

The Use of Distillers Grains Co-Products in Feedlot Diets in the U.S. and Canada

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Abstract

Continued expansion of the ethanol industry in the United States and Canada will have a direct impact in two distinct areas of beef production. First, ethanol production is an important end user of traditional feedstuffs used in beef production (corn, sorghum, wheat), and second, increased production of ethanol will result in an increase in the supply of ethanol co-products. The majority of ethanol plant expansions appear to be dry milling plants, due primarily to their relative simplicity when compared with the wet milling process. The dry milling co-product, referred to as distillers grains (DG), can be fed wet (WDGS; 35 to 50% DM) or dry (DDGS; >88% DM) with or without solubles. Based on the current process of ethanol production from corn grain, all non-starch nutrients are concentrated 300% in distillers grains compared with the original corn grain. Important nutrients to consider in feedlot diet formulation include protein, ether extract (EE), phosphorus (P) and sulfur (S). These nutrient considerations can be grouped into three main categories of interest, which include environmental (protein and P), sulfur toxicity (S) and supplemental fat (EE). Environmental concerns can be mitigated with a sound nutrient management plan. Sulfur levels in DGS should be monitored as they are likely variable and can be quite high. Corn, sorghum and wheat DGS should contain approximately 12.18, 9.09 and 7.02% fat, respectively, suggesting corn DGS will be of greater value in feedlot diets when DG are fed as an energy source compared with either sorghum or wheat DGS. Other than the type of DGS that is being fed, current information regarding feedlot performance suggests the optimum level of DGS in finishing diets is affected by inclusion level of the DG product, grain processing, roughage level, and perhaps inclusion of ionophores and antibiotics.

Résumé

L'expansion continue de l'industrie de l'éthanol aux États-Unis et au Canada influencera directement deux secteurs de l'industrie du bœuf. D'abord, la production de l'éthanol utilise d'importants volumes d'aliments pour bovins de boucherie (maïs, sorgho et blé). Ensuite, la production accrue de l'éthanol augmentera la

disponibilité des co-produits de cette industrie. Par ailleurs, la majorité des nouvelles usines d'éthanol ont recours à la mouture à sec, principalement parce que ce procédé est plus simple que la mouture humide. Le co-produit de la mouture sèche s'appelle drêche de distillerie (*distillers grains*, DG, en anglais). Elle peut être servie au bétail sous forme humide (WDGS, contenant de 35 % à 50 % de M.S.) ou sèche (DDGS, >88 % de M.S.), avec ou sans solubles de distillerie. Le procédé actuel de fabrication d'éthanol à partir de maïs concentre dans la drêche tous les nutriments non associés à l'amidon par un facteur de trois (300 %), par rapport au grain intact. Pour formuler la ration d'un parc d'engraissement, on doit tenir compte des protéines, de l'extrait à l'éther (EE), du phosphore (P) et du soufre (S). Ces considérations nutritionnelles rejoignent trois préoccupations de base : l'aspect environnemental (protéine et P), la toxicité liée au soufre (S) et les matières grasses de supplément, mesurées par l'extrait à l'éther (EE). On atténuera le risque environnemental par une saine gestion des nutriments. Il faut toutefois surveiller la teneur en soufre de la drêche, variable et parfois très élevée. La drêche de maïs, de sorgho et de blé contiendrait environ 12,12 %, 9,09 % et 7,02 % de matières grasses, respectivement, ce qui attribuerait une plus grande valeur énergétique à la drêche de maïs. D'autres facteurs influencent le niveau optimal de la drêche dans les aliments de finition et les performances d'engraissement : la transformation du grain, la proportion de drêche et de fourrage et, vraisemblablement, l'apport d'ionophores et d'antibiotiques.

