# Chapter 17

# Use of DDGS in Dairy Cattle Diets

## Introduction

Wet and dry distiller's grains are excellent feed ingredients for use in lactating dairy cow rations. Of all U.S. livestock and poultry industries, dairy and beef cattle continue to be the largest consumers of distiller's co-products. Distiller's grains are high in energy, readily fermentable fiber, and protein for lactating dairy cows as well as calves and replacement heifers. Refer to Chapter 4 "**Nutrient Composition and Digestibility of DDGS: Variability and *In Vitro* Measurement"** for a detailed description of DDGS nutrient values to use in dairy ration formulation. An excellent literature review on the use of distiller's products in dairy cattle diets was published by Schingoethe et al. (2009), and is excellent supplemental reading for this chapter of the Handbook.

## Nutritional Value of DDGS for Dairy Cattle

Schingoethe et al. (2009) summarized various studies involving the feeding value of distiller's grains with solubles for dairy cattle. Distiller grains with solubles are a good source of crude protein source (>30% CP on a dry matter basis) which is high in ruminally undegradable protein (~55% of crude protein). Distiller's grains with soluble are also an excellent source of energy (net energy for lactation is approximately 2.25 Mcal/kg of dry matter). The intermediate fat concentration (10% on a dry matter basis) and readily digestible fiber (~39% neutral detergent fiber) contribute to the high energy content in DDGS. Lactation performance is usually similar when cows are fed wet or dried distillers grains with solubles, but some research results show a slight advantage for feeding wet distillers grains with solubles. Distiller's grains can be used as a partial replacement for both concentrates and forages, but generally DDGS is used as a concentrate replacement.

Adequate effective fiber is needed to avoid milk fat depression when DDGS is used to replace forages in lactating cow diets. Lactating dairy cow diets can contain 20% or more DDGS on a dry matter basis as long as diets are nutritionally balanced. Feeding DDGS diets containing up to 30% DDGS provide similar or increased milk production compared with when cows are fed traditional feeds. Although DGS can be added at levels in excess of 30% of the diet on a dry matter basis, gut fill may limit dry matter intake and production in diets if more than 20% wet distiller's grains are added. The fiber in DDGS, is usually considered to be a replacement for high-starch feed ingredient such as corn, and as a result, minimizes problems with acidosis but does not necessarily eliminate it.

# DDGS in Lactating Dairy Cow Rations

In order to understand the effects of feeding level and moisture content (wet vs. dry) of distiller's grains on dry matter intake, milk production, and milk composition, Kalscheur (2005) conducted a meta-analysis of data from 23 previous experiments and 96 treatment comparisons that involved feeding distiller's grains to lactating dairy cows. These studies were published between 1982 and 2005. Although the quality and nutrient composition of distiller's grains may have improved over this time period, all studies were included in the analysis to determine the overall effect of feeding distiller's grains to dairy cows. To evaluate the level of dietary inclusion of distiller's grains on lactation performance, treatments were divided into 5 categories of feeding levels: 0%, 4 to 10%, 10 to 20%, 20 to 30%, and greater than 30% on a dry matter basis. The form of the distiller's grains (wet or dried), was also used to separate responses in the analysis.

## Effect of feeding distiller's grains on dry matter intake

Dry matter intake (DMI) was affected by both dietary inclusion level and form of the distiller's grains fed (**Table 1**). Intake was increased by the addition of distiller's grains in dairy cow diets. For cows fed DDGS, intake increased as the dietary DDGS inclusion level increased, and was greatest for cows fed between 20 and 30% DDGS. These cows consumed 0.7 kg more feed (DM basis) than cows fed the control diets containing no DDGS. Cows fed greater than 30% DDGS consumed about the same amount of feed as cows fed control diets.

