Sorghum in Dairy Cattle Production
Feeding Guide

When determining the value of your feedstuffs it is important to remember:

- ***Color only matters when you don't know the nutritional value of your dry distillers grain product.***

- ***You should ask your distillers marketer for your dry distillers grain nutritional facts.***

Sorghum in Dairy Production Feeding Guide

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SORGHUM CHECKOFF SM

Feeding Value of Sorghum Grain and Forage in Dairy Diets

Introduction

Sorghum, both grain and forage, is an important feedstuff for livestock. In general, sorghum has been raised in areas like western Kansas where the precipitation does not support the economical production of corn or other crops, which would require almost twice the moisture as sorghum. Over the past 10 years, U.S. producers have harvested an average of nearly 7 million acres of sorghum for grain resulting in over 350 million bushels of annual grain production. In addition, just over 350,000 acres have been harvested for silage. Sorghum grain can be utilized in the rations of dairy cattle as a replacement for corn. Although research has shown sorghum grain to be comparable to corn in lactating dairy cow diets, the market often values sorghum less than corn. Over the last 10 years, sorghum price has lagged behind corn by about $0.12 per bushel resulting in an average loss to sorghum producers of $42 million each year. In 2008, the spread between corn and sorghum price increased to $0.70 per bushel reducing the value of the crop by over $330 million. Discounting the value of sorghum is not justified by the data from many research studies. However, livestock producers and the market place continue to discount the value of sorghum in the diets of dairy cattle. A comprehensive review of the published literature concerning the performance of lactating dairy cattle and heifers when fed sorghum grain, sorghum forage and sorghum distillers grains are needed to help educate livestock producers and other professionals on the true value of sorghum to the dairy industry. The following is a review and summary of the published research concerning the use of sorghum grain and forage in the diets of dairy animals with an emphasis on the published research from the past 15 years.

"Sorghum contains more crude protein than corn..."

GRAIN

NUTRIENT COMPOSITION OF SORGHUM GRAIN AS COMPARED TO CORN, BARLEY AND WHEAT

Barley, corn, sorghum and wheat are all potential sources of energy for dairy animals. Depending upon local climatic conditions, one grain may be preferred over another. Corn is usually the energy source of choice. However, some climatic conditions may limit or negate its productivity. Average nutrient values for sorghum, corn, barley and wheat are reported in Table 1. Values were obtained from two National Research Council (NRC) publications (NRC, 1996 and 2001) 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. The Forage One data is the average reported value for all samples analyzed from May 2000 through April 30, 2010. Crude protein levels from samples analyzed by Dairy One are lower for all grains as compared to the NRC values. This is likely due to an increase in starch levels due to increasing grain yield over the past couple of decades. Sorghum contains

more crude protein than corn but less than that found in barley or wheat. Fiber, as measured by acid detergent fiber (ADF), is lowest for corn and wheat and higher for sorghum and barley. The values for sorghum and barley are variable and may be a reflection of an increased proportion of seed coat to endosperm and germ as compared to corn or wheat. This also likely contributes to the overall greater level of ADF found in the sorghum and barley. While differences exist, these are small and would not have a large negative effect on ruminant digestion. Energy values are expressed in terms of net energy for maintenance (NEm), gain (NEg) and lactation (NEl). These are a reflection of how an animal would utilize energy from the feedstuffs. Comparing the NRC value to the more recent laboratory values, it appears that the levels have increased. This is likely due to changes in plant genetics and agronomic practices which yield greater levels of starch today than in the past. Sorghum and corn are very comparable in terms of energy. Tabular values indicate a slight advantage for

"Sorghum and corn are very comparable in terms of energy."

Table 1. Comparison of nutrient values obtained from three sources

Item	Grain	Beef NRC[1]	Dairy NRC[2]	Dairy One[3]
Crude Protein, %	Sorghum	12.60	11.60	10.53
	Corn	9.80	9.40	9.20
	Barley	13.20	12.40	12.22
	Wheat	14.20	14.20	13.67
Acid Detergent Fiber, %	Sorghum	6.38	5.90	7.90
	Corn	3.30	3.40	3.63
	Barley	5.77	7.20	7.62
	Wheat	4.17	4.40	4.72
NEm[4], Mcal/lb	Sorghum	0.91	0.88	0.96
	Corn	1.02	0.93	1.00
	Barley	0.93	0.92	0.89
	Wheat	0.99	0.98	0.93
NEg[5], Mcal/lb	Sorghum	0.61	0.59	0.65
	Corn	0.70	0.63	0.69
	Barley	0.63	0.62	0.60
	Wheat	0.68	0.67	0.63
NEl[6], Mcal/lb	Sorghum	-----	0.82	0.91
	Corn	-----	0.87	0.94
	Barley	-----	0.84	0.85
	Wheat	-----	0.90	0.88
Ash, %	Sorghum	1.87	2.00	1.92
	Corn	1.46	1.50	1.55
	Barley	2.40	2.90	2.93
	Wheat	2.01	2.00	1.97

[1]Nutrient Requirements of Beef Cattle, 1996
[2]Nutrient Requirements of Dairy Cattle, 2001
[3]Dairy One Forage Laboratory, 2010
[4]Net Energy of Maintenance
[5]Net Energy of Gain
[6]Net Energy of Lactation

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 genetics, grain sources should be analyzed and the resulting nutrient profiles used to formulate animal diets rather than utilizing the tabular values.

