75% of the starch level of corn and is priced about 30% less than corn. However the cost per unit of starch still favors corn.
- Although the ideal starch concentration in the diet of the lactating cow is between 24% and 26%, it may be reduced by replacing it with byproducts that contain highly digestible fiber such as corn gluten feed and soybean hulls. Due to their lower price, ration costs may be decreased by $0.20 per cow/day when they are fed at 10% of ration dry matter and starch concentration is reduced by 2.5% units (gluten feed) to 4% (soybean hulls) by partially replacing corn.
- Although dried distillers grain with solubles is very low in starch, it is an excellent source of protein (30.3%), fat (13%), and digestible fiber and therefore has an energy density very similar to corn. One pound of distillers can replace about 0.6 pounds of corn and 0.4 pounds of soybean meal. If corn and soybean meal are priced at $182 and $266 per ton, then the breakeven price for DDGS is $215/ton.
- Growing corn silage hybrids having higher starch contents can reduce the need of ground corn in the diet.
- Glycerol, a byproduct of making diesel fuel from animal or vegetable fat, can be fed at 5 to 10% of ration DM as a corn replacement. Concentrations of methanol in glycerol-based products that exceed 0.015% prevent glycerol from being considered a safe feed by FDA.
- Close attention must be paid to ensure that byproducts have consistent and high quality nutrients over time. Elevated phosphorus, fat, and damaged protein should be monitored for regularly in for most byproducts.

Introduction

Corn has been a staple ingredient in lactating dairy cow rations for a hundred years. That corn has been “home-grown.” The 10 Midwestern states of Iowa, Illinois, Nebraska, Minnesota, Indiana, South Dakota, Wisconsin, Ohio, Kansas, and Missouri have traditionally contributed about 80% of the total number of acres of corn grown in the U.S. Florida accounts for only 0.08% of corn acres grown. As a result, Florida dairy farms import corn as a commodity from the Midwest to feed to their dairy cows. The price of this imported corn has been fairly stable the last 25 years for Florida dairies.

In recent times, the U.S. government is trying to reduce our dependence on foreign oil by supporting efforts to produce fuel (ethanol) from renewable resources like corn or cellulose. There is widespread public support for incorporating ethanol into our fuel-burning vehicles (gasoline and diesel) because ethanol addition results in greater combustion of these fuels and is nontoxic and biodegradable in the water and the soil. In 2005, the U.S. Congress passed legislation called a renewable fuels standard (RFS) that will at least double the use of ethanol and biodiesel by the year 2012. The number of U.S. plants producing ethanol from corn equal 100; 33 new plants are under construction. This growth in ethanol production has reduced the amount of corn available for livestock feed and concurrently increased its market price. Corn marketed in Florida has risen from about $125 to $185 per ton, a 50% increase in the last few months. For a ration containing 18% corn on a dry matter basis, this increase in corn price increases the cost of the ration by about $0.31 per cow per day. In order to compensate for this increase in ration cost, the price of milk would need to rise from $15.00 to $15.50 per hundred pounds. Alternatively, partially replacing corn with other less expensive feedstuffs may be an effective strategy.

Alternate Ration Strategies

<u>Other grain sources of dietary starch</u>

Grains, like corn, are an excellent source of starch, and starch is highly fermentable by ruminal microorganisms. Ruminal bacteria multiply well and produce a lot of propionic acid when offered starch. The propionic acid produced by the bacteria is converted to glucose by the cow's liver and the glucose is used to make milk. In addition, the bacteria provide about 50 to 60% of the protein needs of the cow as they are washed out of the rumen and are digested in the abomasum and small intestine. To optimize milk production, starch should make up 24 to 26% of the dietary dry matter. Since grains are the best source of starch and corn has become so expensive, what about barley or wheat for Florida cows? Barley production is concentrated in the far north-central states and is limited in supply and too expensive to bring into the south. According to Mike Casey of Furst McNess, ground wheat (63% starch) can be purchased and delivered in Georgia, South Carolina, and North Carolina for about 75 days from May into July at a cost of about $165 per ton which would make it a better buy than corn for a limited time period. Shifting cow diets between corn and wheat needs to be done slowly. The starch in wheat is more rapidly available compared to corn so quick dietary changes can result in digestive upsets and lowered ruminal pH. Wheat flour can sometimes be bought for $10 per ton less than corn, but it is very dusty and potentially explosive so it is often avoided by mills. Some in the field have reported that it might 'paste up" in the rumen, so it is not a popular feed ingredient.