While DMI was increased for cows fed diets containing up to the 20 to 30% DDGS, DMI of cows fed WDGS diets was greatest at lower inclusion levels (4 to 10% and the 10 to 20% levels). When WDGS was included at concentrations greater than 20%, DMI decreased. In addition, cows fed over 30% WDGS ate 2.3 kg/d less DMI than the control group, and 5.1 kg/d less than those fed the 4 to 10% levels.

In general, distiller's grains are considered to be highly palatable, and research supports this because DMI is stimulated when distiller's grains are included up to 20% of the DM in dairy cow diets. Decreases in feed intake at higher inclusion levels may be caused by high dietary fat concentrations, or in the case of WDGS, high dietary moisture concentrations.

## Effect of feeding distiller's grains on milk production

Milk production was not impacted by the form of distiller's grains fed, but there was a curvilinear response to increasing distiller's grains in dairy cow diets (**Table 1**). Cows fed diets containing 4 to 30% distiller's grains produced the same amount of milk, approximately 0.4 kg/d more, than cows fed diets containing no distiller's grains. When cows were fed the highest dietary inclusion rate (>30%) of distiller's grains, milk yield tended to decrease. These cows produced 0.8 kg/d less milk than cows fed no distiller's grains. Cows fed more than 20% WDGS had decreased milk production, which was most likely related to decreased DMI.

**Table 1. Dry matter intake and milk yield of dairy cows fed increasing levels of distiller's grains as either dried or wet.**

| Inclusion level | DMI, kg/d | | | Milk, kg/d | | |
|---|---|---|---|---|---|---|
| (DM basis) | Dried | Wet | All | Dried | Wet | All |
| 0% | 23.5[c] | 20.9[b] | 22.2[b] | 33.2 | 31.4 | 33.0 |
| 4 – 10% | 23.6[bc] | 23.7[a] | 23.7[a] | 33.5 | 34.0 | 33.4 |
| 10 – 20% | 23.9[ab] | 22.9[ab] | 23.4[ab] | 33.3 | 34.1 | 33.2 |
| 20 – 30% | 24.2[a] | 21.3[ab] | 22.8[ab] | 33.6 | 31.6 | 33.5 |
| > 30% | 23.3[bc] | 18.6[c] | 20.9[c] | 32.2 | 31.6 | 32.2 |
| SEM | 0.8 | 1.3 | 0.8 | 1.5 | 2.6 | 1.4 |

[a,b,c] Values within a column followed by a different superscript letter differ ($P < 0.05$).
No superscript within a column indicates that there was no significant difference between distiller's grains dietary inclusion level.

## Effect of feeding distiller's grains on milk composition

Milk fat percentage varied among dietary distiller's grains inclusion levels but was not significantly affected by dietary level or form (**Table 2**). Milk composition responses observed in this extensive dataset do not support the theory that feeding distiller's grains results in milk fat depression. Many factors can affect milk fat depression. First, when formulating lactating dairy cow diets, it is important to include sufficient fiber from forages in order to maintain adequate rumen function. Distiller's grains are comprised of 28-44% neutral detergent fiber, but this fiber is finely processed and rapidly digested in the rumen. As a result, fiber from distiller's grains is not considered ruminally effective fiber and should not be considered equal to forage fiber. Second, high levels of fat provided from distiller's grain may also impact rumen function leading to milk fat depression, but it is often a combination of dietary factors which lead to significant reduction in milk fat percentage.

Milk protein percentage was not different among cows fed diets containing 0 to 30% distiller's grains, and the form of the distiller's grains did not alter milk protein composition (**Table 2**). However, milk protein percentage decreased 0.13 percentage units when distiller's grains was included at concentrations greater than 30% of the diet compared to cows fed control diets. At the higher dietary inclusion levels, distiller's grains most likely replaced all other sources of protein in the diet. At these high levels of dietary inclusion, lower intestinal protein digestibility, lower lysine concentrations, and an unbalanced amino acid profile may all contribute to a lower milk protein percentage. It should be noted that the lower milk protein percentages were most evident in studies conducted in the 1980's and 1990's. Newer studies are not as consistent in showing this effect. Lysine is very heat sensitive, and can be negatively affected in DDGS by high temperatures used during the production and drying in some ethanol plants. Improved processing and drying procedures in fuel-ethanol plants built in recent years, have improved amino acid digestibility of DDGS.

