SORGHUM USE IN BEEF CATTLE FINISHING DIETS

SORGHUM THE SMART CHOICE

INTRODUCTION

Grain sorghum is an important feedstuff for livestock production. The majority of sorghum produced in the U.S. is grown from South Dakota to southern Texas, primarily on dryland or limited irrigated acres. Sorghum is a water efficient crop, tolerating heat and moisture stress better than most crops. It also fits well within a crop rotation, particularly broadleaf crops, by breaking the disease, insect and weed life cycles common in these cropping systems. Livestock production systems central to the Sorghum Belt often utilize this cereal grain as a cost efficient replacement to corn. Although research has shown grain sorghum to be comparable to corn in beef finishing rations, sorghum price has lagged behind corn by approximately 10 percent, often citing increased processing costs. The major source of digestible energy in feedlot rations comes from starch found in cereal grains. Grain inclusion in finishing cattle rations ranges from 50-90 percent of dry matter (DM) according to a recent survey of consulting nutritionists (Samuelson et al., 2016). Commonly fed grains include corn, wheat, sorghum and barley.

Corn continues to be the primary grain fed to cattle on finishing diets in the United States (Galyean and Gleghorn, 2001; Vasconcelos and Galyean, 2007; and Samuelson et al., 2016). Therefore, sorghum is often compared to corn when evaluating its use in feedlot rations. The preference for corn does not indicate that other grains are inferior to corn, it is simply that nutritionists and feedlot operators prefer to utilize corn as the primary energy source due to the high avliabilty of the crop, with typically over 90 million acres grown in the U.S. each year. Starch utilization in the rumen is critical when increasing animal performance. As a result, determining and understanding the ruminal fermentation patterns of various grain sources is important when attempting to achieve high levels of feed efficiency and increasing average daily gain (ADG). This feeding guide was designed to present current information on sorghum use in finishing cattle diets.

GRAIN SORGHUM FEEDING VALUE

Corn, sorghum, wheat and barley are all potential sources of energy for beef animals. Depending on local climatic conditions, one grain may be preferred over another. Corn is usually the energy source utilized, but some climatic conditions may limit or negate its productivity. Average nutrient values for sorghum, corn, wheat and barley are reported in Table 1. Values were obtained from the Nutrient Requirements of Beef Cattle (National Research Council [NRC], 2016) and from the Dairy One Forage Laboratory located in New York. The values obtained from the NRC are based on published values prior to the publication date of 2016. The Dairy One data is the average reported value for all samples analyzed from May, 2000 through April 30, 2016. Published book values should be used with caution since growing conditions, management practices, hybrid selection and numerous other factors may impact the nutritional value of a feed grain. Likewise, improvements in crop genetics over time will also impact nutritive value, which often increases starch yield, resulting in a dilution of other nutrients. These changes in nutritive value are apparent when reviewing dated published feed values.

GRAIN SORGHUM FEEDING VALUE

TABLE 1. SORGHUM NUTRITIVE VALUES COMPARED TO OTHER FEED GRAINS, WITH THE NORMAL NUTRIENT RANGE LISTED BELOW IN PARENTHESIS[1].

ITEM		SORGHUM	CORN	WHEAT	BARLEY
DM, %	DAIRY ONE	90.2	88.9	89.0	89.5
	NRC	88.7	87.2	88.9	89.7
TDN, %	DAIRY ONE	87.4	88.1	83.8	80.9
	NRC	86.0	87.6	86.8	84.1
CP, %	DAIRY ONE	12.5	9.0	13.6	11.9
	NRC	11.6	8.8	13.8	12.8
NDF, %	DAIRY ONE	8.4	10.0	13.2	19.0
	NRC	7.2	9.7	12.4	18.3
ADF, %	DAIRY ONE	5.1	3.7	4.7	7.6
	NRC	4.6	3.6	4.2	7.1
ASH, %	DAIRY ONE	2.6	1.6	2.2	3.0
	NRC	2.1	1.4	2.3	2.8
NE_M, MCAL/LB	DAIRY ONE	1.00	1.00	0.93	0.89
	NRC	0.96	0.98	0.97	0.93
NE_G, MCAL/LB	DAIRY ONE	0.68	0.69	0.63	0.60
	NRC	0.66	0.68	0.67	0.64

[1]Source: Dairy One Laboratory, Ithica, NY. Samples analyzed between May 2000 to April 2016. Nutrient Requirements of Beef Cattle (NRC), 2016.