Hominy contains less starch (about 53% starch) but more protein, fiber, and fat compared to corn, however their energy density is similar (Table 1). Hominy can be brought to the farm for about $30 per ton less than currently-priced corn. Replacing all of the corn (at 18% of diet) with hominy will reduce the dietary starch concentration about 3 percentage units (~25% to 22%). (This may be an acceptable decrease but more will be said later about reducing the starch concentration in the diet.) Dietary costs would be reduced by ~$0.20 per 100 lb of dry TMR or ~$0.11 per cow per day. If no milk is lost in this shift, then profit is improved. Experiments comparing performance of cows fed ground corn versus hominy could not be located. However, many Florida dairies feed hominy successfully. Even replacing half the corn with hominy can be a reasonable strategy, possibly saving $0.05 to 0.06 per cow per day in feed costs. Because hominy is higher in fat and phosphorus than corn, care should be taken to avoid overfeeding these nutrients.

Table 1. Chemical composition (DM basis) of select feedstuffs used in Florida dairy diets[1].

Feedstuff	% starch	% sugar	% CP	% NDF	% P	NEL, Mcal/lb
Alfalfa hay	2.2	9.0	21.2	38.7	0.28	0.625
Brewers grains	5.3	2.7	29.9	48.1	0.68	0.806
Citrus pulp	3.1	25.0	6.9	23.9	0.12	0.740
Corn grain	70.6	3.3	9.5	9.8	0.32	0.946
Corn bran	36.4	7.1	11.2	43.7	0.64	0.885
Corn gluten feed	16.3	6.4	23.5	36.1	1.09	0.771
Corn silage	30.3	3.5	8.3	44.6	0.24	0.713
Cottonseed	1.2	5.0	24.2	52.8	0.715	0.917
Distillers grains	5.9	4.9	30.3	33.5	0.92	0.936
Hominy	53.4	5.5	10.5	17.9	0.59	0.937
Molasses	1.1	55.3	9.3	0.8	0.28	0.740
Oat silage	3.4	6.2	13.0	59.0	0.331	0.542
Rice bran	19.0	7.3	14.6	29.2	1.82	0.937
Rye silage	1.8	8.1	14.8	58.4	0.36	0.553
Sorghum silage	10.0	5.7	9.4	57.4	0.24	0.531
Soybean hulls	1.6	3.8	14.2	61.4	0.20	0.664
Soybean meal	2.0	13.2	51.4	13.1	0.77	0.840
Wheat grain	62.8	6.0	13.7	13.9	0.43	.884
Wheat bran	22.5	8.3	17.4	41.0	1.13	0.711
Wheat midds	25.8	8.2	18.4	37.4	1.11	0.802

[1] Average values from Dairy One (http://www.dairyone.com/Forage/FeedComp/disclaimer.asp).

Low starch feedstuffs as possible substitutes for corn

Because other grain sources rich in starch such as barley or wheat are not economically available in Florida for most of the year, other commodity feeds must be considered. Those ingredients that are priced less than corn may be successfully used to partially replace corn. As shown in Table 1, all of the commonly fed feedstuffs contain quite a bit less starch than corn. The best starch sources after corn include corn silage at 30%, wheat midds at 26%, wheat bran at 23%, rice bran at 19%, and corn gluten feed at 16% (DM basis). Everything else is less than 10% starch. Replacing some of the corn with these feeds will reduce dietary starch to less than 25%. How far can dietary starch be reduced without significantly affecting milk production? Experiments examining the replacement of corn with these feedstuffs will be helpful in answering this question.

Wheat midds. Wheat midds contain 26% starch (Table 1) and 18% protein. They are priced about $30 to $35 per ton lower than corn if the midds are contracted at the right time of the year (August to September). Wheat midds have not been evaluated as a substitute for corn in many experiments. In a recent study, wheat midds were fed at about 7.5% of the diet by replacing some of the corn and soybean meal (Knowlton et al., 2001). Corn in the diet dropped from 34.1 to 28.9%. Cows fed wheat midds tended to eat less feed dry matter (45.7 vs. 50.7 lb/day) but milk production (72.4 vs. 77.3 lb/day) and milk composition were not affected. This reduced feed intake may have been because wheat midds have a high water-holding capacity, thus increasing gut fill with fiber. Cows fed wheat midds appeared to have looser manure than those fed more corn and soybean meal. In a second study, wheat midds were fed at 0 or 22.4% of the diet, replacing 35% of the ground corn and 30% of the soybean meal (Bernard and McNeill, 1991). Intake of feed dry matter (46.8 lb/day average), production of milk (61.3 lb/day), and milk composition were not different between the two groups of cows which averaged 150 days in milk at the start of the study. However the digestibility of dry matter and neutral detergent fiber were lower by cows fed wheat midds. Therefore wheat midds do not appear to be an effective feed replacement for ground corn except for lower producing cows.