**Table 2. Milk fat and protein percentage from dairy cows fed increasing levels of distiller's grains.**

| Inclusion level (DM basis) | Fat, % | Protein, % |
|---|---|---|
| 0% | 3.39 | 2.95[a] |
| 4 – 10% | 3.43 | 2.96[a] |
| 10.1 – 20% | 3.41 | 2.94[a] |
| 20.1 – 30% | 3.33 | 2.97[a] |
| > 30% | 3.47 | 2.82[b] |
| SEM | 0.08 | 0.07 |

[a,b] Values within a column followed by a different superscript letter differ ($P < 0.05$).
No superscript within a column indicates that there was no significant difference between distiller's grains dietary inclusion level.

# Other Factors to Consider when Formulating DDGS Diets for Lactating Dairy Cows

Dietary inclusion level of distiller's grains is not the only factor to be considered when formulating lactating dairy cow diets. Several other dietary factors that affect milk production and milk composition when distiller's grains are added to the diet should be considered. These include: wet vs. dry distiller's grains with soluble, type of forage, ratio of forage to concentrate, high oil content of distiller's grains, and formulating diets on an amino acid basis. The impact of these dietary factors on milk production and milk composition was evaluated using the same 23 published reports as described previously. There were 96 treatment comparisons included in this database.

## Type of forage

To evaluate whether type of forage had an impact on cow performance, each diet was identified by the ratio of corn silage to alfalfa. Twenty-three diets contained 100% corn silage, 38 diets contained 55 to 75% corn silage, 19 diets contained 45 to 54% corn silage, and 16 diets contained only alfalfa silage or hay (0% corn silage) as the forage source. In general, a combination of forages is preferred over using single forage sources in order to balance nutrient requirements and provide effective fiber for normal rumen fermentation. However, the type of forages included in dairy cow diets is mostly dictated by local supply. In some areas, alfalfa can be grown effectively, and therefore, it may be the predominant forage included in dairy cow diets, whereas in other regions of the U.S., corn silage is the predominant source.

Results from this review showed that forage type had no impact on dry matter intake, milk production, or milk fat composition. However, forage type did affect milk protein composition.

Cows fed diets containing 55 to 75% corn silage produced milk with the highest concentration of protein (3.04%). Cows fed diets containing 100% alfalfa/grass forage with 0% corn silage resulted in the lowest concentration of milk protein (2.72%). Cows fed 45 to 54% corn silage and 100% corn silage produced milk with intermediate levels of protein (2.98% and 2.82%, respectively). Cows fed diets with a blend of corn silage and alfalfa produced milk with greater milk protein percentage suggesting that diets formulated with one forage source are more likely to be insufficient in amino acids needed to maximize milk protein percentage.

## Forage:concentrate ratio

Forage to concentrate ratio is another dietary factor that may affect lactation performance of the dairy cow when distiller's grains are included in the diet. To evaluate the effect of forage to concentration ratio, treatments were classified into one of three categories: diets containing <50% forage, diets containing 50% forage and 50% concentrate, and diets containing >50% forage. Dry matter intake, milk production, and milk protein percentage were not affected by the forage to concentrate ratio. However, the percentage of milk fat was reduced by 0.36 percentage points in diets containing <50% forage. These results support the hypothesis that lack of adequate forage in the diet, which is likely due to insufficient effective fiber, is a major contributing factor for causing reduced milk fat percentage, and does not simply result from the inclusion of distiller's grains in the diet. Upon initial consideration, neutral detergent fiber (NDF) levels appear adequate because of the fiber provided by distiller's grains. However, this fiber has a small particle size and does not provide effective fiber needed for normal rumen function. Results from a recent experiment conducted at South Dakota State University tested this hypothesis directly (Cyriac et al., 2005). As forage level decreased in the diet from 55 to 34%, milk fat percentage decreased linearly from 3.34 to 2.85%, even though the concentration of NDF remained similar across diets. Therefore, when formulating diets containing high levels of distiller's grains, it is important to be certain that they contain adequate levels of effective fiber from forage. The remaining fiber from distiller's grains will be quickly digested and used to produce VFA's in the rumen.