CRUDE PROTEIN PROFILE

Given information published through 2016, sorghum appears to contain more crude protein than corn but less than the amount found in wheat. In general, one could expect sorghum to contain approximately 35 percent more crude protein than corn.

FIBER PROFILE

Fiber, as measured by acid detergent fiber (ADF), is lowest for corn and wheat and higher for sorghum and barley. While differences exist, they are small and would not have a large negative effect on ruminant digestion.

ENERGY VALUE

Energy values are expressed in terms of total digestible nutrients (TDN), net energy for maintenance (NEm) and net energy for gain (NEg). These are a reflection of how efficiently an animal would utilize energy from the feedstuffs. Sorghum and corn are very comparable in terms of energy. Tabular values indicate a slight advantage for corn over sorghum, but the difference is relatively small. Small differences in tabular values may not be detected in animal trials. Due to the influence of climate, agricultural practices and improving genetics, grain sources should be analyzed and the resulting nutrient profiles used to formulate animal diets rather than utilizing tabular values.

SORGHUM COMPARED TO OTHER GRAINS

Differences in cattle performance when fed different grain sources typically relate to starch content and digestibility of the grain. In a meta-analysis that included data from feedlot trials conducted from 1974 to 1997 and included over 22,000 head of cattle, Owens et al. (1997) concluded finishing cattle ADGs were not different between barley, corn, sorghum, oats and wheat when averaged across processing method (Table 2). When comparisons were made between processing method, different types of grain processing resulted in some additional conclusions. Feeding high moisture corn or sorghum resulted in lower rates of gain as compared to other types of processing (Table 3). When feeding sorghum, dry matter intakes were reduced with increasing degree of processing (Table 4) and feed efficiencies improved (Table 5). Steam rolling sorghum resulted in a 15 percent increase in feeding efficiency as compared to dry rolling. Processing, with an emphasis on thermal processing, should be considered when feeding sorghum and comparing the efficiency to corn. In general, carcass characteristics remain unchanged when feeding sorghum compared to corn (Zinn 1991; Sindt et al., 1993).

SORGHUM COMPARED TO OTHER GRAINS

TABLE 2. LEAST SQUARES MEANS OF FEEDLOT CATTLE PERFORMANCE WHEN FED DIFFERENT GRAIN TYPES AND AVERAGED ACROSS ALL PROCESSING METHODS

	SORGHUM	CORN	WHEAT	BARLEY	OATS
AVERAGE DAILY GAIN, LB	3.06	3.15	3.06	3.13	3.31
DRY MATTER INTAKE, LB/D	20.8^{A}	19.7^{B}	20.8^{B}	19.3^{B}	20.2^{AB}
FEED:GAIN	6.9^{A}	6.3^{B}	6.9^{B}	6.2^{B}	6.1^{AB}

Adapted from Owens et al., 1997.
[a,b]Within a row, means with different superscripts differ ($P<0.05$).

TABLE 3. COMPARISON OF RATE OF GAIN (LB/D) RESULTING FROM FIVE GRAINS PROCESSED BY VARIOUS METHODS AND UTILIZED IN FEEDLOT DIETS

	SORGHUM	CORN	WHEAT	BARLEY	OATS
DRY-ROLLED	3.15^{A}	3.20^{A}	3.04	3.20	3.38
HIGH MOISTURE	2.84^{B}	3.02^{B}	---	---	---
STEAM-ROLLED	3.09^{AB}	3.15^{A}	3.04	2.93	3.26
WHOLE	---	3.20^{A}	---	3.04	---
RECONSTITUTED	2.89^{AB}	---	---	---	---

[ab]Within a column, means with different superscripts differ ($P<0.05$).
Adapted from Owen et al., 1997.