Corn gluten feed. Corn gluten feed (**CGF**) is a byproduct of the manufacture of corn sweeteners, corn starch, corn syrup, and corn oil using the wet milling process. The corn starch is used to make ethanol. The CGF consists of the corn bran and a steep liquor (fermented nutrients extracted from water used to soak corn grain) mixed in approximately a 2:1 ratio. It is marketed in the wet or dry form but Florida dairies see it as a dry commodity. It contains 16% starch, 36.1% NDF, and 23.5% protein, the protein being highly degradable in the rumen (Table 1). It is priced about $40 per ton less than corn. Table 2 lists those studies in which CGF was asked to serve as a concentrate, in that it replaced only the corn and soybean meal in the diets of lactating dairy cows. Table 3 lists those studies in which CGF was asked to serve as both a concentrate and a fiber source, in that it replaced both concentrate and traditional forages. The CGF was generally included between 10 and 45% of the diet although some studies went higher. When CGF was fed at about 20% of ration DM, milk production was decreased statistically in 1 study (Staples et al., 1984), increased in 1 study (VanBaale et al., 2001), and unchanged in 9 other studies. Cows in these studies were milking between 50 and 90 pounds per day. Increasing the CGF to 30, 40 or even 57% of the diet did not reduce milk in any study with the exception of Staples et al. (1984). In two studies, in which CGF was fed between 38 and 40% of the diet replacing both forage and concentrate starting at calving, average milk yield was increased significantly by feeding the corn gluten feed (Boddugari et al., 2001; Kononoff et al., 2006; Table 3).

Because CGF contains less starch than corn, adding CGF reduces dietary starch. Very few studies report the starch values for their experimental rations so I calculated a dietary starch value for all of the diets listed in Tables 2 and 3 using “book values” and plotted dietary starch against milk production in Figure 1. Each box represents one diet. Boxes connected by a line represent diets fed in the same study. Those data points to the right of the “26% starch” line were diets that contained more than the targeted 24 to 26% starch concentration. To the left of that same “26% starch” line, are the boxes that represent diets that were below the target. As more CGF replaced more corn, the dietary starch concentrations dropped, going as low as 15% in some cases. In spite of lowered starch intake, milk yield did not drop significantly. The bulk of these studies indicate that dietary starch could be reduced by replacing some corn and protein meals with the digestible fiber found in CGF.

Table 2. Dry matter intake and milk yield of dairy cows fed wet (WCGF) or dry corn gluten feed (DCGF) in partial replacement of grains and protein meals.

Reference	Dietary Treatments				Comment
Staples et al., 1984 (IL)	0% WCGF	20% WCGF	30% WCGF	40% WCGF	CGF replaced up to 82% of corn/SBM in a corn silage-based TMR; (just past peak milk)
DM intake, lb/day	52.9 [a]	51.4 [b]	48.9 [c]	47.4 [d]	
Milk, lb/day	67.2 [a]	65.9 [b]	61.9 [c]	61.9 [d]	
MacLeod et al., 1985 (Canada)	0% WCGF	20% WCGF	40% WCGF		
DM intake, lb/day	44.3	41.7	40.1		
Milk, lb/day	72.3	66.6	64.6		
Armentano and Dentine, 1988 (WI)	0% WCGF	11.1% WCGF	22.6% WCGF	33.6% WCGF	CGF replaced up to 77% of corn/SBM in a corn-alfalfa silage-based TMR; older cows; (71 DIM)
DM intake, lb/day	49.6	48.9	48.9	50.0	
Milk, lb/day	67.2	67.9	68.8	67.9	
Gunderson et al., 1988 (CO)	0% WCGF	10% WCGF	20% WCGF	30% WCGF	CGF replaced up to 68% of hominy /SBM in a corn silage-alfalfa-oat hay-based TMR; (190 DIM)
DM intake, lb/day	47.2	47.2	46.3	46.3	
Milk, lb/day	50.5	50.7	50.9	51.1	
Fellner and Belyea, 1991 (MO)		21% DCGF	38% DCGF	57% DCGF	CGF replaced up to 100% of corn, wheat, & SBM in a corn silage-alfalfa hay-based TMR (103 DIM)
DM intake, lb/day		54.9	49.8	54.5	
Milk, lb/day		59.3	58.9	58.9	
Boddugari et al., 2001 (NE) [1]	0% WCGF	21.9% WCGF	33.8% WCGF	45.3% WCGF	CGF replaced up to 100% of ground corn and SBM; (64 DIM); Gain in BW was less for CGF-fed cows
DM intake, % BW	4.30 [a]	4.00 [b]	4.05 [b]	3.85 [b]	
Milk, lb/day	67.0	67.2	67.9	65.0	
Coomer et al., 1993 (GA)	4% DCGF +SBH [2]	13.8% DCGF + SBH	25.2% DCGF + SBH		CGF & SBH replaced up to 59% of ground corn and wheat in a sorghum silage-based TMR (45 DIM)
DM intake, lb/day	55.6	53.6	53.6		
Milk, lb/day	89.1	85.8	84.9		
Mowrey et al., 1999 (MO)	8.5% DCGF + SBH + WM [3]	15.5% DCGF + SBH + WM	22.5% DCGF + SBH + WM		CGF, SBH, and WM replaced up to 49% of corn and SBM in corn silage/alfalfa hay based TMR (112 DIM)
DM intake, lb/day	53.1	50.9	51.4		
Milk, lb/day	63.1	58.6	62.6		