## High oil content of distiller's grains

The relatively high oil content of distiller's grains is a potential concern when it is included in dairy cow diets. Corn oil in distiller's grains is relatively high in linoleic acid (~60%), which is a long-chain, unsaturated fatty acid. High levels of vegetable oil can potentially cause incomplete biohydrogentation in the rumen resulting in milk fat depression. Results from this review of previously published studies did not reveal a strong relationship between dietary feeding level of distiller's grains and milk fat depression. However, it is possible that there could be interactions between the concentration of oil and the lack of effective fiber in distiller's grains which could result in milk fat depression.

## Formulating diets on an amino acid basis

This literature review also evaluated the effect of formulating dairy cow diets on an amino acid basis vs. a crude protein basis. Data used in this analysis included experiments where rumen-protected lysine and methionine, or a high protein feedstuff (e.g. blood meal) providing a significant source of lysine was added to the diets. Lysine may be deficient in dairy cow diets where corn feedstuffs are the predominant ingredients. Results from this analysis suggest that milk protein percentage tended to increase when diets included a source of supplemental lysine. However, additional research is needed to determine if supplemental lysine would allow for additional amounts of distiller's grains to be included in dairy cow diets.

## Performance results from recent studies

Kleinschmit et al. (2006) conducted a study to evaluate the effects of feeding total mixed diets containing 20% DDGS from 3 different sources on milk production and composition in dairy cows. The DDGS replaced a portion of the ground corn and soybean meal in the diets and they had a forage-to-concentrate ratio of 55:45. Dry matter intake (21.4 kg/d) was similar among diets, but cows fed diets containing DDGS had greater milk yield (34.6 vs. 31.2 kg/d), 4% fat-corrected milk (32.7 vs. 29.6 kg/d), and energy-corrected milk (35.4 vs. 32.3) compared with cows fed the diet with no DDGS. Cows fed DDGS had improved feed efficiency compared with cows fed the control diet (1.78 vs. 1.63). Milk fat yield was greater in cows fed DDGS compared with those fed the control diet (1.26 vs. 1.14 kg/d), but milk protein percentages (3.28, 3.13, 3.19, and 3.17% for control, DDGS-1, DDGS-2, and DDGS-3, respectively) were higher for cows fed the control diet compared with DDGS diets, and tended to be lower for cows fed DDGS-1 than for DDGS-2 and DDGS-3. However, milk protein yields tended to be greater for cows fed DDGS than for those fed the control diet (1.09 vs. 1.02 kg/d). Results from this study suggest that the DDGS sources used in this study did not affect lactation performance.

Anderson et al. (2006) determined the effects of feeding 10% or 20% dried or wet distiller's grains with soluble in 25% corn silage, 25% alfalfa hay, and 50% of concentrate mixes to dairy cows on lactation performance. Feeding dried or wet distiller's grains with solubles improved feed efficiency and energy-corrected milk/kg of DMI by increasing yield of milk, protein, and fat while dry matter intake tended to decrease.

Kleinschmit et al. (2007) compared feeding 15% DDGS to lactating dairy cows using corn silage, alfalfa hay, or a combination of corn silage and alfalfa hay as the primary forage source in the diets. They observed that replacing corn silage with alfalfa hay in diets containing 15% DDGS increased milk yield, and tended to linearly increase milk protein yield in cows during late lactation. Furthermore, feeding alfalfa hay as the sole forage source improved feed efficiency compared with diets containing corn silage.

