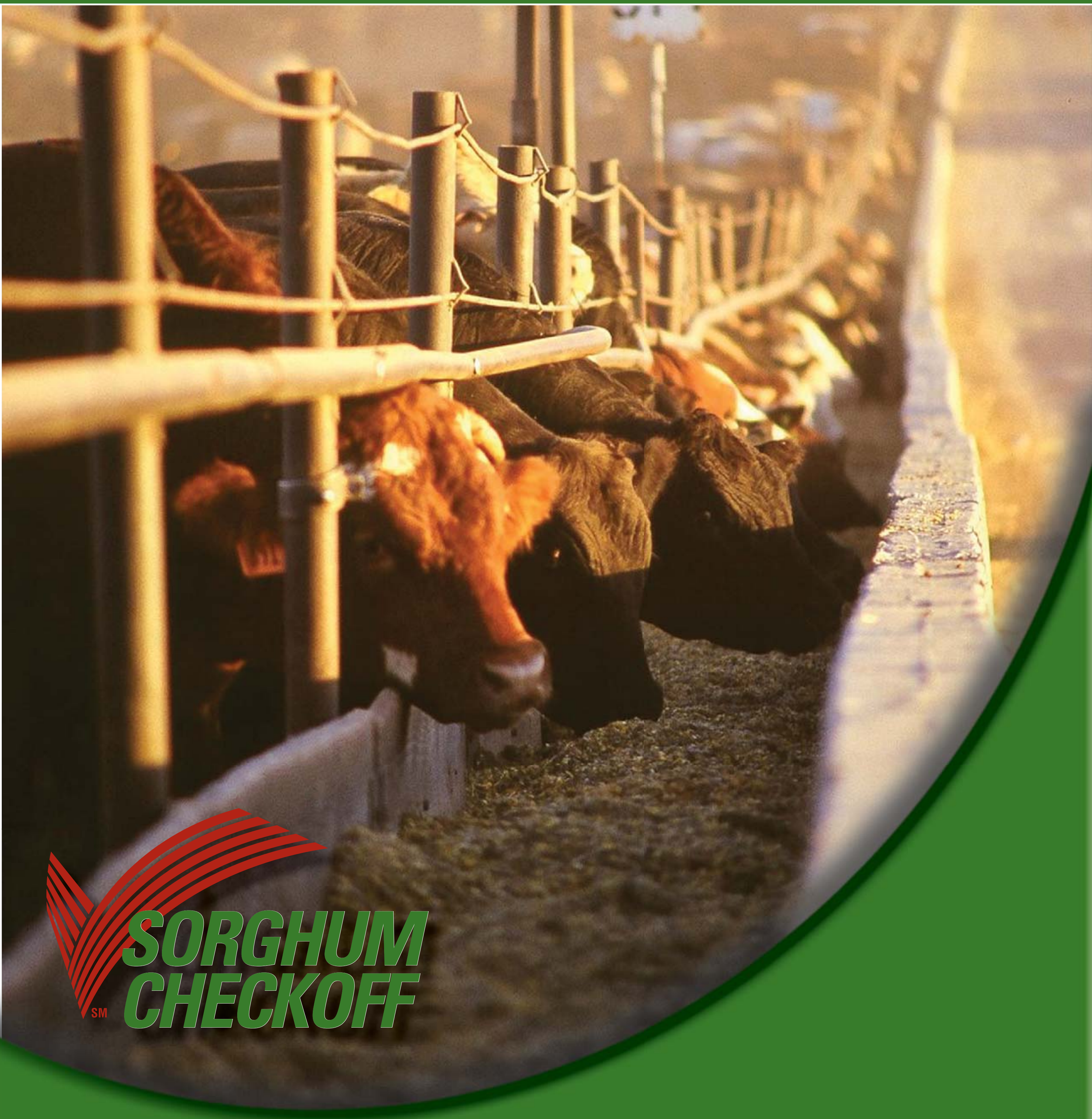
Sorghum in Beef Production Feeding Guide



SORGHUM CHECKOFF

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 compared to sorghum. Over the past 10 years, US 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 beef cattle as a replacement for corn. Although, research has shown sorghum grain to be comparable to corn in beef finishing 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 beef cattle.

"Sorghum grain can be utilized in the rations of beef cattle as a replacement for corn."