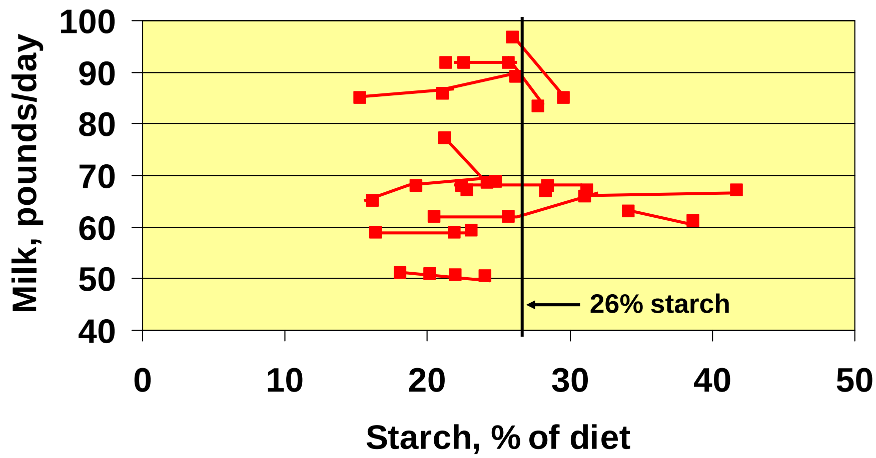
[1] Corn gluten feed mixed with corn gluten meal and additional sources of RUP.
[2] SBH = soybean hulls.
[3] WM = wheat midds.
[a,b,c,d] Values with different letters are statistically different from one another.

Table 3. Dry matter intake and milk yield of dairy cows fed wet (WCGF) or dry corn gluten feed (DCGF) in partial replacement of both forages and concentrates.

Reference	Dietary treatments				Comments
Bernard and McNeill 1991 (TN)	0% DCGF	22.4% DCGF			CGF replaced 32% of corn/SBM & 13% of corn silage (150 DIM)
DM intake, lb/day	47.0	48.5			
Milk, lb/day	61.1	63.1			
Bernard et al., 1991 (TN)	0% CGF	27.1% WCGF	27.1% DCGF		CGF replaced 32% of corn/SBM and 19% of corn silage (2 to 24 wk postpartum)
DM intake, lb/day	45.9	46.3	48.7		
Milk, lb/day	65.7	65.5	68.1		
VanBaale et al., 2001 (KS)	0% WCGF	19.2% WCGF	26.5% WCGF	33.6% WCGF	CGF replaced up to 43% of ground corn and 42% of alfalfa hay-corn silage
DM intake, % BW	4.25 [b]	4.42 [a]	4.43 [a]	4.20 [b]	
Milk, lb/day	83.3 [a]	91.7 [b]	91.7 [b]	91.7 [b]	
Boddugari et al., 2001 (NE) [1]	0% WCGF	40% WCGF			CGF replaced 51% of corn/SBM and 31% of corn silage/alfalfa silage (at calving)
DM intake, lb/day	57.8 [a]	54.9 [b]			
Milk, lb/day	85.1 [a]	96.8 [b]			
Schroeder et al., 2003 (ND)	0% WCGF	15% WCGF	30% WCGF	45% WCGF	CGF replaced up to 59% of barley/SBM/sunflower seeds/beet pulp and 34% of corn & alfalfa silage (83 DIM)
DM intake, lb/day	48.3	53.8	49.4	48.3	
Milk, lb/day	63.5	74.3	65.5	58.9	
Kononoff et al., 2006 (NE)	0% WCGF	37.9% WCGF			CGF replaced 49% of ground corn/SBM and 37% of forage (305 days of lactation)
DM intake, lb/day	46.7 [a]	56.0 [b]			
Milk, lb/day	68.6 [a]	77.2 [b]			

[1] Corn gluten feed mixed with corn gluten meal and additional sources of RUP.
[a,b] Values with different letters are statistically different.