Janicek et al. (2008) conducted two studies to evaluate the effects of feeding 0%, 10%, 20%, and 30% DDGS where DDGS replaced a portion of the forage and concentrates in the diets. Dry matter intake increased when feeding 30% DDGS compared to 0% DDGS, but milk production, and the percentages of milk fat and protein were not different between the control and DDGS diets. Therefore, these results suggest that lactating dairy cow rations can contain as much as 30% DDGS and support satisfactory lactation performance and milk composition.

Sasikala-Appukuttan et al. (2008) compared the effectiveness of using 10% and 20% corn condensed distiller's solubles (CCDS) with 18.5% DDGS, and a combination of 18.5% DDGS and 10% CCDS, on dry matter intake, milk yield and milk composition of lactating Holstein cows. The diets were formulated to provide 17% crude protein with variation in acid detergent fiber, neutral detergent fiber, and fat concentration (2 to 4%). Their results showed that CCDS is as effective as DDGS in replacing soybean meal and corn grain in the total mixed ration.

## Feeding DDGS to Lactating Dairy Cows in Hot, Humid Sub-Tropical Climates

Most of the DDGS research involving dairy cattle has been conducted in temperate climates. To study the production responses of lactating dairy cows in hot, humid climates, the U.S. Grains Council sponsored a feeding trial on a commercial dairy farm in central Taiwan from September to November, 2003 (Chen and Shurson, 2004). The objectives of this feeding trial were to compare the feeding value of DDGS with corn, SBM, and roasted soybeans in lactating dairy cow rations and test the feasibility of DDGS in dairy rations in a hot and humid sub-tropical environment.

DDGS storage conditions during the U.S. Grains Council sponsored commercial dairy trial in Taiwain.

Lactating Holstein dairy cows used in the U.S. Grains Council sponsored DDGS dairy trial in Taiwan.

Fifty primparous Holstein cows were randomly assigned to the control and DDGS treatment groups based on their Days In Milk (DIM), pre-treatment milk production, and body condition score (BCS). The average DIM of two groups was the same (149 d). The average milk production of the control and DDGS group at grouping was 22.3 kg and 22.4 3.7 kg, respectively. The average BCS of the control and DDGS group at grouping was 3.0 kg and 3.1 kg, respectively. The feeding trial consisted of a two-week adjustment period to allow the cows to adapt to the pen, followed by an eight-week experimental period for data collection.

Cows were fed a total mixed ration (TMR) containing either 0% (control) or 10% (DDGS) DM from DDGS. DDGS partially replaced some of the soybean meal, corn, steam-flaked corn, and roasted soybeans in the TMR ration. The rations were formulated using Cornell Net Carbohydrate and Protein System (Barry, et al., 1994) to meet the requirement of metabolizable protein (MP), metabolizable energy (ME), calcium, and phosphorus.

Average daily dry matter intake (DMI) of the control and DDGS groups were 17.8 and 17.6 kg, respectively. The addition of DDGS to the ration did not influence DMI (**Table 3**), but the actual DMI was lower than the DMI prediction by Cornell Net Carbohydrate and Protein System (version 4.26; Barry, et al., 1994). This difference was likely due to the heat-stressed conditions of cows during the trial.

The average milk production of all cows in the control and DDGS groups on each Dairy Herd Improvement (DHI) day is shown in **Figure 1**. Cows in the DDGS group tended to have a higher average milk production than cows in the control group. Cows fed DDGS produced more milk than the cows in the control group. The increase in milk production of cows fed the DDGS ration was likely due to the higher feeding value of DDGS. Therefore, DDGS has an advantage of supporting higher milk production of mid-lactating cows under heat-stressed conditions. Both groups showed a significant drop in milk production in the last DHI test. The temperature-humidity index increase during this period of time and feeding poor corn silage were possible reasons for this decline.