UTILIZATION OF SORGHUM GRAIN IN LACTATING DAIRY COW DIETS

Sorghum grain can be an effective source of starch for dairy cattle. Starch is the primary energy source in dairy cow diets when feeding for high levels of milk production. Utilization of starch in the rumen is a primary concern for improving milk yield and efficiency of production. As a result, determining and understanding the ruminal fermentation patterns of various grain sources is important when attempting to achieve high levels of milk production and increasing production efficiency.

Ruminal fermentation patterns of dry matter, crude protein and starch varies for different grains. Figures 1, 2 and 3 demonstrate the observed differences in the rates of fermentation of five grains. In all cases, sorghum ferments slower than other grains. It does reach a similar point after 48 hours of ruminal exposure. However, it takes a longer residence time in the rumen to reach this point. In some cases, a mixture of grains may provide a more optimal ruminal fermentation pattern than a single grain. For example, a small amount (1-2 pounds) of wheat, barley or oats added to a TMR will increase the amount of starch available immediately after feeding. When combined with either corn or sorghum, this provides a higher and more stable level of rumen available starch over the span of time between feedings. This often has a positive effect on milk production and efficiency of production.

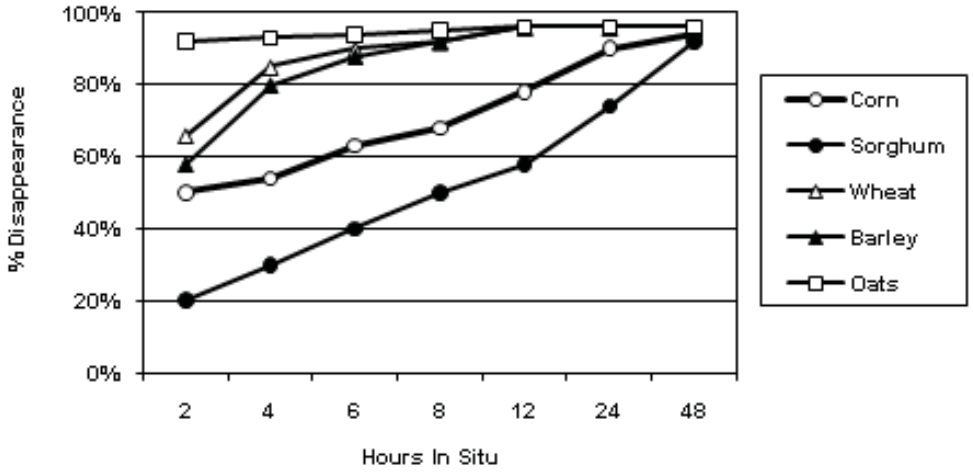
"...sorghum and corn can be interchanged in the diet of lactating dairy cows..."

The differences in ruminal fermentation of sorghum grain are the result of a starch-protein matrix, which is more resistant to moisture and enzyme penetration than that of corn or other grains (Herrera-Saldana et al., 1990 and Theurer, 1986). For many years, sorghum was considered to be of lesser value than corn due to its decreased digestibility when either dry rolled or ground. However, this decreased digestibility did not always result in a significant decrease in milk production when feeding rolled or ground grains (Mitzner et al., 1994). There is a wealth of data that supports the replacement of corn with sorghum in lactating cow diets without decreasing milk production or performance (Mitzner et al., 1994 and Theurer et al., 1999). Mitzner and coworkers (1999) fed rolled and finely ground corn and sorghum and observed no differences in dry matter intake, milk yield, milk fat percentage or body weight due to the source of grain. Based on this evidence and others, it can be concluded that sorghum and corn can be interchanged in the diet of lactating dairy cows. However, processing should be considered and can be found in the "Effects of Thermal Processing on Animal Performance" section of this guide.

UTILIZATION OF SORGHUM IN DRY COW DIETS

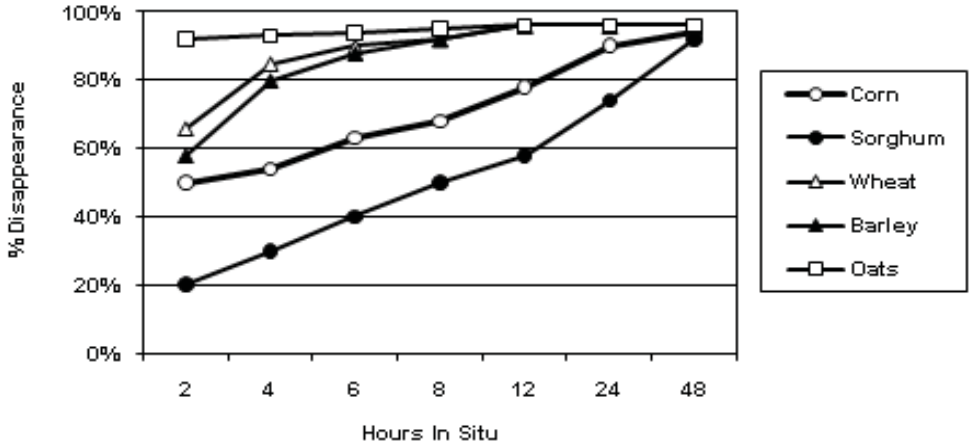
Specific references to the feeding of sorghum grain to dry dairy cows were not found. However, it could be assumed that the relationships found in lactating dairy cattle

Figure 1. In situ dry matter disappearance of five grains.