TABLE 4. COMPARISON OF DRY MATTER INTAKE (LB/D) RESULTING FROM FIVE GRAINS PROCESSED BY VARIOUS METHODS AND UTILIZED IN FEEDLOT DIETS

	SORGHUM	CORN	WHEAT	BARLEY	OATS
DRY-ROLLED	23.09[A]	20.84[A]	19.78	19.76	20.29
HIGH MOISTURE	20.18[B]	19.23[B]	---	---	---
STEAM-ROLLED	19.14[C]	18.41[C]	17.86	18.19	20.11
WHOLE	---	18.87[BC]	---	20.51	---
RECONSTITUTED	19.38[BC]	---	---	---	---

[abc]Within a column, mean with different superscripts differ ($P<0.05$).
Adapted from Owen et al., 1997.

TABLE 5. COMPARISON OF FEED EFFICIENCY (FEED/GAIN) RESULTING FROM FIVE GRAINS PROCESSED BY VARIOUS METHODS AND UTILIZED IN FEEDLOT DIETS

	SORGHUM	CORN	WHEAT	BARLEY	OATS
DRY-ROLLED	7.43[A]	6.57[A]	6.59[A]	6.25	6.01
HIGH MOISTURE	7.12[AB]	6.43[A]	---	---	---
STEAM-ROLLED	6.33[C]	5.87[B]	5.92[B]	6.19	6.18
WHOLE	---	5.95[B]	---	6.66	---
RECONSTITUTED	6.75[BC]	---	---	---	---

[abc]Within a column, mean with different superscripts differ ($P<0.05$).
Adapted from Owen et al., 1997.

FERMENTATION RATE

When compared to other grains (wheat, triticale, barley and corn), sorghum was the least likely to induce ruminal acidosis. The slower fermentation rate is likely due to a combination of characteristics, such as the starch:protein matrix, high ratios of amylose compared to amylopectin and small starch granule size compared to other grains (Rooney and Pflugfelder, 1986; Opatpatanakit et al. 1994; Lean et al. 2013). The slower fermentation rate of grain sorghum is likely a contributing factor to the positive associative effects reported when grain sorghum was fed in combination with more highly fermentable grains (Stock et al., 1987; Huck et al., 1998). It is important to note that while sorghum ferments slower than other cereal grains, it does reach a similar point of disappearance in the rumen, typically after 48 hours (Herrera-Saldana et al., 1990). As a result, a combination of grains may provide a more stable level of starch availability in the rumen between feedings.

UTILIZATION OF SORGHUM GRAIN IN BEEF DIETS

Sorghum grain is one of the most difficult whole grains for cattle to crush when chewed. As a result, processing sorghum grain is the most common method to increase the rate and extent of starch digestion. Most feedlot and/or dairy nutritionists will choose to feed one grain over another based on the cost of the grain and the cost to process it. Minimal processing options for sorghum include cracked, ground, dry-rolled or raw. Examples of more extensive processing techniques include steam-flaked, reconstitution, high moisture, popping, exploding, roasting or micronizing (Theurer, 1986). Thermal processing has been utilized in the feedyard industry for decades. The proper combination of heat, pressure and moisture are key to disrupting the complex starch:protein matrix found in sorghum. As a result, the most common grain processing method currently used in feedyards is steam-flaking. The second most common method is dry-rolling (Samuelson et al., 2016). The goal of grain processing is to increase energy/starch availability in the rumen. When processed correctly, sorghum can replace corn in cattle diets and maintain production levels. Nutritional values of both dry-rolled and steam-flaked corn and sorghum can be found in Table 6.

UTILIZATION OF SORGHUM GRAIN IN BEEF DIETS

TABLE 6. NUTRITIONAL COMPOSITION OF CORN AND GRAIN SORGHUM WHEN FED TO CATTLE (DRY BASIS)

	DRY-ROLLED		STEAM-FLAKED	
	SORGHUM[2]	CORN[1]	SORGHUM[1]	CORN[1]
DM, %	88.6	87.2	81.0	80.7
TDN, %	80.6	87.6	93.0	95.0
CP, %	11.6	8.8	10.1	8.5
NDF, %	10.9	9.7	9.7	9.0
ADF, %	5.9	3.6	6.3	4.0
FAT, %	3.1	3.8	2.3	3.2
ASH, %	2.0	1.4	1.4	1.3
NDICP, %	2.8	-	-	-
ADICP, %	1.0	3.1	-	-

[1]Nutrient Requirements of Beef Cattle (2016).
[2]Nutrient Requirements of Dairy Cattle (2001).