Figure 1. Changing Milk Yield as Dietary Starch is Decreased by Feeding Corn Gluten Feed



Dropping dietary starch from 26 to 21% may be an acceptable compromise. Feeding CGF at 0%, 10%, and 20% of the diet reduced the dietary starch from 25.9 to 23.5% to 20.9% in the rations described in Table 4. As CGF increased in the diet, the proportion of extruded soy meal increased in order to keep the ruminally undegradable protein constant in the diet. In addition, the proportion of whole cottonseed had to be reduced in order to keep the dietary crude protein from exceeding 17%. The cost of these diets decreased from $4.42 to $4.22 to $4.00 per cow per day. As long as milk production remains unchanged, then increased profit should result. This is the million dollar question. The studies in Tables 2 and 3 provide some assurance that milk and feed intake will be maintained when CGF is fed at 20% of dietary DM. But feeding CGF at 10% of the diet may be a preferred approach initially to “play it safe.” Some signs to watch for that may indicate that the dietary starch has gotten too low include dropped milk production, stiffer manure, increases in milk urea nitrogen, and loss of body condition.

The drying of CGF can reduce the digestibility of the protein if the drying temperature is too high. This is determined by analyzing CGF for acid detergent insoluble protein (ADIN). Bernard et al. (1991) reported that dried CGF had higher concentrations of ADIN than wet CGF. In recent years, high ADIN may not be as big of a problem in CGF based upon analyses reported by Dairy One. The ADIN values were less than 5% of the nitrogen in the majority of samples; ADIN is usually not considered a problem until it makes up 10% of the total nitrogen in the feed.

Commodities need to have some consistent level of nutrient density from delivery to delivery in order to keep the daily ration nutrients consistent for the cows. Dairy One lists on their web site the normal range and standard deviation of the nutrients of most

Table 4. Ingredient, chemical composition, and cost of sample diets formulated to contain 0, 10, or 20% corn gluten feed (CGF).

Feedstuff	0% CGF	10% CGF	20% CGF
	- - - - - - - - - - -	% of dietary DM	- - - - - - - - -
Corn silage	32.8	32.8	32.8
Sorghum silage	6.3	6.3	6.3
Bermuda hay	2.0	2.0	2.0
Alfalfa hay	5.0	5.0	5.0
Corn gluten feed	0	10	20
Corn	20.2	14.6	8.8
Soybean meal	9.4	5.6	1.5
Extruded soy	4.0	5.3	6.7
Citrus pulp	4.1	4.1	4.0
Wet brewers grains	5.5	5.5	5.5
Whole cottonseed	3.3	1.4	0
Molasses	3.7	3.7	3.7
Mineral mix	3.7	3.7	3.7
Total	100	100	100
Chemical			
Starch, % of DM	25.9	23.5	20.9
Protein, % of DM	17.0	17.0	17.0
Sugar, % of DM	7.9	7.9	7.8
NDF, % of DM	30.8	33.0	35.6
ADF, % of DM	18.3	18.9	19.5
Fat, % of DM	4.2	4.2	4.3
NEL, Mcal/lb	0.772	0.757	0.742
Phosphorus, % of DM	0.35	0.38	0.42
Intake and cost			
Intake, lb/day	53.4	53.4	53.4
Cost, $/day	4.42	4.22	4.00

[1] Prices used to calculate daily ration cost were $182/ton for corn, $134/ton for CGF, $266/ton for soybean meal, $258/ton for extruded soy,

of the feeds they have analyzed over the past 6 years. The standard deviation is a mathematical expression of how consistent a measure is. The mean and standard deviation for protein, NDF, starch, fat, and phosphorus for 7 feeds are listed in Table 5. For example, the average starch value for corn is 70.6%. The standard deviation is 5.1%. This means that two-thirds of the samples that were analyzed ranged between 65.5% and 75.7% which is 5.1% units added to or subtracted from the mean of 70.6%. This also means that one-third of the samples analyzed were outside this range. This is a fairly narrow range compared to the byproducts. The starch in CGF samples has a typical variation between 8.6% and 24.0% with a mean of 16.3%. This large variation is likely due to the fact that the production of CGF is not standardized from corn mill to corn mill. Likewise, starch in hominy typically ranges between 42.9% and 63.9% with a mean of 53.4%. By feeding these byproducts in smaller amounts, the potential negative effect of nutrient variation on cow performance is reduced. When contracting for these commodities, an acceptable range in variation between loads should be agreed upon ahead of time. Loads delivered outside this agreed-upon-range would be refused.