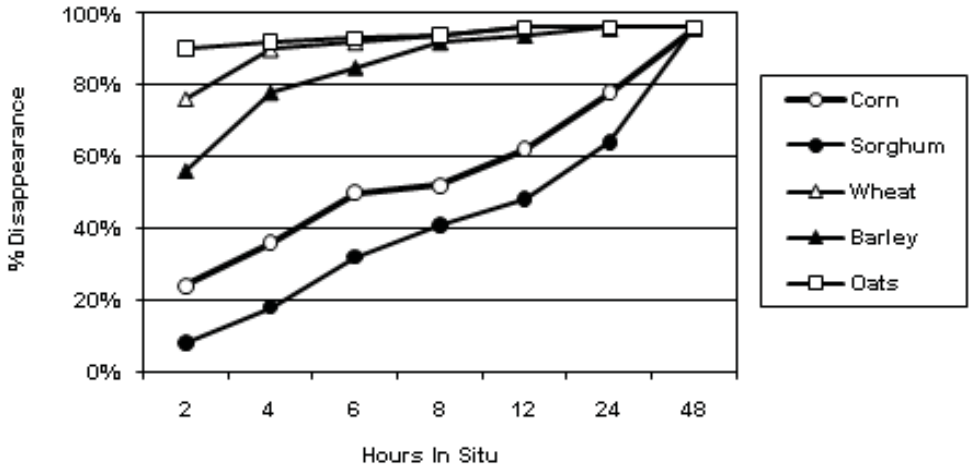
(Adopted from Herrera-Saldana et. al, 1990)

Figure 2. In situ crude protein disappearance of five grains.



(Adopted from Herrera-Saldana et. al, 1990)

Figure 3. In situ starch disappearance of five grains.



(Adopted from Herrera-Saldana et. al, 1990)

concerning the feeding of sorghum grain would apply to dry dairy cows. Feeding sorghum grain as a replacement for corn in dry cow diets would be acceptable and should not result in any adverse affects. However, it is important to apply accepted ration balancing guidelines to control energy intake during this period to avoid weight loss or excessive weight gain.

UTILIZATION OF SORGHUM IN CALF AND HEIFER DIETS

The feeding of sorghum grain to calves has been evaluated in several studies. These studies have focused on the impact of processing upon calf growth. Abdelgadir and Morrill (1995) fed sorghum grain that was raw, roasted or conglomerated. They reported no difference in calf performance due to grain processing. Khan and others (2007, 2008) utilized ground corn, ground barley, ground wheat and crimped oats at 25 percent of the calf starter dry matter. They observed calves that had been fed corn had greater body weight gain and total dry matter intake as compared to the other treatments. They also observed that feed efficiency was greater when feeding either corn or wheat as compared to the barley or oat diets. While sorghum was not one of the grain sources tested, one might speculate that sorghum grain might perform similar to corn based on the fermentation curves presented in figures 1-3. Recent research has emphasized the importance of calf growth during the first year of life. Further investigation into the impact of sorghum on calf performance is required to fully evaluate the use of sorghum in this area of production.

"Feeding sorghum grain as a replacement for corn in dry cow diets would be acceptable"

Feeding sorghum to growing dairy heifers has not been evaluated in published research; however, several studies have evaluated the use of sorghum in growing beef rations. Diets containing more than 65 percent high-tannin sorghum grain have been shown to reduce animal growth (Larrain et al., 2009; Maxson et al., 1973). Most sorghum grown today has lower amounts of tannins, so this is no longer an issue. Although, it appears that processing has an important impact on ruminal bacterial protein production. Rahnema and others (1987) reported an increase in ruminal bacterial protein production when feeding steam-flaked as compared to steam-rolled sorghum. Processing is important for utilization of the sorghum starch in the rumen. When processed, it appears that sorghum is a replacement for corn in growing diets.

EFFECT OF PARTICLE SIZE ON ANIMAL PERFORMANCE

Of the factors surrounding the use of sorghum in ruminant diets, the most researched is processing. The normal processing methods are dry-rolling, grinding, steam-rolling, steam-flaking and pelleting. Mitzner and others (1994) found no differences due to grain source when compared dry-rolling with fine grinding of both corn and sorghum. However, Bush and others (1972) reported that coarse ground sorghum resulted in lower milk production as compared to finely ground sorghum. In another report, Titgemeyer and Shirley (1997) reported that pelleting sorghum grain improved it nutritional value as compared to dry-rolled. It appears that particle size or further processing may be necessary for sorghum grain to be utilized efficiently. This becomes even more evident when considering the effects of thermal processing upon sorghum utilization.

Table 2. Steam-flaked compared to steam-rolled corn in lactating dairy cow diets.