TABLE 7. COMPARISON OF CORN AND SORGHUM PROCESSING ON FEED CONVERSION AND AVERAGE DAILY GAIN IN BEEF CATTLE FINISHING TRIALS

	FEED/LB GAIN		DAILY GAIN (LB)	
	SORGHUM	CORN	SORGHUM	CORN
DRY-ROLLED	7.3	6.9	2.65	2.65
FLAKED	6.5	6.3	2.65	2.65
RECONSTITUTED	6.3	6.4	2.65	2.87
MICRONIZED, EXPLODED, POPPED	6.5	---	2.65	---

Adapted from Theurer, 1986.

Data presented in Table 7 demonstrates the increase in feed conversion when corn or sorghum grain is processed by steam-flaking as compared to dry-rolling (Theurer, 1986). As noted by the data, there was no increase in average daily gain (ADG) due to processing. Feed conversions and average daily gain for processed corn and sorghum were also similar. When using minimal processing (dry-rolling), there was an advantage for corn as compared to sorghum. The increase in feed efficiency was associated with a change in the location of starch digestion. Zinn et al. (2008) also reported ADG was not different between cattle fed dry-rolled or steam-flaked sorghum-based diets. However, cattle consuming the steam-flaked diet consumed 9 percent less and had a 13 percent greater gain:feed efficiency, which is comparable to the 15 percent increase in feed efficiency as reported by Owens et al., 1997.

Theurer (1986) compiled the results of several studies that reported the impact of grain processing technique on starch utilization and found total starch digestion increased from 91 percent for minimally processed sorghum (dry-rolled or ground) to 98 percent

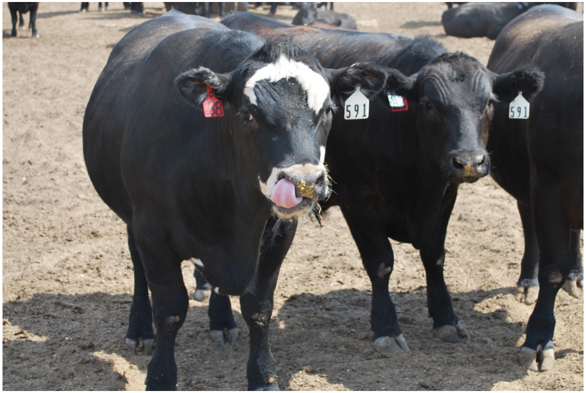
for extensively processed sorghum (steam-flaked, micronized or reconstituted). More recent studies report total tract digestibility to be 91 percent for dry-rolled sorghum and 99 percent for steam-flaked sorghum (Zinn et al., 2008). The improved starch utilization of processed sorghum is due to increased ruminal fermentation and digestibility in the small intestine. Theurer (1986) reported that ruminal starch digestibility was increased from 57 percent for minimally processed sorghum to 76 percent for extensively processed sorghum, representing a 33 percent increase in ruminal starch digestibility. When similar data was compared for corn, ruminal starch digestibility increased by 22 percent. Harbers (1975) demonstrated extensive processing changes the starch structure found within sorghum grain, making it more vulnerable to amylase enzymatic breakdown. Post-ruminal digestion of organic matter, nitrogen and starch was also improved by more extensive processing of sorghum (Swingle et al., 1999; Theurer et al., 1999b; Zinn et al., 2008). When compared to other grains, processing significantly improved the feeding value of sorghum.

UTILIZATION OF SORGHUM GRAIN IN BEEF DIETS

THERMAL PROCESSING

It is well documented that the rate and extent of starch digestibility is improved when sorghum is more extensively processed. Another benefit to shifting starch digestion from the small intestines to the rumen is an increased production of high-quality microbial protein (Theurer et al., 1999b). The amino acid content of the grain is not as important in ruminant diets, as compared to monogastrics, since it should be converted to higher-quality microbial protein in the rumen. Early research indicated the protein fraction in sorghum is less digestible when compared to corn (Oltjen et al. 1967, Saba et al. 1964), indicating that processing is critical to improving the feeding value for livestock (Rooney and Pflugfelder, 1986).