Introduction

The Renewable Fuels Standard (RFS), passed by the United States Congress in 2005, requires the use of 7.5 billion gallons of biofuels by the year 2012.¹ The Ethanol Expansion Program in Canada has a national mandate to have 35% of the country's gasoline consumption to contain 10% ethanol by 2010.³¹ Currently in the United States, there are more than 120 ethanol plants in operation estimated to produce six billion gallons of ethanol, and all indications suggest that ethanol production will well exceed the 7.5 billion gallons in 2012.¹ In the prairie provinces of Canada (Alberta, Saskatchewan and Manitoba) the ethanol industry is

beginning to expand with approximately five ethanol plants in operation and an additional 15 ethanol plants in various phases of development.²⁴ Increased production of ethanol in the United States and Canada is important to the feedlot sector of beef production for two reasons: 1) increased ethanol production will be an important end-user of traditional feedstuffs (corn, sorghum, wheat), and 2) increased ethanol production will dramatically increase the supply of ethanol co-products.

The majority of ethanol plant expansions appear to be dry milling plants that produce distillers grains, distillers grains plus solubles, and distillers solubles from corn, sorghum and wheat in both a wet (WDGS; 35 to 50% DM) and dry (DDGS; >88% DM) form.^{10,11} Distillers grains plus solubles (DGS) are attractive to the feedlot sector of the beef industry as an energy source in finishing rations. However, two of the main questions often asked concerning the feeding of DGS are, "how much of the ethanol co-product can be fed to cattle" and "what are the limitations of feeding an ethanol co-product to cattle."

The objectives of this paper are 1) to review the nutritional differences in DGS produced from corn, sorghum and wheat, 2) discuss the primary ration formulation considerations when feeding DGS as a component of the finishing diet and 3) to evaluate the impact of DGS feeding on economically important feedlot performance outcomes.

DGS from Corn, Sorghum, and Wheat

The dry milling ethanol process appears to be attractive due to its relative simplicity. In dry milling, a starch source (corn, sorghum, wheat) is ground, fermented and the starch converted to ethanol and CO₂ (Figure 1). When using corn as the grain source, the net result of the dry milling process is that one-third of the dry matter (DM) remains as the co-products distillers grains and distillers solubles.¹⁰ Therefore, the remaining nutrients in the DGS are concentrated three-fold. The importance of understanding the dry milling process is that the nutrient profile of DGS produced from different starchy cereal grains can be estimated simply by multiplying the non-starch components of the source grain by a factor of three. The following discussion will compare the difference in corn, sorghum and wheat DGS.

The 1996 Beef NRC reports corn to contain 9.8% crude protein (CP), 4.06% ether extract (EE), 0.32% phosphorus (P) and 0.11% sulfur (S).³⁰ Nutrients in distillers grains plus solubles produced from dry milling corn should increase three-fold, and therefore contain approximately 29.4% CP, 12.18% EE, 0.96% P and 0.33% S. Sorghum is reported to contain 12.6% CP, 3.03% EE, 0.34% P and 0.14% S.³¹ Following dry milling, sorghum

DGS should contain approximately 37.8% CP, 9.09% EE, 1.02% P and 0.42% S. Wheat is reported to contain 14.2% CP, 2.34% EE, 0.44 P and 0.14 S.³¹ Accounting for the three-fold increase in nutrients following dry milling, wheat DGS should contain approximately 42.6% CP, 7.02% EE, 1.32% P and 0.42% S.

Theoretical calculations of nutrient profiles for different types of DGS allow for the nutrient differences in grains to become much more apparent. For example, when using DGS as an energy source in feedlot diets, the theoretical differences in EE in corn, sorghum and wheat suggest corn DGS is a better source of energy than sorghum DGS or wheat DGS, and sorghum DGS is a better source of energy than wheat DGS. Although these theoretical calculations can be helpful to evaluate relative difference in corn, sorghum and wheat DGS, the actual nutrient profile of the feedstuff is much more valuable when formulating feedlot diets.