Use of sorghum in beef feedlot diets has been limited as indicated by a survey of 42 consulting nutritionists located in the Midwest, High Plains and Southwest areas of the United States (Vasconcelos and Galyean, 2007). Twenty-nine of the nutritionists completed the survey and based on self-reported numbers of animals serviced each year, the group represented about 69% of the total animals on feed in 2007. All nutritionists completing the survey indicated that corn was the primary grain used in finishing diets. Thirty-one percent indicated that sorghum was utilized as a secondary grain. An earlier study (Galyean and Gleghorn, 2001) found that 10 percent of the nutritionists were using a mixture of corn and sorghum as the primary source of grain in finishing diets and 31.5 percent used sorghum as a secondary grain. This data indicates that there may be a slight shift away from sorghum toward corn as a primary grain source in beef feedlot diets. This demonstrates the need for additional information and research directed toward the benefits of utilizing sorghum in feedlot diets.

A comprehensive review of the published literature concerning the performance of growing cattle, finishing cattle, brood cows and heifers when fed sorghum grain, sorghum forage and sorghum distillers grains is needed to help educate livestock producers and other professionals on the true value of sorghum to the beef cattle industry. The following is a report of a current review of the literature pertaining to the feeding of sorghum to beef cattle.

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

Barley, corn, sorghum and wheat are all potential sources of energy for beef 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 Dairy 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. In general, today one could expect sorghum to contain about 14 percent more crude protein than corn. Data summarized in the NRC publications would indicate 23-28 percent more, but changes in plant genetics have likely resulted in a greater yield of starch which would dilute the amount of crude protein. 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 net energy for maintenance (NEm) and gain (NEg). These are a reflection of how efficiently 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 resulting in greater yields of starch today than in the past. 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 genetics, grain sources should be analyzed and the resulting nutrient profiles used to formulate animal diets rather than utilizing the tabular values.

“Sorghum contains more crude protein than corn...”

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
NE_n[4]m Mcal/lb	Sorghum	6.38	5.90	7.90
	Corn	3.30	3.40	3.63
	Barley	0.93	0.92	0.89
	Wheat	0.99	0.98	0.93
NE_g[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
Ash, %	Sorghum	1.87	2.00	1.92
	Corn	1.43	1.50	1.55
	Barley	2.40	2.90	2.93
	Wheat	2.01	2.00	1.97

[1]Nutrient Requirements od Beel 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

UTILIZATION OF SORGHUM GRAIN IN BEEF DIETS

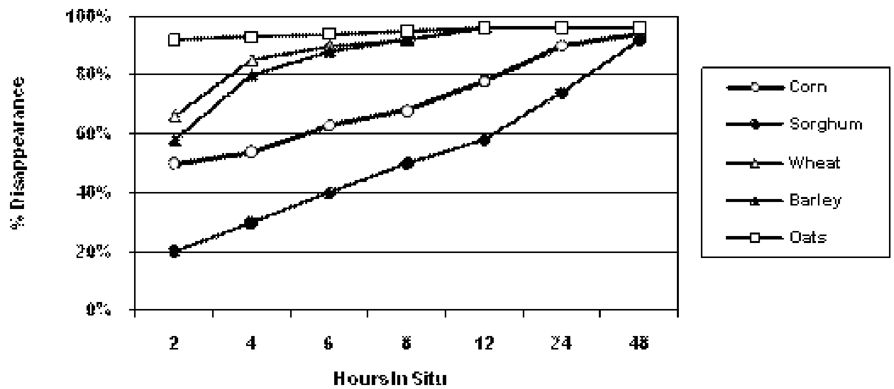
Cereal grains are the most common source of energy for livestock diets and may comprise up to 95 percent of the total diet for feedlot animals. In the US the most common cereal grains utilized are corn, milo, barley, wheat and oats. Based on surveys of beef nutrition specialists (Galyean and Gleghorn, 2001; Vasconcelos and Galyean, 2007) corn is the grain of choice and the other grains are considered secondary energy sources. This does not indicate that the other grains are inferior to corn, just a preference by nutritionists and feedlot operators to utilize corn as the primary source of energy. 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.

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. However, calculated digestion rates for crude protein, starch and dry matter were similar for corn and sorghum (Herrera-Saldana, 1990). After 48 hours of ruminal exposure, all feeds ended at a similar endpoint. 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. Huck and co-workers (1998) reported that feeding a mixture of 2:1 steam-flaked sorghum:corn resulted in greater average daily gain and feed efficiency as compared to diets based on either grain alone. Feed efficiency was improved by 5 percent with the mixture of sorghum and corn.

"When feeding sorghum, dry matter intakes were reduced..."