Table 5. Average value and standard deviation of select nutrients in feeds submitted for chemical analyses to Dairy One Forage Lab (Ithaca, NY) between 2000 and 2006.

Feed	Crude protein	NDF	Starch	Fat	Phosphorus
Corn silage	8.3 ± 1.03	44.6 ± 6.1	30.3 ± 7.6	3.3 ± 0.5	0.24 ± 0.04
Corn	9.5 ± 1.6	9.8 ± 3.2	70.6 ± 5.1	4.4 ± 1.3	0.32 ± 0.10
Corn gluten feed	23.5 ± 7.0	36.1 ± 6.8	16.3 ± 7.7	3.9 ± 1.8	1.09 ± 0.26
Distillers grains	30.3 ± 3.6	33.4 ± 4.9	5.9 ± 3.4	13.0 ± 2.9	0.92 ± 0.14
Hominy	10.5 ± 1.9	17.9 ± 5.7	53.4 ± 10.5	7.2 ± 2.6	0.59 ± 0.22
Soybean hulls	14.2 ± 6.8	61.4 ± 9.8	1.6 ± 1.2	3.1 ± 2.7	0.20 ± 0.25
Soybean meal	51.4 ± 4.6	13.1 ± 5.2	2.0 ± 1.2	3.6 ± 3.7	0.77 ± 0.12

Dried Distillers Grains Plus Solubles (DDGS). Dry corn put through the dry-milling process will produce ethanol, carbon dioxide, and DDGS. Each 56-pound bushel of corn processed through the dry milling process results in 2.85 gallons of ethanol, 18 pounds of carbon dioxide, and 18 pounds of DDGS. Plants using the dry milling process are less expensive to build than the plants using the wet milling process, thus about 75% of the ethanol produced from corn comes from the dry milling process. The production of DDGS increased tenfold between the years 1980 and 2000, increasing from 320,000 to 3.5 million metric tons (1 metric ton = 2205 pounds). It doubled between 2000 and 2004 to over 7.3 million metric tons (Kaiser and Shaver, 2007). Every dairy cow in the U.S. would need to consume 7.3 pounds per day of DDGS over a 305-day lactation in order to use up this supply, but of course DDGS is also fed to other livestock and is exported. China will backhaul products like DDGS in ships as they bring their exports to the U.S.

During the production of ethanol from corn, a syrup product and a cake product are produced. The plant adds them together in different proportions to form DDGS. Depending on the plant, the DDGS may be a mixture of syrup to cake ranging in proportion from 35:65 to 55:45. Because of the variation in the ratio of syrup to cake used by different plants to form DDGS, the nutrient concentration of the DDGS will vary from one plant to another. However the variation looks to be less than that of CGF

(Table 5). The mean and standard deviations of the major nutrients in DDGS are given in Table 5. Although DDGS is very low in starch, it is an excellent source of protein (30.3%) and fat (13%) and therefore has an energy density very similar to corn. In addition, the ethanol-making process increases the digestibility of the fiber. Unlike CGF, DDGS is a very good source of ruminally undegradable protein (RUP) but if the temperature of the drying process is too high, the protein can be rendered indigestible. Purchasers of DDGS should analyze DDGS for ADIN regularly.

Kalscheur et al. (2005) reviewed 24 experiments in which 98 comparisons were made between cows fed diets containing DDGS and those not fed DDGS. Table 6 shows the performance of the cows broken down by the proportion of DDGS in the ration. Cows fed DDGS at up to 30% of the ration produced as much milk as those not fed any DDGS (about 73 lb/day). In spite of decreasing starch content, milk production was maintained. In a study conducted at the University of Florida, whiskey DDGS were fed at 0% or 20% of a 55% concentrate:45% forage diet. The forage was all corn silage in one set of diet and 50% corn silage:50% rhizome peanut silage in another set of diets. The DDGS replaced around 40% of the corn and soybean meal. Milk production was increased from 59.0 to 60.7 pounds per day without changing milk fat test. The effect of DDGS was the same regardless of whether the forage was totally corn silage or an equal mixture of corn silage and rhizome peanut silage. However, a maximum feeding level of DDGS might be 15% in order to prevent the overfeeding of protein, RUP, unsaturated fat, and phosphorus. Increased corn oil in the DDGS can also be a problem by decreasing milk fat so fat content of DDGS should be monitored regularly. Feeding DDGS at 20% of the diet will increase the fat in the diet by 2.6%. This will likely be a concern if the diet also contains other supplemental fats. Dietary fat should be kept below 6%. The feeding of one pound of DDGS can replace about 0.6 pounds of corn and 0.4 pounds of soybean meal. If corn and soybean meal are priced at $182 and $265 per ton, then the breakeven price for DDGS is $215/ton. Current market price for DDGS in Florida is around $160/ton.