The majority of research on DGS as an energy source in feedlot diets has occurred with corn DGS. Because corn is the primary grain used in the dry milling ethanol process, we have a much better understanding of corn DGS when compared with sorghum or wheat DGS. The average nutrient profile of corn DDGS from 3,500 samples received at Cargill laboratories during 2006 has been reported.^{19,30} Crude protein averaged 29.96%, which is very similar to the theoretical estimate of 29.4% calculated by multiplying the CP content of corn reported by the 1996 Beef NRC by a factor of three.^{19,30} Fat averaged 11.9%, which is also very similar to the theoretical estimate of 12.18% EE calculated by multiplying the EE content of corn reported by the 1996 Beef NRC by a factor of three.^{19,30} Far fewer samples detailing the nutrient profile of sorghum and wheat DGS have been reported compared with corn; however, it should be reasonable to assume the three-fold theoretic-

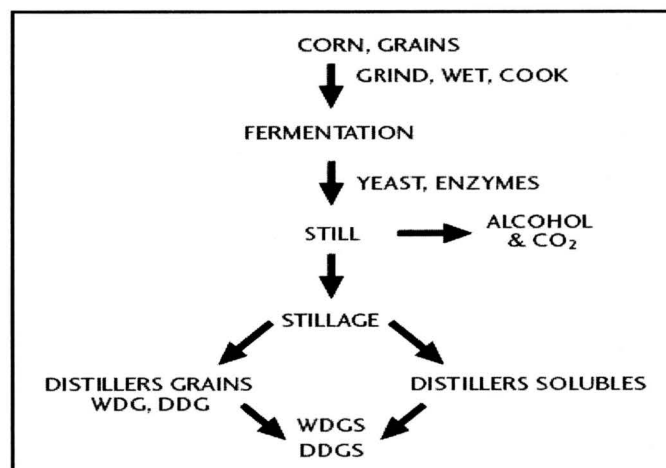


Figure 1. Schematic of the dry milling industry with the feed products produced.¹⁰

cal calculation of nutrient profile of DGS from different source grains will give us a general understanding of the feeding value of those products.

Although theoretical nutrient profiles assist diet formulation, the high level of variation in nutrient profiles associated with DGS should also be noted. As one report pointed out, diet formulation consistency may be an issue when using corn DGS products.²⁰ Variation in some nutrients are likely more critical than others. For example, DM is important in terms of pricing and feeding correctly, S is important for toxicity concerns at higher feeding rates and fat is important relative to energy. Sulfur and fat are likely the most variable nutrients, and will be discussed in more detail in the following sections.^{9,20} The important recommendation here is to sample the DG being fed and develop a database with a meaningful nutrient profile with site specific information. It is likely that ethanol plants will not offer this service, and will not have sufficient data about nutrient profiles of their DG products to make diet formulation recommendations.

Diet Formulation Considerations

Due to the expected three-fold increase in nutrients in DGS as a result of removing starch to produce ethanol, there are some interesting diet formulation considerations when feeding DGS to feedlot cattle. For example, nutrients that were once expensive and fed at levels necessary only to meet animal requirements are now affordable and often included in feedlot diets at levels well beyond animal needs.³² This is a perspective rarely considered in research, especially when multiple nutrients are fed in excess simultaneously.³² Although many important nutrient excesses occur when feeding high dietary levels of DGS in feedlot diets,³² the primary diet formulation considerations discussed in this paper include crude protein, phosphorus, sulfur and fat. Each of the previously listed nutrients presents its own unique challenge when formulating feedlot diets with high levels of DGS and can be categorized into three main areas of interest, which include environmental (protein and P), sulfur toxicity (S) and supplemental fat.

Environmental

Once expensive supplements in the diets of beef cattle, protein and P are two nutrients in DGS that become elevated to such an extent supplementation of protein and P in diets containing high levels of DGS is no longer needed. Further, feeding protein and P above animal requirements could lead to important environmental concerns that should be addressed when feeding DGS to feedlot cattle. Environmental concerns stem from the fact that animal manure is typically land-applied to supply nutrients for crop growth, but nitrogen

(N) and P are in imbalance in manure relative to crop needs.²³ Additionally, livestock utilize P inefficiently, excreting 80-90% of that consumed,³⁴ whereas excess protein is excreted as N, primarily in the urine. Nitrogen is volatile whereas P is not, which helps create the imbalance of N and P in livestock manure. An understanding of the impact of DGS feeding on protein and P levels in finishing diets will help feedlots manage the environmental aspects of DGS feeding.