Increased microbial protein production has been reported with more extensive processing (Rahnema et al., 1987). Zinn et al. (2008) reported a 14 percent increase in microbial crude protein for steam-flaked compared to dry-rolled sorghum and an increased total tract nitrogen digestibility. The increased microbial protein production could, in part, be attributed to an increased amount of blood urea nitrogen cycling to the rumen, intestines and total gut tissues (Theurer et al., 2002). Increasing the supply of microbial crude protein, in addition to improving ruminal and total tract starch digestibility, are important for increasing animal performance. **When feeding sorghum, steam-flaking has an advantage over other processing methods and should be considered the processing method of choice.**



EFFECTS ON ANIMAL PERFORMANCE

SORGHUM PROCESSING

Animal research studies have demonstrated processing of sorghum increases its value to the livestock industry. Current research suggests thermal processing via steam-flaking seems to offer the best solution for increasing the efficiency of sorghum digestion. Flaking can increase the feeding value of sorghum by 12 to 15 percent over dry-rolling by increasing the digestibility of starch in the rumen and total tract. It also increases the digestibility of the crude protein found in sorghum. Differences in cattle performance, mill throughput and processing costs (equipment, labor, energy) should be taken into consideration when feeding steam-flaked sorghum since approximately 75 to 80 percent of feedlot expenses are related to feed costs. As the grain becomes more digestible due to processing, cattle will be more prone to acidosis and bloat. As a result, more skill will be required to achieve ideal flake densities, manage bunks and check cattle for metabolic disorders.

EFFECTS ON ANIMAL PERFORMANCE

STEAM-FLAKING

Steam-flaking is the most common method to process sorghum for beef cattle rations because cattle consistently perform better on steam-flaked compared to dry-rolled sorghum grain-based rations. Recommended flake densities for sorghum vary slightly but range from 22 to 30 lbs/bu (Xiong et al., 1991; Reinhardt et al., 1997; Theurer et al., 1999b; Alio et al., 2000). Most studies suggest flaking sorghum below 28 to 30 lbs/bu does not improve cattle performance due to reduced DMI and ADG. Likewise, given the increased electrical costs and lower animal production rates associated with milling sorghum to a lower bulk density, a bulk density of 28 lbs/bu is the most efficient flake density to feed finishing cattle (Reinhardt et al., 1997; Swingle et al., 1999). Most consulting nutritionists recommend feeding steam-flaked sorghum with a 26 lb/bu flake density (Samuelson et al., 2016).

SORGHUM VARIETIES & TANNIN

High tannin or 'bird resistant' sorghum varieties are grown in certain regions of the world. However, **commodity grain sorghum grown in the United States has no detectable levels of tannin (U.S. Grains Council, 2017)** Tannin can have either a positive or negative impact on ruminants when consumed based on quantity, chemical structure and the physiological status of the animal consuming them. Frutos et al. (2004) reviewed digestive mechanisms pertaining to the consumption of tannins by ruminants. Tannins are known for their ability to bind to proteins within the rumen and thereby, reduce the immediately degradable protein fraction. Cattle feeding studies have reported reduced protein digestibility (McCollough and Brent 1972; Streeter et al. 1990), reduced starch digestibility (Hahn et al., 1984) and poorer animal performance (Maxson et al., 1973; Larrain et al., 2009) when a high-tannin sorghum variety was fed. However, given that low/no-tannin varieties are now grown in the U.S., reduced animal performance due to high-tannin sorghum is no longer an issue.

EFFECTS ON ANIMAL PERFORMANCE

Any grain or starch source can be utilized to produce ethanol. In the U.S., corn is the primary grain used in the ethanol fermentation process. Sorghum grain is the second most common grain used to produce ethanol (Wang et al., 2008), especially in areas with lower annual rainfall. Starch comprises about two-thirds of these grains. When the starch within the grain is removed and converted to ethanol, the remaining nutrients within the byproduct, such as protein, fat, fiber and minerals, are concentrated approximately threefold. Because sorghum has more protein and fiber than corn, these differences in nutrient content are reflected in the distillers grain.

The solubles from the distillation process are typically added back to the distillers grains to create distillers grains with solubles (DGS) product, but the amount added back to the distillers grains may vary and thus reduce nutritional composition and consistency of the byproduct. Distillers grains can also be dried (dried distillers grains with solubles; DDGS) at various temperatures and timeframes for transport which may affect nutritive value. Likewise, new ethanol processing technologies, such as oil recovery, may further add to nutritionally inconsistent byproducts between plants and likely contribute to some of the varying results observed in animal feeding trials.