Table 6. Dry matter (DM) intake, milk yield, milk fat, and milk protein concentration of dairy cows fed diets containing wet or dried corn distillers grains with solubles (DGS).[1]

% DGS in ration	DM Intake	Milk	Fat	Protein
	(lb/day)		(%)	
0	48.7[b]	72.8[ab]	3.39	2.95[a]
4 – 10	52.2[a]	73.6[a]	3.43	2.96[a]
10 – 20	51.6[ab]	73.2[ab]	3.41	2.94[a]
20 – 30	50.3[ab]	73.9[a]	3.33	2.97[a]
> 30	46.1[c]	71.0[b]	3.47	2.82[b]
Standard error	1.8	3.1	0.08	0.06

[a,b,c] Values within a column followed by a different superscript differ ($P < 0.05$).
[1]Adapted from Kalscheur (2005) as reported by Schingoethe (2007).

*Soybean Hulls (**SBH**).* During the processing of soybeans for oil and meal, the hulls are separated, ground, and sold as soybean hulls. They consist largely of the outer covering of the soybean so they are high in fiber (~61% NDF) and contain moderate amounts of protein (~14%) but very little starch (Table 1). The protein concentration will depend upon how well the hulls are cleaned. Positive characteristics include a high content of lysine (0.72%), a low content of phosphorus (0.2%), and a highly digestible fiber (~90% if left in a ruminal environment for 96 hours). Its fat content can vary widely. The availability of SBH is likely to increase in coming years as more acres are planted to soybeans in order to use soybean oil for biodiesel production.

In 13 separate experiments published between 1976 and 2002, SBH (fed at up to 20% of the dietary DM) successfully replaced ground corn or high moisture corn in rations for lactating cows (Ipharraguerre and Clark, 2003). In most of these studies, the dietary starch levels were probably greater than what is recommended today, based upon the proportion of corn in the diets fed in these studies (between 34 and 48% corn). Therefore the replacement of corn with SBH still left enough starch to support adequate intake and milk production. One study (Stone, 1996) did feed a more conservative amount of corn in their control diet that deserves further attention here. The control diet was 23% high moisture corn, 26% corn silage, and 26% alfalfa silage. Adding SBH to the diet at 14% of the dietary DM reduced the corn to 9% of the diet. This dropped the starch from roughly about 25% to 15%, based upon my calculations because Stone (1996) did not provide starch values. The diets were fed starting at 8 days fresh. Lactating cows ate more feed DM when offered the ration containing SBH (49.8 vs. 45.6 lb/day) but milk production was not changed (92.4 versus 89.7 lb/day). Lactating heifers fed SBH ate the same amount of feed (37.7 versus 36.6 lb/day) and produced the same amount of milk (69.4 versus 69.4 lb/day) as those not fed SBH. Concentrations of milk fat (3.6%) and protein (2.9%) were unchanged. Replacing 60% of the corn with SBH, so that SBH made up 14% of the ration, was effective to support high milk production in early lactation. With loose SBH priced at $125 per ton, a savings of $0.30 per cow/day was achieved.

Even though dietary NDF increases in the diet when SBH replace corn, feed intake has not been decreased. This is in contrast with the well-documented fact that as traditional forage replaces concentrate in the diet, concentration of dietary NDF increases and feed intake decreases. However the NDF in nonforage fiber byproducts like SBH do not have the same physical characteristics as the NDF in traditional, properly chopped forage. The fiber in SBH is highly digestible and it is very short and has a specific gravity that allows it to move out of the rumen quickly (Ipharraguerre and Clark, 2003) so that SBH fiber does not pack the rumen like forage fiber would if fed at similar NDF concentrations. In order to use SBH most efficiently, the diet should contain sufficient "effective" fiber from traditional forages.

Corn Silage. Corn silage hybrids differ in the proportion of grain making up the crop at harvest. Selecting to plant corn silage hybrids that contain more starch will reduce the amount of ground corn you need to purchase. In a test of 55 corn silage hybrids grown in Gainesville in 2006, starch concentration ranged from 22% to 35% of silage dry matter, with an average of 29.3%. (You can see the results of the corn hybrid tests at http://dairy.ifas.ufl.edu). Selecting a corn silage hybrid that is a good source of starch and digestible fiber, while at the same time yields good tonnage, could be a good choice if one is trying to reduce corn costs in the ration. For example, Vigoro V58YR2 has had very good starch and digestible fiber contents in hybrid tests in 2005 and 2006 although yields have been average. How much could be saved? If a corn silage hybrid had 33% starch instead of 30%, and if the corn silage was fed at 33% of the ration dry matter, the ground corn could be reduced in the diet from 18% to 16.5%, which is about 1 lb/day less ground corn. The cost savings would depend upon the price of the commodity(s) used to replace the pound of corn. For instance, if citrus pulp priced at $100 per ton replaced the pound of ground corn at $180 per ton, the cost savings would be $0.04 per cow per day.