A survey of six consulting nutritionists servicing feedlots in Arizona, Kansas, Oklahoma, Nebraska and Texas found CP levels in finishing diets ranged from 12.5 to 14.4%.¹⁵ Every consultant surveyed included supplemental urea (0.5 to 1.5%) to increase CP of the diet.¹⁵ A second consulting nutritionist survey conducted in 2000 revealed CP levels in finishing diets ranged from 12.5 to 14.0%.¹⁴ Additionally, the 2000 consulting nutritionist study showed that urea was supplemented at an average of 1.05% of diet dry matter (range, 0.78 to 1.35%).¹⁴ Conceivably, if corn DGS were included at 20% of diet dry matter, approximately 6% CP would be supplied to the diet by DGS. Six percent CP would supply more than enough N to the animal to remove the 1% supplemental urea on a CP basis. If sorghum and wheat DGS were included at 20% of diet dry matter, approximately 7.6 and 8.6% CP would be supplied from DGS, respectively. Also interesting to note, consultants appeared to be formulating for CP concentrations greater than would be expected by the 1996 Beef NRC system for determining the protein requirements for beef cattle.¹⁵ When feeding high levels of DGS to feedlot cattle it is expected that protein will be fed above animal requirements, and therefore more excess N will be excreted by the animal.

Research has shown the P requirement for finishing beef calves and yearlings are much lower than 1996 Beef NRC recommendations.^{12,13,30} The P requirement for finishing yearlings (ave. initial wt. = 849 lb) has been shown to be < 0.14% of diet dry matter.¹³ The P requirement for finishing calves (ave. initial wt. = 583 lb) has been shown to be < 0.16% of diet dry matter.¹² In a more recent study with even lesser amounts of P fed to finishing heifers, it was determined that the requirement for growth and bone mineral was approximately 0.11% of diet DM.¹⁶ The 2000 consulting nutritionist study found that feedlot diets formulated by the 19 nutritionists surveyed contained 0.31% P (range 0.25 to 0.35%) on a dry matter basis,¹⁴ which appears to be much higher than reported animal requirements.^{12,13} Therefore, grain supplies more P than required in all finishing situations. Feeding feedlot cattle high levels of DGS exacerbates this amount of excess P, which is all excreted by the animal. For example, the estimated P concentrations of corn, sorghum and wheat DGS are 0.96, 1.02 and 1.32%, respectively. It is likely that feedlot diets

will contain 0.4 to 0.6% P when DGS are included, but it is level dependent, and grain alone will meet the P requirement.

The consequences of overfeeding protein and P to beef cattle are relatively minor from the animal performance perspective. For protein, it is thought underfeeding is much more detrimental to animal performance when compared with overfeeding. As discussed previously, when protein is fed above animal requirements, the animal simply excretes the excess protein as N. Dietary P concentration did not affect average daily gain (ADG), dry matter intake (DMI), or the DMI:ADG ratio in yearling steers, and it has been shown that DMI and ADG did not change due to P treatment in calves.^{12,13} Although over feeding protein and P to cattle appears to have little consequence on animal performance, research has historically focused on determining the least amount of protein and P required by the animal before performance is negatively affected. With the widespread adoption of DGS in feedlot diets, perhaps future research will evaluate if there is an upper threshold for protein and P in beef cattle diets.