Currently, there are no defined grading systems or regulated quality standards to indicate the nutritional value of DDGS. For decades, color has been used as a subjective measurement of corn DDGS quality, with a lighter, golden colored product having a perceived higher value than a darker product. When feed ingredients are overheated during the production process, chemical (Maillard) reactions can occur between sugars and amino acids (especially lysine) which render them less digestible in monogastric animals, such as poultry and swine. The characteristics of feed ingredients that have been overheated include a darker color, dry matter greater than 90 percent, burned flavor and smoky smell. Numerous research studies have been conducted to determine the correlation between corn DDGS quality and color (Cromwell et al., 1993; Batal and Dale, 2006; Urriola et al., 2013). Results indicate that while some nutritional components are correlated with color, color should not be the only or the best indicator of DDGS quality. Likewise, because sorghum grain color can vary from red to white, the resulting DDGS product can also vary in color due to the parent grain and not simply due to the ethanol fermentation/heating process' impact on nutritional value. As a result, color is not a reliable indicator of sorghum DDGS quality.

TABLE 8. FEEDLOT AND DAIRY CATTLE PERFORMANCE WHEN FED SORGHUM DISTILLERS GRAINS COMPARED TO CORN DISTILLERS GRAINS.

INVESTIGATOR	CORN-BASED DIET[1]	DGS INCLUSION RATE	PRODUCT FORM	RESPONSE CRITERIA	RELATIVE VALUE, PERCENT OF CORN
AL-SUWAIEGH ET AL., 2002	DR	30%	WET	DMI ADG G:F	107 104 97
DEPENBUSCH ET AL., 2009	SF	15%	DRY	DMI ADG G:F	101 102 101
	SF	15%	WET	DMI ADG G:F	102 102 99
MAY ET AL., 2010	SF	15%	WET	DMI ADG G:F	106 101 96
	SF	30%	WET	DMI ADG G:F	102 99 97
WOOD ET AL., 2011	HM	20%	DRY	DMI ADG G:F	102 95 90
OPHEIM ET AL., 2016	SF	25%	DRY	DMI ADG G:F	96 89 93
	SF	25%	WET SORGHUM; DRY CORN	DMI ADG G:F	100 98 98

[1]BASE DIET HAS EITHER DRY-ROLLED CORN (DR), STEAM-FLAKED CORN (SF) OR HIGH MOISTURE CORN (HM).

SORGHUM DISTILLERS GRAINS

DGS IN BEEF CATTLE DIETS

The expansion of the U.S. ethanol industry in recent years has increased the amount of grain byproducts on the market today, with the most common byproduct being DGS. As a result, over 95 percent of consulting feedlot nutritionists are including DGS in their rations. The use of wet DGS is more common than the use of dry DGS (70.8 percent and 16.7 percent, respectively) in finishing rations that utilize grain byproducts (Samuelson et al., 2016). The drying process may damage proteins, volatilize compounds, and create binding cross linkages within the starch:protein matrix, all of which have the potential to lower the feeding value of the dry DGS product.

Both corn and sorghum DGS are common feedstuffs used in beef cattle diets. However, few studies have directly compared cattle performance due to grain type, physical form (wet vs dry product) and inclusion rates when sorghum DGS was fed. Studies evaluating sorghum-based DGS have reported variable results (Table 8). Inconsistent findings may be the result of differences in the quality and quantity of solubles added back to the DGS, technology differences used at the plants (such as oil recovery) and many others.

SORGHUM DISTILLERS GRAINS

Olentine (1986) reviewed numerous factors that can impact the nutritive value of DGS. In addition, the digestibility of the DGS can be affected by the rumen environment. Different dietary attributes (basal diet grain type, grain processing, grain inclusion levels, roughage source, roughage level, etc.) can also modify rumen pH and microbial fermentation of DGS.