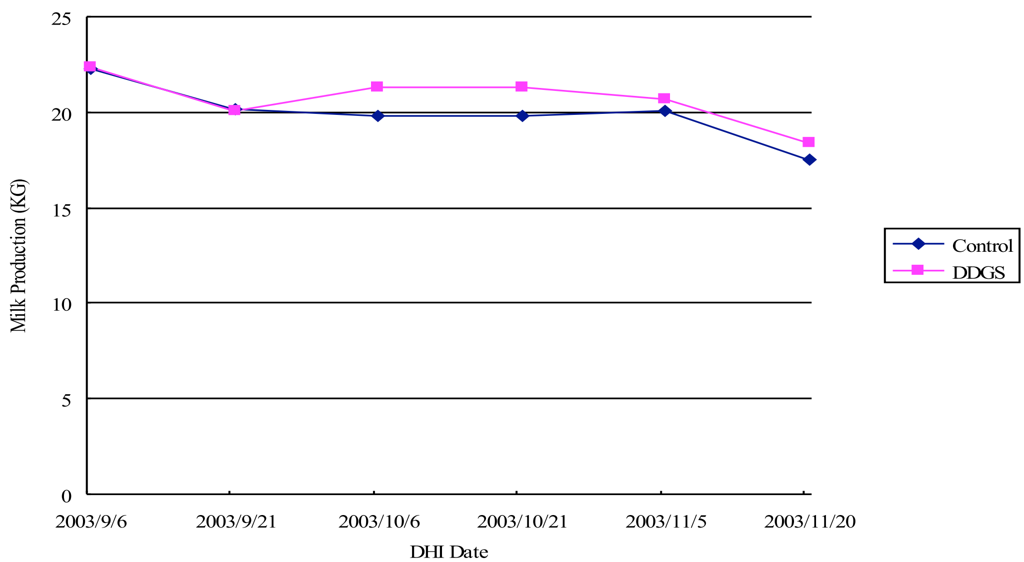


**Figure 1. Average Milk Production of Cows fed the Control and DDGS TMR.**

As shown in **Table 3**, cows fed DDGS produced significantly more milk (0.9 kg/d) than the cows in the control group. The ration containing DDGS provided more fat and energy to cows in the DDGS group, which likely explains the higher level of milk production. Although milk fat percentage was not different between dietary treatments, cows fed DDGS tended to produce more milk fat per day than cows in the control group, which was likely due to the higher level of milk production of cows fed DDGS. Although the addition of 10% DDGS in the ration decreased milk protein percentage, the amount of milk protein produced per day was not affected. One of the concerns regarding the use of DDGS in lactating dairy cow rations is its high fat content, which may interfere with ruminal fermentation and may decrease microbial protein production and milk protein. However, the higher level of milk production of cows in the DDGS group compensated for the negative effects of feeding DDGS on milk protein percentage. Body condition scores of cows were not significantly different between dietary treatments.

**Table 3. Effects of Feeding TMR[1] with and without 10% DDGS on the Milk Production, Milk Composition and Body Condition Score of Mid-Lactating Cows under Heat-stressed Conditions.**