Currently, the primary concern with overfeeding protein and P is related to increased animal excretion of N and P. Excess N and P excretion is a concern because animal manure is typically land-applied to supply nutrients for crop growth.²² Historically, there is an imbalance of N and P in manure relative to crop needs.⁸ When feedlot diets contain high levels of DGS, the imbalance of N and P in manure becomes even greater.²⁷ The consequence of the N and P imbalance in manure is that manure must be land-applied on a P basis rather than an N basis. Land-applying manure on a P basis to mitigate accumulation of P in soils adds costs to a feedlots nutrient management plan and increases the amount of land needed to spread manure. Feedlot diets containing high levels of DGS present an interesting challenge concerning N and P management, but with the proper nutrient management plan, feedlots will still have the opportunity to utilize a growing supply of DGS. For example, one study evaluated the cost of distributing P on increased land based on feeding 0, 20, or 40% DGS.²² Their conclusions were that costs increase by approximately \$1 to \$3 per animal depending on the size of feedlot by using DGS at 40% of diet DM compared with traditional grain-based finishing diets. Therefore, profitability must be increased by more than this amount to offset extra costs. Interestingly, research has shown feeding returns of \$20 to \$40 per animal when feeding corn WDGS at various inclusion levels,³⁸ which dwarfs the extra cost of distributing manure P. Another interesting conclusion concerning increased P in manure was that manure value was actually increased more than the extra cost if manure can be marketed based on fertilizer nutrient value.²²

Sulfur toxicity

Much like CP and P, S levels in ethanol co-products can be quite high and are often variable. High S levels in DGS have also been implicated in an increased occurrence of polioencephalomalacia (PEM) in cattle.³² As discussed previously, the S levels in corn, sorghum and wheat DGS should be expected to average 0.33, 0.42 and 0.42%, respectively. However, because there is variation in nutrients from the original cereal grain, DGS should be expected to have three times the amount of variation as the original grain. Results from a survey of 12 ethanol plants indicated that the range of S levels in corn DDGS could be as low as 0.33% and as high as 0.74%.³⁶ A different report found S levels in corn DDGS from four different plants ranged from a low of 0.35% to a high of 0.69%.²⁰ Recent research at the University of Nebraska found a range of 0.4 to 1.7% S with a mean of 0.7 to 0.8% S across five plants and 50 samples from each plant.⁹ Although less is known about the variability of S levels in sorghum and wheat DGS, the important finding here is that S levels in DGS should be monitored as they are likely variable and can be quite high.

The 1996 Beef NRC suggests the maximum tolerable S concentration in diets for finishing beef cattle is 0.40%.³⁰ It is thought that the consequence of high S levels in feedlot diets is the increased risk of PEM related to excess S. Although the 1996 Beef NRC does not mention sulfur-induced PEM, the NRC Mineral Tolerances of Animals suggests PEM is generally tied to thiamin deficiencies.^{29,30} However, the occurrence of PEM-like signs are not always associated with lowered blood thiamine concentrations.^{18,33} A different report suggests PEM-like signs in cattle fed high S diets could be a result of H₂S poisoning.¹⁷ The H₂S likely originates from the reduction of sulfates to sulfides.³² Although the symptoms of PEM and CNS disorders are similar, H₂S induced CNS disorder is not really the same thing as the PEM that can be treated with thiamine.³² Further, a common diagnosis of mortality associated with high S diets is bloat.³² Research has shown rumen motility is reduced when there is an accumulation of ruminal H₂S.^{3,21} In some cases, non-ambulatory cattle suffering from a CNS disorder could conceivably succumb to bloat, but the cause of the bloat might stem from a diet induced H₂S insult.³²

Adding to the confusion about the mechanism of S toxicity, high S diets do not result in all cattle in a pen becoming clinically ill, morbidity is often sporadic, and overall pen performance will likely be unaffected.³² It is interesting to note when all cattle within a pen are fed a high S diet, most of the cattle seem unaffected.³² Although the mechanisms related to S toxicity due to elevated dietary S levels are still poorly understood, and there appears to be no dose dependent response to the level of dietary S, there are some factors that should be

considered when feeding high levels of DGS to feedlot cattle. One researcher suggests that the simple solution would be for ethanol plants to not add S to the co-product stream.³² Anecdotal evidence would suggest that some ethanol plants have made that decision, but it will be important to communicate the value of avoiding added S for plants to change their SOPs.³² In terms of managing total S levels in the feedlot, it is important to know the sulfate content of the water supply, the typical S content of the DGS being fed and the S level in the remainder of the dietary components. This information can be used to help determine the level of DGS that can safely be fed after accounting for other sources of S. Some nutritionists recommend feeding thiamine at 150 to 200 mg per steer to help offset challenges related to S-induced PEM. However, data are variable on the effectiveness of this strategy. Although more research is needed to better define the mechanism of S toxicity in cattle, understanding the current limitations of feeding DGS to feedlot cattle in relation to dietary S should allow feedlots to utilize DGS quite successfully.