Item	SR[1]	SF[2]	P value
Dry matter intake, lb/d	58.4	58.4	0.93
Milk, lb/d	78.9	83.8	0.02
Protein, %	2.99	3.06	0.11
Protein, kg	2.36	2.56	0.01
Fat, %	3.11	2.98	0.02
Fat, kg	2.47	2.49	0.44
Total track starch digestion, %	87.4	95.7	0.05

[1]Steam-rolled to a density of 38 lb/bu.
[2]Steam-flaked to a density of 28lb/bu.
Adapted from Threurer et al., 1999.

"...steam-flaked corn and sorghum were similar in intakes and lactation performance."

EFFECTS OF THERMAL PROCESSING ON ANIMAL PERFORMANCE

Theurer and co-workers (1999) completed a review of the literature examining the effects of thermal processing of corn and sorghum and its relationship to milk production. In summary of 19 lactation trials, they found that steam flaking of either corn or sorghum resulted in a 20 percent increase in net energy for lactation as compared to dry-rolled grains. They also concluded that the feeding value of steam-flaked corn and sorghum were similar. Summarization of 6 studies comparing steam-flaked corn to steam-rolled corn showed an increase in milk production, milk protein yield and milk fat percent when feeding steam-flaked corn (Table 2). Intakes and production efficiency were not affected by treatment and total digestive tract starch digestion was increased. The same comparison was made for sorghum with 24 studies (Table 3) and steam-flaking improved intake, milk production, milk protein percent and yield, and milk fat percent. Total digestive tract starch digestibility was also increased by 17 percent. The group then made direct comparisons of corn and sorghum (Table 4) and found that steam-flaked corn and sorghum were similar in intakes and lactation performance. Thus, from the data, corn and sorghum are both equally effective as a starch source for lactating dairy cow diets.

Researchers (Theurer et al., 1999) then examined the site and extent of starch digestion. When comparing steam-flaking to dry-rolling, they found an increase in ruminal starch digestion for both corn and sorghum. This is significant as ruminal starch digestion increases ruminal microbial protein production which can increase available protein for milk production.

The main advantages of thermal processing are an increase in ruminal starch digestion and the resulting improvement in net energy for lactation. It is estimated that when compared to dry-rolled sorghum, net energy values should be increased by 13 to 20 percent (Theurer et al., 1999).

ADDING VALUE TO SORGHUM GRAIN THROUGH PROCESSING

Processing sorghum grain by grinding, rolling, steam-rolling or steam-flaking is necessary to disrupt the protein matrix surrounding the starch granules and the disorganization of the starch granules. The greater disruption of the protein matrix and starch granules results from steam-flaking as compared to the other methods. This is because it combines moisture, pressure and heat in a consistent process, which renders a greater proportion of the starch available to the rumen microbes. Steam-flaking may increase the energy value of sorghum by as much as 20 percent. This additional energy can be utilized for greater milk production or in the case of late-lactation cows, result in a reduction of the amount of grain required in the diet. Many economic factors including local grain availability, transportation, processing cost, facilities, etc., must be considered when determining the value of additional processing on a dairy. For those dairies located near beef feedyards, it may be possible for the feedyard to steam-flake grain for the dairy. In many cases, the feedyard may have excess flaking capacity and be willing to flake grain for the dairy producer.

"Steam-flaking may increase the energy value of sorghum by as much as 20 percent."

Table 3. Steam-flaked compared to steam-rolled sorghum in lactating dairy cow diets.

Item	SR[1]	SF[2]	P value
Dry matter intake, lb/d	56.4	55.3	0.23
Milk, lb/d	78.5	82.5	0.01
Protein, %	2.95	3.02	0.01
Protein, kg	2.34	2.51	0.01
Fat, %	3.20	3.03	0.01
Fat, kg	2.51	2.51	0.90
Total track starch digestion, %	83.7	97.1	0.01

[1]Steam-rolled to a density of 38 lb/bu.
[2]Steam-flaked to a density of 28lb/bu.
Adapted from Threurer et al., 1999.

Table 4. Steam-flaked corn and sorghum grain in lactating dairy cow diets.

Item	SFS[1]	SFC[2]	P value
Dry matter intake, lb/d	57.1	57.6	0.82
Milk, lb/d	80.5	81.4	0.84
Protein, %	2.96c	3.00	0.58
Protein, kg	2.38	2.43	0.71
Fat, %	3.19	3.11	0.45
Fat, kg	2.56	2.51	0.81
Total track starch digestion, %	98.6	97.9	0.86

[1]Steam-flaked sorghum to a density of 28 lb/bu.
[2]Steam-flaked corn to a density of 28lb/bu.
Adapted from Threurer et al., 1999.

NUTRITIONAL ADVANTAGES OF SORGHUM GRAIN IN DAIRY DIETS

Sorghum contains more crude protein than corn. Based on the reported values, each pound of sorghum will provide and additional 0.013 pounds of crude protein over corn. If feeding 12 pounds of grain each day, this amounts to about 0.15 pounds of crude protein which could replace about 0.3 pounds of soybean meal. At $350/ton for soybean meal, this amounts to about $0.05/cow each day. Amino acid quality is not as important for ruminant animals as most of the sorghum protein should be converted into microbial protein in the rumen. Sorghum does have a slightly greater ash content than corn, but it will have minimal effects upon the mineral supplementation of dairy diets. Thus the main advantage would be the opportunity to reduce the supplemental crude protein level of the diet if sorghum is replacing corn.