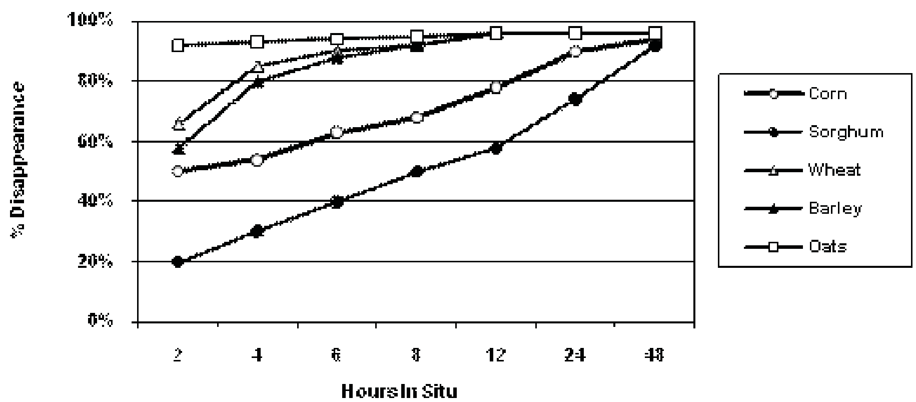
Owen et al. (1997) reviewed 605 comparisons of different methods of processing with five different grains and concluded that feeding sorghum resulted in similar average daily gains as corn when fed to feedlot animals (Table 2). Comparisons reported are the average responses to feeding a type of grain without considering the effect of processing. Additional comparisons of different types of 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 increased (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 of corn and sorghum grain.

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



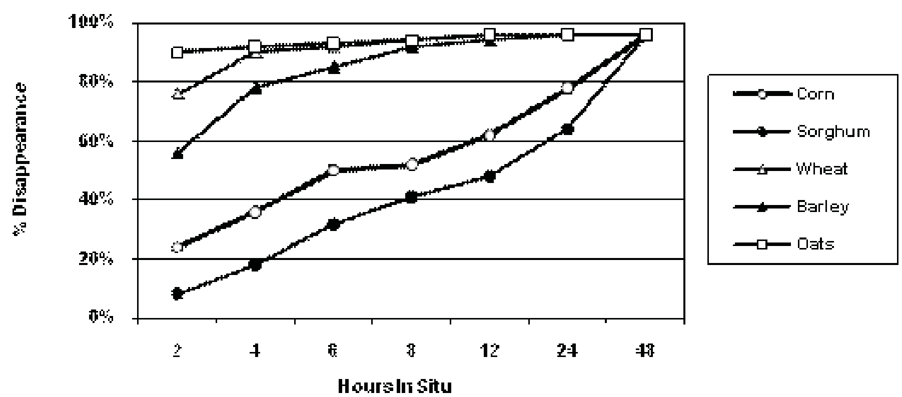
Adapted from Herrera-Saldana et at., 1990.

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



Adapted from Herrera-Saldana et at., 1990.

Figure 3. In situ start disappearance of five grains.



Adapted from Herrera-Saldana et at., 1990.

Table 2. Comparion of animal performarce date for five grains in feedlot diets.

Item	Barley	Corn	Sorghum	Oats	Wheat
Average daily gain, lb	3.13	3.15	3.06	3.31	3.04
Dry matter intake, lb	19.34[b]	19.69[b]	20.79[a]	20.18[ab]	19.07[b]
Feed.gain	6.24[b]	6.32[b]	6.88[a]	6.12[ab]	6.34[b]

[ab]Within a row, mean with differant superscripts differ (P<0.05).
Adapted fro Owen et al, 1997.

Table 3. Comparison of rate of gain (lb/d) resulting from five grains processed by various methods and utilized in feedlot diets.

Item	Barley	Corn	Sorghum	Oats	Wheat
Dry Rolled	3.20	3.20[a]	3.15[a]	3.38	3.04
High Moisture	-----	3.02[b]	2.84[b]	-----	-----
Steam Roll	2.93	3.15[a]	3.09[ab]	3.26	3.04
Whole	3.04	3.20[a]	-----	-----	-----
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) resultung from five grains processed by various methods and utilizewd in feedlot diets.