Supplemental fat

The feedlot sector of the beef industry has been attracted to the growing supply of DGS in part due to the elevated concentration of fat in DGS compared with the source grain utilized in the dry milling ethanol process. Ether extract content of corn, sorghum and wheat DGS are estimated to be 12.18, 9.09 and 7.02%, respectively. Even though all the starch has been removed from DGS during the dry milling ethanol process, as previously discussed the fat level in DGS is increased three-fold over the concentration of fat in the source grain. Therefore, in many cases DGS are included in feedlot diets as an energy source when corn DGS is fed at greater than 15% of the diet dry matter.¹¹

Although increasing the energy density of feedlot diets is attractive, there appears to be limitations as to how much supplemental fat can be added to feedlot diets. Results from the 2000 consulting nutritionist survey reported that fat supplementation in finishing diets averaged 3.68% (range 2.5 to 6.5%).¹⁴ Research has shown, in order to maximize production, the maximum level of total fat provided by the diet should not exceed 0.72 g per lb of body weight.³⁹ In a study discussing the upper limit for caloric density in feedlot diets it is suggested that total fat above 6 to 7% in feedlot diets will result in decreased intake to a level at which DMI:ADG is maintained or increased.²⁵ Research data appear to be in agreement with the level of supplemental fat currently being used in feedlot diets by consulting nutritionists, and support the plateau in DMI:ADG observed above 6 to 7% supplemental fat.^{14,25,39}

When feeding a feedlot diet containing 20% DGS on a dry matter basis, corn, sorghum and wheat DGS

will provide approximately 2.4, 1.8 and 1.4% fat. Assuming the upper limit for fat supplementation is near 7%, and dry rolled corn is the primary concentrate, the level at which supplemental DGS would approach the limit of being detrimental to cattle performance would be estimated at 30, 60 and 100% of diet dry matter for corn, sorghum and wheat DGS, respectively. Wheat DGS would need to be fed at 100% of diet dry matter due to the fact that wheat DGS is estimated to contain 7.02% fat. When formulating feedlot diets not to exceed 7% fat, the use of corn DGS could be limited due to the high level of fat contained in corn DGS. Inclusion levels of sorghum and wheat DGS will likely be limited by a factor other than level of fat in the finishing diet due to the high inclusion levels needed to reach the 7% total dietary fat threshold in finishing diets. The important point here is to understand that one of the factors determining the optimal level of DGS in feedlot diets will likely be the type of grain used in dry milling ethanol production. Inclusion levels of corn DGS could be limited due to elevated fat, whereas wheat DGS may not contain enough fat to be considered an energy source in feedlot diets and inclusion levels of wheat DGS in feedlot diets may be limited by a factor other than fat (i.e. sulfur).

In the future, it is likely that distiller grains feeds will change as processes evolve. For example, there are a few plants that have begun to "fractionate" during the dry milling ethanol process whereby a portion of the oil is removed prior to fermentation. Therefore, measuring the fat content of the distillers grains is critical as well as understanding the production process to make sound nutrition decisions.

Feedlot Performance

The majority of research on distillers grains as an energy source has been conducted on finishing cattle with corn as the type of grain used in the dry milling ethanol process.¹⁰ Sorghum DGS appears to be gaining attention in the Central and Southern Plains of the United States, whereas wheat DGS will likely be the dominate type of DGS available in Western Canada. There is very little research evaluating the feeding value of sorghum and wheat DGS in the United States and Canada. There are also few data evaluating DGS in combination with different grain sources. That is in contrast to corn DGS, where a growing body of evidence suggests corn DGS can be fed quite successfully to feedlot cattle at relatively high dietary inclusion rates. The following discussion will attempt to highlight recent findings concerning the use of corn, sorghum and wheat DGS in feedlot diets and introduce some factors which may generate conflicting results when reviewing the performance response from cattle fed corn DGS.