SORGHUM FORAGE

"Sorghums have an advantage over corn of a shorter growing season..."

Sorghum can also be grown either as a grain or forage crop. In some instances both sorghums have an advantage over corn in that they require less water, are more drought tolerant, have less input costs, and because of their regrowth potential, can be harvested multiple times. They fit well into dryland and limited irrigation situations because of their tolerance to drought. It is in these systems that sorghums may have the greatest potential. If managed properly, they make excellent hay for supplemental feeding during times of inadequate forage production. Perhaps the greatest advantage of sorghum is the diversity of management options that the grower has to choose from in order to match his production needs. Depending on which species and variety selected, sorghum may be used for grazing pasture, hay production, silage and green-chop. Their ability to tiller and regrow after cutting or defoliation makes them ideal for multiple cut hay crops and grazing situations. The sorghum species that are generally considered for silage fall into three main categories: forage sorghum, grain sorghum, and sorghum-sudangrass hybrids. Forage sorghums are the most popular for use as silage.

Forage sorghum silage production studies have been conducted since 1999 at the Texas Agricultural Experiment Station, near Bushland, Texas. Studies have compared forage sorghum types and varieties for agronomic characteristics, water use efficiency, standibility, forage and grain yield, and nutritional value. Comparisons were also made to corn varieties planted in an adjacent trial. Key production practices in growing quality forage sorghum silage are: 1) variety selection, 2) utilize management practices that minimize lodging, and 3) timely harvest. The key advantage for forage sorghum over corn for silage its ability to produce high quality silage under low water input conditions.

VARIETY SELECTION

Forage sorghum types range from sudangrass to traditional grain sorghum. In addition, forage sorghums can be brown midrib (BMR) or photoperiod sensitive (PS). Which type and variety that is best utilized will depend on its end use. For silage pro-

duction, generally forage sorghums rather than sudangrass or sorghum/sudangrass hybrids are the best choice. Within the forage sorghums, both BMR and non-BMR varieties can produce quality silage. BMR sorghums, as the name implies, have a brown midrib. More importantly they have less lignin content in the plant making them, on average, higher in digestibility than non-BMR sorghums. Average in-vitro digestibility (IVTD) of BMR varieties has been higher than non-BMR varieties (Table 5). On average, the BMR varieties have yielded 10 to 11 percent less in most years than non-BMR varieties. However, in recent studies the gap between the yield of BMR and non-BMR varieties appears to be narrowing. PS varieties stay in the vegetative stage until day length becomes less than approximately 12 hours and 20 minutes. In the Texas Panhandle environment, these varieties consistently produced the highest yield but lowest digestibility. Another problem with the PS varieties has been high moisture at harvest making them unsuitable for silage unless the crop was dried prior to ensiling.

It is important to note that there is a considerable amount of overlap between BMR and non-BMR varieties in respect to yield and digestibility. It would be a mistake to assume that BMR varieties are always superior in digestibility than non-BMR varieties and that thier yield will always be less. When choosing a variety it is important to examine a particular variety's characteristics rather than assuming anything based on it being a BMR or non-BMR variety.

"... sorghum forages offer the advantage of reducing ration cost as compared to shipping forages from other areas."

Table 5. Forage sorghum in-vitro digestibility and yield by type (2000-2004). McCollum et al.

Characteristic		Non-BMR[1]	BMR	PS	SEM	P value
Yield, tons DM/ac	Mean	8.5a	7.5b	10.7c	0.45	<0.001
	s.d.	1.8	1.8	2.9		
IVTD, % DM	Mean	76.2a	80.7b	68.5c	0.90	<0.001
	s.d.	4.3	2.3	2.6		

[1]Non-BMR, n = 154 entries; BMR, n = 99 entries; PS, n = 17 entries.

MINIMIZING LODGING

The perception among many producers is that lodging is worse with the BMR varieties. In research studies this has not been observed (Bean 2006). It is true, however, that a higher percentage of the BMR varieties tend to have at least some observable lodging compared to the non-BMRs (Figure 1). Lodging can be minimized by variety choice, not over fertilizing with nitrogen (N), and planting a lower seeding rate. In 2003, two BMR varieties were planted at three seeding rates (30,000, 60,000 and 120,000 seed/acre) and fertilized at two N rates (50 and 100 lbs/acre) (Figure 2). The BMR 106 variety had very little lodging regardless of N or seeding rate. However, lodging of BMR 100 was greatly increased at the higher N and higher seeding rates. If a variety is being grown that has a tendency to lodge, N fertilizer rate should be carefully monitored. The recommendation for N fertilization is eight to nine pounds of N per ton of expected yield (at 65 percent moisture). Be sure and subtract from the fertilizer recommendation any residual N that is in the soil. Seeding rates had a very large influence on lodging. As seeding rates increased, so did lodging.

Lowering the seeding rate will clearly help if lodging is an anticipated problem. Results suggest that lowering seeding rate, to 60,000 - 80,000 seed/acre, will normally not reduce yield and significantly reducing lodging under most conditions.

TIMELY HARVEST

Harvesting forage sorghum at the correct stage is essential in producing quality silage and to minimize lodging. Ideally forage sorghum should be harvested when the whole plant moisture content is between 63 and 68 percent. With grain producing forage sorghums the correct moisture content is generally reached when the grain has reached the soft dough stage.