Item	Barley	Corn	Sorghum	Oats	Wheat
Dry Rolled	19.76	20.84[a]	23.09[a]	20.29	19.78
High Moisture	-----	19.23[b]	20.18[b]	-----	-----
Steam Roll	18.19	18.41[c]	19.14[c]	20.11	17.86
Whole	20.51	18.87[bc]	-----	-----	-----
Reconstituted	-----	-----	19.38[bc]	-----	-----

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

Table 5. Comparison feed efficiency (feed/gain) resultung from five grains processed by various methods and utilized in feedlot diets,

Item	Barley	Corn	Sorghum	Oats	Wheat
Dry Rolled	6.25	3.57[a]	7.43[a]	6.01	6.59[a]
High Moisture	-----	6.43[a]	7.12[ab]	-----	-----
Steam Roll	6.19	5.87[b]	6.33[c]	6.18	5.92[b]
Whole	6.66	5.95[b]	-----	-----	-----
Reconstituted	-----	-----	6.75[bc]	-----	-----

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

EFFECTS OF THERMAL PROCESSING ON ANIMAL PERFORMANCE

Thermal processing has been utilized in the feed yard industry for many decades. In general, processed grains would include: steam-flaking, reconstituting, early harvest ensiling (high moisture), popping, exploding, roasting or micronizing; in contrast to nonprocessed which would include whole grains or those minimally processed: cracked, ground, dry-rolled or raw (Theurer, 1986). 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. Data presented in Table 6 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 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. Similar comparisons and results have been made with lactating dairy cattle (Theurer et al., 1999).

"...this data emphasizes the increased value added to sorghum when it is steam flaked..."

Total tract starch digestibility for corn was increased from 91 to 99 percent when comparing steam-flaking to other processing methods. In the case of sorghum, it increased from 91 to 98 percent with steam-flaking. Ruminal starch digestibility increased from 70 to 86 percent for corn when steam-flaked as compared to other processing methods and from 57 to 76 percent for sorghum. This represents about a 23 percent increase in ruminal starch digestion for corn and about 33 percent increase for sorghum. While total tract starch digestibility is similar for corn and sorghum, this data emphasizes the increased value added to sorghum when it is steam flaked through the greater increase in ruminal starch digestion as compared to corn. Not only is the site of ruminal starch altered by steam-flaking, but there is also an increase in the amount of rumen bacteria synthesis and the availability of ruminal bacterial protein in the small intestine (Rahnema et al., 1987). Increasing the supply and digestibility of bacterial protein is important in increasing animal performance. When feeding sorghum, steam-flaking has an advantage over other processing methods and should be considered the processing method of choice.

Table 6. Comparison of corn and sorghum processing on feed conversion and average daily gain in beef cattle finishing trials

	Feed/lb gain		Daily gain (lb)	
Processing method	Corn	Sirghum	Corn	Sorghum
Dry-rolled	6.9	7.3	2.65	2.65
Flaked	6.3	6.5	2.65	2.65
Reconstituted	6.4	6.3	2.87	2.65
Mocronized, exploded, popped	----	6.5	-----	2.65

Adapted from Theurer, 1986.

Flake density may also impact animal performance. Swingle and co-workers (1999) steam flaked sorghum to four different densities (32, 28, 24 and 20 pounds per bushel) and conducted two studies. They observed that decreased flake density (increased processing) increased in vitro starch availability and total track starch availability. However the greatest increase was associated with lowering flake density from 32 to 28 pounds per bushel. Decreased flake density also linearly decreased average daily gain during the feeding period. Electrical costs increased linearly as flake density decreased. Based on the animal response and energy requirements, they concluded that the optimal flake density was 28 pounds per bushel. Theurer and co-workers (1999) observed similar results for starch availability when comparing sorghum steam flaked at 32, 28 and 22 pounds per bushel. In both of these studies, ruminal starch digestibility was increased to 81 percent of total starch intake and increased total track starch digestibility while reducing the amount of starch digested in the small intestine. Results of these studies were similar to the results reported earlier by Reinhardt et al. (1997).

EFFECT OF SORHUM HYBRIDS UPON ANIMAL PERFORMANCE

Several studies have examined the differences between sorghum hybrids (Larrain et al., 2009; McCollough et al., 1972; Maxson et al., 1973; Goldy et al., 1987; Streeter, et al., 1990; and Pederson et al., 2000). 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). However, a mixture of high-tannin sorghum and corn grain has been shown to improve animal performance (Larrain et al., 2009). However, most sorghum grown today has lower amounts of tannins so this is no longer an issue. Streeter et al. (1990) evaluated four diverse sorghum hybrids (yellow, cream, hetero-yellow and red). When compared to corn, the cream hybrid resulted in similar total track starch digestibility and calculated feed:gain ratio with the other sorghum types resulting in lower values. This data supports that that differences exist in animal performance when feeding different sorghum hybrids. In addition, environmental conditions during the growing season may further impact these differences. Pederson et al. (2000) reported a new 12-hour in vitro procedure that may be utilized to evaluate grain hybrids for changes in grain digestion parameters. This could be very useful in estimating the feeding value of sorghum resulting from different hybrids or from different growing environments.