Corn DGS

Recent research with corn DGS has focused on the optimum dietary inclusion level in feedlot diets.^{5,37} In a study evaluating the effects of increasing dietary inclusion of corn WDGS as a replacement for dry rolled and high moisture corn on feedlot performance and carcass characteristics of finishing yearling steers (ave. initial wt. = 733 lb), results indicated that corn WDGS could be used effectively in finishing diets, with optimum performance being observed at 30 to 40% dietary inclusion.³⁷ Hot carcass weight was maximized at 30 to 40% dietary inclusion of corn WDGS, and was the only carcass attribute affected by dietary inclusion of corn WDGS.³⁷ When corn WDGS was included in the diet at 40% of diet dry matter, DMI:ADG was improved from 6.52 for control to 5.68 for cattle fed 40% corn WDGS.³⁷ Hot carcass weight averaged 777 lb for control cattle compared with 825 lb for cattle receiving diets containing 40% corn WDGS.³⁷ Research evaluating the effect of including corn DDGS at levels of 0, 10, 20, 30 and 40% of diet dry matter (replacing dry rolled corn) found the optimum inclusion level to be 20%.⁵ For cattle receiving the 20% corn DDGS diet, DMI:ADG averaged 5.60, compared with 6.32 for control cattle.⁵ Hot carcass weight was the only carcass outcome affected by dietary inclusion of corn DDGS, and improved from an average of 782 lb for control cattle to 816 lb for cattle fed 20% corn DDGS.⁵ The two reports discussed here are in agreement with a review article suggesting the feeding of WDGS results in better performance than DDGS.¹⁰ Specifically, a more complete review of the literature suggests corn WDGS fed at 40% dietary inclusion will improve the DMI:ADG ratio 21.5%, compared with an 11.9% improvement when corn DDGS is fed at a 40% inclusion rate.¹⁰

Sorghum DGS

Compared with corn DGS, there is limited research evaluating the feeding value of sorghum DGS in feedlot diets. However, in a study evaluating six dietary inclusion levels of sorghum WDGS (replacing steam flaked corn at levels of 0, 8, 16, 24, 32 and 40% of diet dry matter) fed to yearling heifers (ave. initial wt. = 849 lb), it was found that the amount of sorghum WDGS was optimized at 16%.⁷ Feed efficiency was improved from 6.81 for control heifers compared with 6.19 for heifers fed 16% sorghum WDGS.⁷ Carcass characteristics appeared largely unaffected with the exception of USDA Yield Grade. The authors reported that increasing levels of sorghum WDGS resulted in a linear ($P < 0.02$) decrease in ribeye area and a linear effect ($P < 0.06$) on the percentage of USDA Yield Grade 1 and USDA Yield Grade 3 carcasses.⁷ A separate report comparing the effects of replacing 15% steam flaked corn with sorghum WDGS did not find performance enhancements associated with

sorghum WDGS.³⁵ In that study, steers fed the control diet had an average DMI:ADG ratio of 6.0, compared with the average DMI:ADG ratio of 6.23 for steers fed 15% sorghum WDGS.³⁵ When sorghum WDGS replaced steam flaked corn at 40% dietary inclusion, performance suffered. Control heifers had a DMI:ADG ratio of 6.81 while heifers fed 40% sorghum WDGS had a DMI:ADG ratio of 7.18.⁷ However, a different report suggest sorghum WDGS can replace dry-rolled corn at an inclusion level of 40% of diet dry matter with no negative effects on efficiency of gain ($P > 0.10$).²⁶ Steers fed sorghum DDGS at 40% were less efficient ($P < 0.10$) compared with control cattle and cattle fed sorghum WDGS.²⁶ More research is needed to better define the expected performance response when feeding increasing levels of sorghum DGS, in both the wet and dry form and when replacing corn of different degrees of processing.²