"Harvesting forage sorghum at the correct stage is essential in producing quality silage and to minimize lodging."

Figure 1

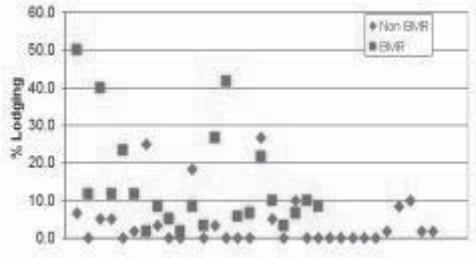


Figure 2

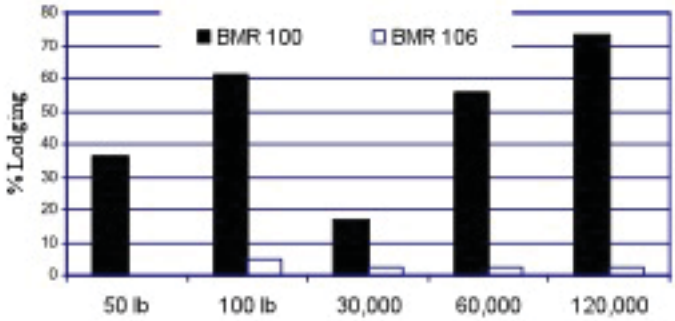


Figure 2. Nitrogen & Seeding Rate Effect on Lodging of BMR 100 and BMR 106 Forage Sorghum Varieties.

WATER USE EFFICIENCY

Forage sorghum silage yields have been similar to those of corn while using 30 to 40 percent less irrigation water. In trials conducted in 2003 and 2004, sorghum silage yield increased approximately 0.75 ton/acre (at 65 percent moisture) for every inch of watered used by the crop. This included water stored in the soil, rainfall and irrigation.

NUTRITIONAL COMPARISONS

Since 2000, researchers have conducted variety tests and other designed trials with normal, BMR, PS, and PS-BMR forage sorghums and sorghum-sudangrasses at the Texas AgriLife Research facilities near Bushland, Texas (approximately 10 miles west of Amarillo). In the variety trials the entries are determined by the companies that submit the materials for testing. Each year there have been varied numbers of

sorghum-sudangrass hybrids, forage sorghums, and varied numbers of varieties from the BMR, PS, and PS-BMR types. Five years of information focusing primarily on forage sorghums were summarized by McCollum et al. (2005). Another four year series of data for sorghum-sudangrasses and forage sorghums is currently being compiled and summarized for publication (B. Bean, unpublished). The following Table 6 and discussion highlights observations from this work. Complete descriptions and summaries of annual variety trials and other field research can be accessed at http://amarillo.tamu.edu.

There is a great deal of variation within a type (i.e. sorghum-sudangrass, forage sorghum or BMR, etc.). Although an average value for one type may be different from or similar to another type, there are many exceptions when the varieties within types are examined. It is highly recommended that any decisions made be based on varietal comparisons rather than general characteristics of the type of forage.

"...lignin concentrations were lower in the BMR types compared to the normal types of sorghum-sudangrass and forage sorghum..."

FIBER AND LIGNIN

Comparing the averages for sorghum-sudangrasses to the forage sorghums, NDF and ADF concentrations were similar and the BMR types were similar to the normals. Although the fiber concentrations were similar, lignin concentrations were lower in the BMR types compared to the normal types of sorghum-sudangrass and forage sorghum, respectively. The PS types contained 11-14 percent units more NDF and 7-9 percent more ADF than the normal and BMR types.

Table 6. Quality parameters of BMR and non-BMR sorghums and corn grown in Bushland (Bean et al. 2001). http://amarillo.tamu.edu

Type		CP (%)	ADF (%)	NDF (%)	Lignin (%)	IVTD (%)
BMR		9.2	27.6	45.9	3.6	81.3
	Range	6.9-10.5	24.3-35.0	40.7-60.1	2.8-4.5	75.1-84.2
Non-BMR		8.3	29.9	49.1	4.4	75.5
	Range	6.3-10.8	21.3-41.7	33.9-67.5	2.7-6.4	60.9-83.6
Corn		9.0	23.9	41.2	3.5	82.7

IN-VITRO TRUE DIGESTIBILITY

Across all observations for the sorghum-sudangrasses and forage sorghums, IVTD was similar for the normal types. In the sorghum-sudangrasses, IVTD for the BMR and normal types were similar (about 76 percent); however in the forage sorghums, IVTD was 5.2 percent higher for the BMR types compared to the normal types. Across the years, IVTD for the pre-ensiled corn silage has been 81-83 percent. The average value for the normal and BMR types of forage sorghums across this time has been about 76 percent and 81 percent, respectively.

The PS trait is associated with lower IVTD. Digestibility across PS types of sorghum-sudangrass was about 6 percent lower than normal types. In the forage sorghums, IVTD of the PS-BMR types was similar to the normal types but about 5 percent lower than the BMR types.