| | **Treatment (T)** | | **Pen (P)** | | **SE** | ***P- value*** | | |
|---|---|---|---|---|---|---|---|---|
| **Response variable** | **Control** | **DDGS** | **1** | **2** | | **T** | **P** | ***T×P*** |
| DMI, kg/d[2] | 17.8 | 17.6 | 17.8 | 17.6 | 0.20 | 0.32 | 0.29 | *0.012* |
| Milk, kg/d | 19.5 | 20.4 | 19.8 | 20.1 | 0.44 | 0.04 | 0.46 | *0.003* |
| Fat, % | 4.51 | 4.45 | 4.43 | 4.53 | 0.13 | 0.61 | 0.41 | *0.69* |
| Fat, kg/d | 0.86 | 0.91 | 0.87 | 0.91 | 0.03 | 0.10 | 0.22 | *0.07* |
| Protein, % | 3.45 | 3.32 | 3.41 | 3.37 | 0.04 | 0.001 | 0.17 | *0.73* |
| Protein, kg/d | 0.66 | 0.68 | 0.67 | 0.67 | 0.02 | 0.40 | 0.97 | *0.02* |
| Lactose, % | 4.85 | 4.90 | 4.92 | 4.83 | 0.03 | 0.07 | 0.004 | *0.84* |
| Total Solids, % | 13.5 | 13.4 | 13.5 | 13.4 | 0.16 | 0.36 | 0.77 | *0.63* |
| MUN, mg/dL[3] | 11.2 | 11.8 | 12.3 | 12.8 | 0.50 | 0.23 | 0.80 | *0.04* |
| SCC, $10^4$/ml[4] | 26.9 | 35.4 | 35.9 | 26.4 | 13.8 | 0.54 | 0.49 | *0.76* |
| *BCS[5]* | *2.96* | *3.01* | | | | *0.21* | | |

[1] TMR = total mixed ration
[2] DMI = dry matter intake
[3] MUN = milk urea nitrogen
[4] SCC = somatic cell count
[5] BCS = body condition score

## Feeding DDGS to Growing Dairy Heifers

Although DDGS is considered to be an excellent energy and protein source for ruminants, there is very little information on feeding DDGS to growing dairy heifers. Kalscheur and Garcia (2004) suggested that data from experiments on feeding DDGS to growing beef cattle could be extrapolated, with caution, to expected responses for growing dairy cattle. When wet or dried distiller's grains were fed to growing beef calves, there were no differences in growth rate or body protein accretion (Kalscheur and Garcia, 2004). However, when dried rolled corn was replaced with wet distiller's grains or DDGS, to provide 40% of dry matter intake, growth rate and feed conversion were improved (Kalscheur and Garcia, 2004). Growing cattle fed wet distiller's grains generally have higher feed conversion than cattle fed DDGS. At high DDGS feeding levels, variable amounts of heat-damaged protein among DDGS sources are less of a concern for growing cattle because they consume protein in excess of their requirements (Kalscheur and Garcia, 2004). Therefore, DDGS can be added to growing heifer rations at levels up to 40% of dry matter intake to achieve excellent growth rate and feed conversion.

## Conclusions

Corn DDGS is a good source of protein, fat, phosphorus, and energy for lactating dairy cows. Distiller's grains can be included in dairy cow diets up to 20% of the diet without decreasing dry matter intake, milk production, and milk fat and protein percentage. Inclusion of DDGS from 20 to 30% also supports milk production equal to or greater than diets with no DDGS. However, milk production from cows fed diets containing wet distiller's grains decreases when wet distiller's grains are included at more than 20% of the diet. Milk fat percentage varies, but was not significantly changed by the inclusion of distiller's grains in the diet. Milk protein percentage decreases at the highest dietary inclusion rates of distiller's grains. More research is needed on feeding distiller's grains from new ethanol plants to determine if improved quality corresponds to improved performance. Consequently, distiller's grains from today's ethanol plants may not affect milk protein percentage as did distiller's grains from the 1980's and 1990's. In addition, studies investigating rumen function are needed to determine the impact of distiller's grains on milk fat concentration.

Distiller's grains can replace more expensive sources of protein, energy, and minerals in dairy cow diets. However, when balancing diets containing DDGS, nutritionists must follow acceptable nutritional guidelines to prevent imbalances of nutrients. Corn DDGS can be effectively used in a total mixed ration by mid-lactating dairy cows under heat-stressed climatic conditions, and is a high quality co-product that can be used effectively in the dairy industry in sub-tropical and tropical regions of the world. Although there has been limited research to evaluate feeding DDGS to growing dairy heifers, DDGS has been added to growing beef cattle rations at levels up to 40% of dry matter intake to achieve excellent growth rate and feed conversion. There is no reason to expect that these results cannot also be achieved when feeding DDGS to growing replacement heifers.

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