Recommended inclusion levels of distillers grains vary. In a meta-analysis conducted by Klopfenstein et al. (2008), the authors suggest that feed efficiency was maximized between 30 and 50 percent inclusion of wet corn DGS compared to 10 to 20 percent dry corn DGS in feedlot cattle diets. Grain processing method (dry-rolled or steam-flaked corn) of the basal diet has also been shown to impact recommended inclusion levels of DGS because of the improved feeding value of steam-flaked compared to dry-rolled corn-based diets (Klopfenstein et al., 2008). Opheim et al. (2016) reported lower feeding values of dry sorghum DGS compared to dry corn DGS when fed at 25 percent of the diet, but the wet sorghum DGS product was significantly more digestible than the dry sorghum DGS product, which improved animal performance. In a similar study, when wet corn and sorghum DGS produced at the same ethanol plant were included at 30 percent DM in a finishing ration, DMI was higher for the wet sorghum DGS, but ADG and feed efficiency were not different (Al-Suwaiegh et al., 2002). Studies that have fed sorghum DGS at moderate levels (≤ 15 percent) have found no difference in animal performance due to grain type or between a wet or dry byproduct (Depenbusch et al., 2009; May et al., 2010). Even though direct comparisons between wet and dry DGS sorghum byproducts are lacking, it is generally thought wet DGS has a higher feeding value than dry DGS. This is also likely the reason Klopfenstein et al. (2008) recommends higher inclusion levels of wet compared to dry corn DGS byproducts. Further evaluation of sorghum DGS in finishing cattle diets is needed.

Studies evaluating finishing cattle on corn or sorghum DGS have found few differences in carcass characteristics between the different grain sources (Al-Suwaiegh et al., 2002; Depenbusch et al., 2009; May et al., 2010; Wood et al., 2011; Opheim et al., 2016). Likewise, Gill et al., (2008) reported feedlot rations containing 15 percent of corn or sorghum DGS, in either a wet or dry form, had no impact on Warner-Bratzler shear force or beef sensory attributes, indicating grain source did not impact the final beef product intended for human consumption.

SORGHUM DISTILLERS GRAINS

In addition to the finishing cattle sector, cattle on forage-based systems (calves, yearlings, developing heifers and cows) can also incorporate DGS into their production systems. Distillers grains resulting from sorghum generally have a greater crude protein content compared to corn. Forages are often low in protein and phosphorus, especially when dormant. Through a supplementation program, deficiencies in protein, energy and phosphorus can be met with sorghum DGS. Because the starch has been removed, DGS should not have a negative impact on fiber digestion like a cereal grain would have.

CONCLUSIONS

Corn is the most common cereal grain used as an energy source in beef cattle finishing diets in the U.S. Therefore, most research studies have compared sorghum's feeding value to corn. Feedyards are often located in areas with reduced rainfall. Sorghum is well adapted to areas with reduced rainfall and/or irrigation. Therefore, in these areas, locally grown sorghum can provide a cost-efficient replacement for corn in feedlot rations. Research studies indicate cattle fed properly processed sorghum can have similar daily gains as those fed corn. Processing is critical to achieve maximum utilization of sorghum, and a flake density of 26 to 28 lb/bu is recommended. The use of moisture, heat and pressure to disrupt the starch:protein matrix has been shown to improve the energy value 12 to 15 percent for steam-flaked sorghum compared to dry-rolled sorghum (Owens et al., 1997; Theurer et al., 1999a). The improved utilization of starch in the rumen also increases rumen microbial protein synthesis. Increasing the availability and digestibility of microbial protein in the small intestine improves beef cattle performance. Feeding steam-flaked sorghum and sorghum byproducts to cattle is generally considered to result in similar animal performance as compared to corn, although studies utilizing

CONCLUSIONS

minimum processing met have found an advantage for corn as compared to sorghum.

With the growth of the U.S. ethanol industry, some ethanol plants located in the Midwest and Southwest utilize sorghum as a feedstock because it is readily available and more cost effective than corn. The resulting sorghum byproduct can be used in the cattle feeding sector as a source of energy and protein. The difference in nutrient composition between sorghum DGS and corn DGS is similar to the nutritional differences between the two parent grains. While a number of animal studies have been conducted, results comparing sorghum to corn DGS indicate some inconsistencies. Challenges with feeding DGS are likely due to small differences in any of the processes within plants over time and between plants, such as the quality and quantity of solubles added back, oil recovery, extent of fermentation, drying temperatures and others. Additional research in this area will increase the confidence of animal nutritionists when incorporating sorghum DGS in rations.

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