IN-VITRO NDF DIGESTIBILITY

Averaged across varieties, normal types of sorghum-sudangrasses and forage sorghums had similar NDFD (approximately 50 percent). The NDFD of the BMR types of sorghum-sudangrasses was similar to the normal types. However, in the forage sorghums, NDFD of the BMR types was over 8 percent units greater than observed for the normal types. The difference in NDFD in the forage sorghums reflects the lower lignin content and contributed to the higher IVTD noted for the BMR forage sorghums compared to normal.

Although the PS types had higher NDF concentrations, the observed NDFD was not different than the normals. The lower IVTD of the PS types may simply be due to a higher total fiber concentration.

"...where water is limited or producers desire to conserve or reallocate available water, these forages are an alternative to other crops..."

USING ADF TO ESTIMATE ENERGY VALUES

The relationship between ADF and IVTD for BMR and normal types of forage sorghums was evaluated using indicator regression (McCollum et al., 2005). The regression equations for the BMR and normal types were different (intercept, $P=0.09$; slope, $P<0.01$). Consequently, energy values estimated using equations based soley on ADF do not reflect the higher digestibility of the BMR types and hence underestimate the energy value of the BMR forages. Prediction equations should incorporate estimates of fiber digestibility as well as fiber concentration.

GRAIN CONTENT

The grain production potential varies widely among the forage sorghums. Typically, it is presumed that higher grain content will improve the nutritional value of silage. However, this presumption is usually based on observations within a variety (i.e. silages from a single variety but with varied amounts of grain). This same concept may not apply to comparisons among varieties with differing forage quality.

The percent grain in pre-ensiled forages were compared to the IVTD of the pre-ensiled forage (McCollum et al., 2005). The relationships were evaluated using nonlinear regression techniques. IVTD of the normal forage sorghums increased quadratically and plateaued at 78 percent IVTD and 34.5 percent grain. In contrast, IVTD plateaued at 80.8 percent IVTD when grain content was 2 percent. Varietal differences in grain content appeared have greater influence on IVTD of the non-BMR forage sorghums than on the BMR forage sorghums.

CONCLUSIONS

Forages in the sorghum group require less total water to reach their production potential. In environments where water is limited or producers desire to conserve or reallocate available water, these forages are an alternative to other crops such as corn silage. The PS forage sorghums yield well and utilize water efficiently. However,

their relatively low digestibility and high fiber may limit their broad application. The PS types may be best placed in situations where cattle have lower nutrient requirements. They might also fit into a finishing program in which they trade with corn silage on an NDF basis and corn is added back to the diet. On average, the BMR varieties have higher average IVTD and NDFD than the normal varieties. However, there is a great deal of variation among individual varieties, and decisions must be made based on individual varieties rather than a broad type category. Research has shown that there are forage sorghum varieties that are potential alternatives to corn silage for growers, with limited irrigation capacity or greater risk aversion. (Bean and McCallum 2006)

In the past two decades there has been an increased interest in the BMR genotypes which have greater neutral detergent fiber digestibility than normal genotypes. This is important because corn silage usually contains a greater amount of digestible nutrients than sorghum silage. Incorporation of the BMR genotype may reduce this difference. Some recent studies have reported similar milk production from BMR sorghum silages as compared to corn silage (Aydin et al., 1999; Oliver et al., 2004). Dann et al. (2007) reported similar solids corrected milk when feeding BMR sorghum-sudan silage as compared to corn silage. However, they also reported a reduction in dry matter intake when feeding the sorghum-sudan as compared to corn. Feeding trials in the Texas Panhandle with lactating dairy cows and finishing cattle have demonstrated the potential to replace corn silage with the BMR forage sorghums without losing production. (Hough et al. 2003) However, the variation in nutrient profiles observed suggests that the same potential exists to lose production if the varieties are not scrutinized. More research is needed to fully determine the value of BMR forages in the diets of dairy cows and heifers.

"This could enable producers to increase biomass production on limited water or create a double-crop situation following small grain harvest in early summer."

Utilization of sorghum forage as a total replacement for corn silage in lactating diets is possible. Some studies have indicated a reduction in milk yield when utilizing sorghum-sudan grasses. However, more recent studies using BMR hybrids have resulted in similar levels of production as shown in Table 7 (Contreras-Govea et al., 2010). It is likely that the results of a given experiment or a single year on a dairy farm is not enough information to make definitive decisions due to the issues associated with the influences of climate, growing conditions and management practices from growing through feeding. More research is needed in this area.

Many commercial farms are utilizing sorghum silages in the diets of dry cows and growing heifers. The main advantage of sorghum forages for dairy diets would be the reduction in water required for growing the crop. This could enable producers to increase production on limited water or create a double-crop situation following small grain harvest in early summer. In areas with limited resources for growing corn silage, sorghum forages offer the advantage of reducing ration cost, as compared to shipping forages from other areas. Sorghum forages also offer better control of weight gain in growing and dry cattle.

Table 7. Fat corrected milk (4% FMC, kg day-1) of normal and BMR forage sorghum and corn silage.

Reference	Normal	bmr-6	bmr-12	bmr-18	Corn
Browning & Lusk (1966)	16.2a				16.1a
Lusk et al. (1984)					
Experiment 1			22.3a		21.7b
Experiment 2			24.7a		23.7a
Grant et al. (1995)	17.9b	26.2a			26.6a
Oliver et al. (2004)	29.16b	33.7a		31.2ab	33.3a
Aydin et al. (1999)					
Experiment 1	20.7c	23.7b			29.0a
Experiment 2	31.4b	33.8a			32.4ab

DISTILLERS GRAIN

VALUE OF SORGHUM DISTILLERS GRAINS IN DAIRY DIETS

"...in some areas of the Midwest and Southwest, sorghum is available and more cost effective..."