"...steam-flaking seems to offer the best solution for increasing the efficiency of sorghum digestion."

ADDING VALUE TO SORGHUM GRAIN THROUGH PROCESSING

Animal research has demonstrated that processing of sorghum increases its value to the livestock industry. Based on current research, thermal processing via steam-flaking seems to offer the best solution for increasing the efficiency of sorghum digestion. Flaking can increases the feeding value of sorghum by 12-15 percent over dry-rolling by increasing the digestibility of starch in the rumen and in the total tract. It also results in the improvement of the digestibility of the crude protein found in sorghum. The ideal flake density is reported to be 28 pounds per bushel. Decreasing the flake density below this level results in significant energy usage. Swingle et al. (1999) reported that electrical requirements increase by 50 percent when flake density decreased from 32 to 20 pounds per bushel, but only by 8 percent when going from 32 to 28 pounds per bushel. Reinhardt and co-workers reported a 67 percent increase in energy cost when reducing flake density from 28 to 22 pounds per bushel. When factoring in the animal performance data, Swingle et al. (1999) reported the greatest increase when going from 32 to 28 pounds per bushel while Reinhardt and co-workers (1997) reported a decrease in animal performance as flake density decreased. Thus researchers have concluded that the most cost effective density is 28 pounds per bushel for sorghum grain.

USE OF DISTILLERS GRAINS RESULTING FROM SORGHUM GRAIN

A recent review of the use of distillers by-products in beef cattle feeding (Klopfenstein et al., 2008) indicated that when compared to distillers grains resulting from corn grain, sorghum grain based distillers grains resulted in no significant differences in animal performance. However, authors cautioned that of the four studies reviewed, all showed a numeric advantage to corn over sorghum. One of the challenges of these experiments is obtaining grains produced from the same plant under the same conditions. When comparing corn and sorghum distillers grains, differences in plant design and operation may affect the feeding value of the resulting grains. Only one of the reported studies utilized distillers grains produced from the same plant (Al-suwaiegh et al., 2002). When the diet contained 15 percent distillers grains from either wet or dry sources of corn or sorghum distillers, there were no significant effects on intake, daily gain or gain to feed rations due to grain type. Distillers grains resulting from sorghum also generally have a greater crude protein content due to the greater crude protein found in sorghum as compared to corn. Further evaluation of sorghum distillers grains is needed to fully address this issue. Some of the factors to consider would be distilling methods, plant design and composition of diets.

"Feeding sorghum grain as a replacement for corn will decrease the need for supplemental crude."

CONCLUSIONS

The feeding value of sorghum is most often measured against corn in the US. Surveys of feedlot nutritionists indicate that most consider corn as the primary grain source for feedlot animals and about 30 percent utilize sorghum as a secondary grain source. This may be a reflection of local availability rather than animal performance. Because of the protein-starch matrix found in sorghum, much attention has been given to the use of processing to increase the feeding value of sorghum. The use of moisture, heat and pressure to reduce the bulk density of sorghum, resulting in the disruption of starch-protein matrix as well as the starch matrix have resulted in improved feed conversion. Steam-flaking offers the greatest improvement. The desired flake density is 28 pounds per bushel. Flaking to this density will improve feed efficiency by 12-15 percent over dry-rolling. When using steam flaked sorghum, cattle performance has been found to be similar to that of corn fed animals. However, when using other types of processing, there may be an advantage for corn. Feeding sorghum grain as a replacement for corn will decrease the need for supplemental crude protein. Sorghum grain generally contains about 10 percent more crude protein than corn. About 70-80 percent of the total cost of production in the feed yard is associated with feed cost. The greatest benefit of sorghum may be due to its adaption to areas with reduced rainfall or irrigation. In these areas, sorghum may be grown locally in providing a cost efficient replacement for corn. Several studies have shown similar animal performance between corn and sorghum when the sorghum is processed correctly. Processing to a flake density of 28 pounds per bushel will increase feed efficiency and result in a similar feeding value to corn. Feeding processed sorghum grain or by-products produced from sorghum is generally considered to result in similar animal performance as compared to corn.

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