Wheat DGS

There is perhaps even less information concerning the expected performance response from cattle fed wheat DGS when compared with sorghum DGS, although one study has reported on the optimum level of wheat DDGS for feedlot cattle.²⁸ The level of wheat DDGS fed in the study included 0, 8.1, 16.2, 24.2 and 32.1% of diet dry matter. Increasing dietary inclusion level of wheat DDGS did not affect the DMI:ADG ratio.²⁸ Further, inclusion level of wheat DDGS up to 32.1% of diet dry matter had no positive or negative effects on carcass characteristics. Results from this study indicate wheat DDGS can replace dry-rolled barley grain up to 32% of diet dry matter with no negative effects on feedlot performance. However, wheat DDGS does not appear to provide improvements in efficiency of gain like corn DGS does. Perhaps this response is due to the much lower fat level in wheat DGS (7%) compared with corn DGS (12%). However, it is important to note this study compared wheat DDGS. Research with corn distillers co-products suggests the wet product has a better feeding value when compared with the dry product. More research is needed to determine the effects of wheat DGS in both the wet and dry form as dry milling ethanol plants begin utilizing greater amounts of wheat to produce ethanol, thereby increasing the amount of wheat DGS available to US and Canadian feedlots.

Conflicting results

In the case of feeding corn DGS there appears to be some important factors to consider when reviewing the literature. For example, when feeding corn DGS in corn based diets, corn processing appears to influence cattle performance. In a study evaluating the effect of corn processing and corn WDGS inclusion level in finishing diets, optimal feedlot performance of steer calves was observed when 40, 27.5 to 40 and 15% corn WDGS

replaced dry rolled corn (DRC), high moisture corn (HMC) and steam flaked corn (SFC), respectively.⁶ The authors concluded an interaction between corn processing method and corn WDGS inclusion level occurred, and that there was a greater performance response to corn WDGS inclusion in diets when fed with high-moisture or dry-rolled corn grain.⁶ Also, appropriate roughage levels in feedlot diets may need to be reevaluated when feeding high levels of DGS. Recent research has evaluated the effects of roughage source and level in finishing diets containing corn WDGS.⁴ Results from that study indicated it was not beneficial to completely eliminate roughage from feedlot diets, and there was no difference in DMI:ADG for cattle fed roughage sources of alfalfa hay, corn silage, or corn stalks when the finishing diet contained 30% corn WDGS.⁴ Finally, there appears to be growing interest to re-evaluate the value of feeding ionophores and antibiotics when high levels of corn DGS are included in feedlot diets. It is hypothesized that by replacing highly fermentable grains with DGS in feedlot diets, cattle will be less prone to digestive upsets and liver abscessing, which could possibly reduce the need for ionophores and feed antibiotics; however, research data are needed.

Conclusions

As the United States and Canada increase production of ethanol from corn, sorghum and wheat, there will be an increase in supply of DGS. Feedlots should have no problem identifying and managing the limitations associated with feeding DGS as an energy source to cattle. As previously discussed, the most obvious limitations to feeding DGS can be categorized by environmental concerns (N and P), sulfur toxicity (S) and supplemental fat. An interesting finding was that some nutrients that were once costly (protein and P), and included in feedlot diets at minimal levels, will be fed at elevated levels at relatively low cost when DGS are included in feedlot diets. Further, as alternative feed grains, such as sorghum and wheat, are used in a more mainstream fashion in the dry milling ethanol process, it will be important to remember the co-products from sorghum and wheat DGS will likely be quite different than corn DGS. Finally, as more research surfaces on the feeding value of corn, sorghum and wheat DGS, it will be important to remain cautious when drawing conclusions on their feeding value. It has been shown that grain processing, roughage level and perhaps inclusion of ionophores and antibiotics may interact with level of DGS in feedlot diets. As with most topics in the scientific literature, more research is needed to further explain the performance response in cattle when fed corn, sorghum and wheat DGS, as well as grain type and processing method that the DGS is replacing.

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