Distillers grains are a good source of protein and energy for lactating dairy cattle (Schingoethe et al. 2009). Many lactating dairy cows are fed 3 to 5 pounds of distillers grains each day. It is also used in the calf and heifer diets. Most distillers grains are made from corn, but in some areas of the Midwest and Southwest, sorghum is available and more cost effective than corn. The resulting feed product is very similar except for the color due to the differences in seed coat color and the protein content. Since sorghum grain has a slightly higher concentration of crude protein, distillers grains produced from sorghum may have about 3 percent more crude protein than corn. One published report suggests that milk production and digestibility was slightly lower when sorghum distillers grains were fed as compared to corn distillers grains (Al-Suwaiegh et al. 2002). Distillers grains can vary in nutritional value due to differences in processing methods. Comparisons between corn and sorghum would only be valid if the grains were processed in the same plant under similar processing methods. However, variation in the nutrient composition of the corn and sorghum on a given fermentation run or conditions associated with an individual run could impact the nutritive value of the resulting grains. This is also an area that needs additional research to fully establish the value of sorghum distillers grains in dairy diets.

CONCLUSION

ECONOMIC ADVANTAGE OF SORGHUM IN DAIRY DIETS

The main economic advantages resulting from the utilization of sorghum grain or forage in dairy diets will likely result from savings in the cost of production as compared to corn. Most of these savings will likely be the result of less seed costs and the ability to grow sorghum on much less water than corn. For dairy producers producing their own forage and/or grain, this can be a significant savings over purchasing feedstuffs from others. For producers purchasing feedstuffs, the question is a bit more complicated. In areas with limited rainfall or irrigation water, sorghum offers

that advantage of reduced transportation costs associated with locally grown feedstuffs. Research has shown that when processed correctly, sorghum is equal to corn for lactating dairy cattle. Therefore, one could assume that sorghum grain should be equal to the value of corn in the same region, whether locally grown or transported from another area. However, lack of producer knowledge and in some cases the lack of available research data continues to undervalue sorghum grain and forages in dairy diets.

SUMMARY

Utilization of sorghum grain in lactating dairy cow diets results in similar milk production as corn. This has been proven in numerous research trials. Processing is very important to get maximum utilization of the sorghum. Steam flaking can increase the energy value of sorghum 13-20 percent and increases the utilization of sorghum in the rumen to produce microbial protein. These increases are due to the disruption of the starch matrix and the protein matrix covering the starch due to the moisture, heat and pressure associated with steam flaking. This results in increased milk production as compared to dry rolling. Steam flaked sorghum results in similar milk production as steam flaked corn.

"Steam flaking can increase the energy value of sorghum 13-20 percent and increases the utilization of sorghum in the rumen to produce microbial protein."

Sorghum forages can also be effectively utilized in dairy diets. Brown midrib hybrids likely offer the greatest advantage to lactating dairy cattle due to the increased fiber digestibility. A few recent studies have resulted in similar milk production when brown midrib hybrids have been compared to corn silage. Additional research is needed in this area to fully address how these forages can be utilized in lactating dairy diets. Forage sorghums or sorghum-sudan grass silage can easily replace corn silage in dry cow and developing heifer diets. Sorghum silages offer an advantage over corn silage in these diets because of the need to control weight gain. Corn silage often contains too much energy and its use is limited because of its energy content. Sorghum silages will generally not have this problem.

Example Lactating Cow Diets

Item	Corn Based	Sorghum Based
	lb/dm per cow	lb/dm per cow
Alfalfa Hay	10.0	10.0
Alfalfa Haylage	5.0	5.0
Corn Silage	16.0	0
Sorghum Silage	0	15.0
Corn Grain	10.0	0
Sorghum Grain	0	10.0
Distillers Grains	3.0	3.0
Soybean Meal	6.5	5.5
Whole Cottonseed	4.0	4.0
Mineral and Vitamin	1.5	1.5
Expected Milk, lb	**85**	**85**

Example Dry Cow Diets

Item	Corn Based	Sorghum Based
	lb/dm per cow	lb/dm per cow
Wheat Straw	15.0	15.0
Corn Silage	5.0	0
Sorghum Silage	0	5.0
Corn Grain	1.0	0
Sorghum Grain	0	1.0
Distillers Grains	4.0	4.0
Mineral and Vitamin	1.0	1.0

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Sorghum in Dairy Production Feeding Guide

The goal of the Sorghum Checkoff is to provide end-users with information that will assist them in better utilizing sorghum in their operation. For more information on local opportunities to purchase sorghum, contact a local producer, grain elevator or cooperative, or contact Sorghum Checkoff Marketing Director, Florentino Lopez at florentino@sorghumcheckoff.com.

This feeding guide is based on research conducted by various universities. Always remember to check with your state extension specialist for the most beneficial program for your operation.

The Sorghum Checkoff Program is a producer-funded organization dedicated to the improvement of the sorghum industry through research, promotion and education.

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