Corn silage contains much more starch than the other forages we feed in Florida. Feeding more corn silage in the ration and less sorghum silage, cottonseed hulls, or bermudagrass will increase the starch in the diet and allow for less ground corn to be fed. If corn silage inventory allows, increasing the corn silage from 33 to 38% of the diet DM by replacing another forage like sorghum silage, will allow ground corn to be reduced by 1.5 percentage units, resulting in a cost savings of about $0.08 per cow/day.

Glycerol. Glycerol is a byproduct made as plant and animal fats are processed to make diesel fuels. This diesel fuel produced from fat burns cleaner, as there is no soot or particulate matter produced. Starting with animal fat to make diesel fuel is more profitable than starting with vegetable oil because animal fats are cheaper. However, diesel made from animal fat may not work as well in colder climates because it "clouds up." This process is expanding worldwide and therefore the supply of glycerol in the future is likely to increase. Ten pounds of glycerol result from every 100 pounds of biodiesel produced.

The purity of this byproduct can vary widely. The more impure the product, the more water, methanol, phosphorus, and potassium it contains. A product with these contaminants is labeled glycerin. The glycerin fed in a German study contained 2.2% potassium and up to 2.4% phosphorus. Methanol is present due to its use in the manufacture of biodiesel. Although the ruminal bacteria can detoxify methanol, it can be problematic if it is a large contaminant of glycerol. According to the FDA, glycerin is considered a substance that is GRAS (Generally Recognized as Safe) for general purpose use in animal feed, unless methanol is present at concentrations exceeding 150 ppm (0.015%). The energy content of glycerol is similar to corn (~0.90 Mcal/lb of DM) when fed in high starch diets. Dietary glycerol would be converted mainly to propionate and butyrate by ruminal bacteria. As a feed ingredient, it could substitute for corn or molasses. Prices vary from about $100/ton in Florida to $160/ton in Georgia.

Little research has been done regarding the feeding of glycerol to dairy cows. South Dakota State University reported that lactating dairy cows (average of 192 days in milk) fed glycerol (1.3% methanol) at either 0%, 2.7%, or 5.3% of dietary dry matter ate the same amount of feed (41.1 lb of feed DM) and produced the same amount of milk (65 lb/day) (Linke et al., 2006). Milk composition was unchanged with the exception that milk urea nitrogen concentrations were lower in cows fed glycerol. Efficiency of fat-corrected milk production was improved from 1.46 to 1.59 and 1.60 lb of FCM yield per lb of feed dry matter intake. Interesting, animals of other species consumed more water when they were fed glycerol. This may have a benefit to dairy cows managed under heat stress conditions. German researchers fed glycerol up to 10% of ration DM successfully. If 25% of the corn could be replaced with glycerol, a savings of $0.11 per cow per day could be realized with glycerol at $100/ton. Glycerol appears to be a good pelleting agent when added at 5%.

Future new byproducts from new technologies to improve ethanol production. As the ethanol manufacturing industry works at improving the efficiency of conversion of corn to ethanol, different byproducts will become available. Applegate et al. (2006) lists the following potential corn byproducts. 1) Called the "quick germ quick fiber method," an enzyme is added to the water used to soak the ground corn, causing the germ and fiber to float before the fermentation process begins. The product from this process contains 28% protein, 5% fat, and 25% NDF. 2) Collecting the pericarp fiber and germ prior to fermentation by modifying the dry grinding process (drum degerminator) results in a product that is 24% protein, 8-9% fat, and 28% NDF. 3) Removing the fiber by sieving and air aspiration (elusieve process) results in a product that is 40+% protein, 15% fat, and 20% NDF. 4) Modifying the yeasts used to ferment the sugar to ethanol could allow for an increased concentration of lysine in DDGS, thus giving DDGS a more favorable amino acid profile. As each mill adopts what they consider the best ethanol-producing technology, the feeding industry will be faced with a variety of byproducts on the market which will need to be properly identified prior to purchase.

Summary

With the increased price being paid to corn growers due to the increased demand for ethanol, farmers will be planting more of their acres to corn. This will reduce the number of acres committed to other crops, such as cottonseed. This shift will likely have a large impact on the market price of a number of feed commodities. The availability and price of each commodity will need to be followed closely and attention paid for timely contracting. There are some acceptable alternative feeds that would allow some reduction of corn grain in the diet of lactating dairy cows.

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Notes