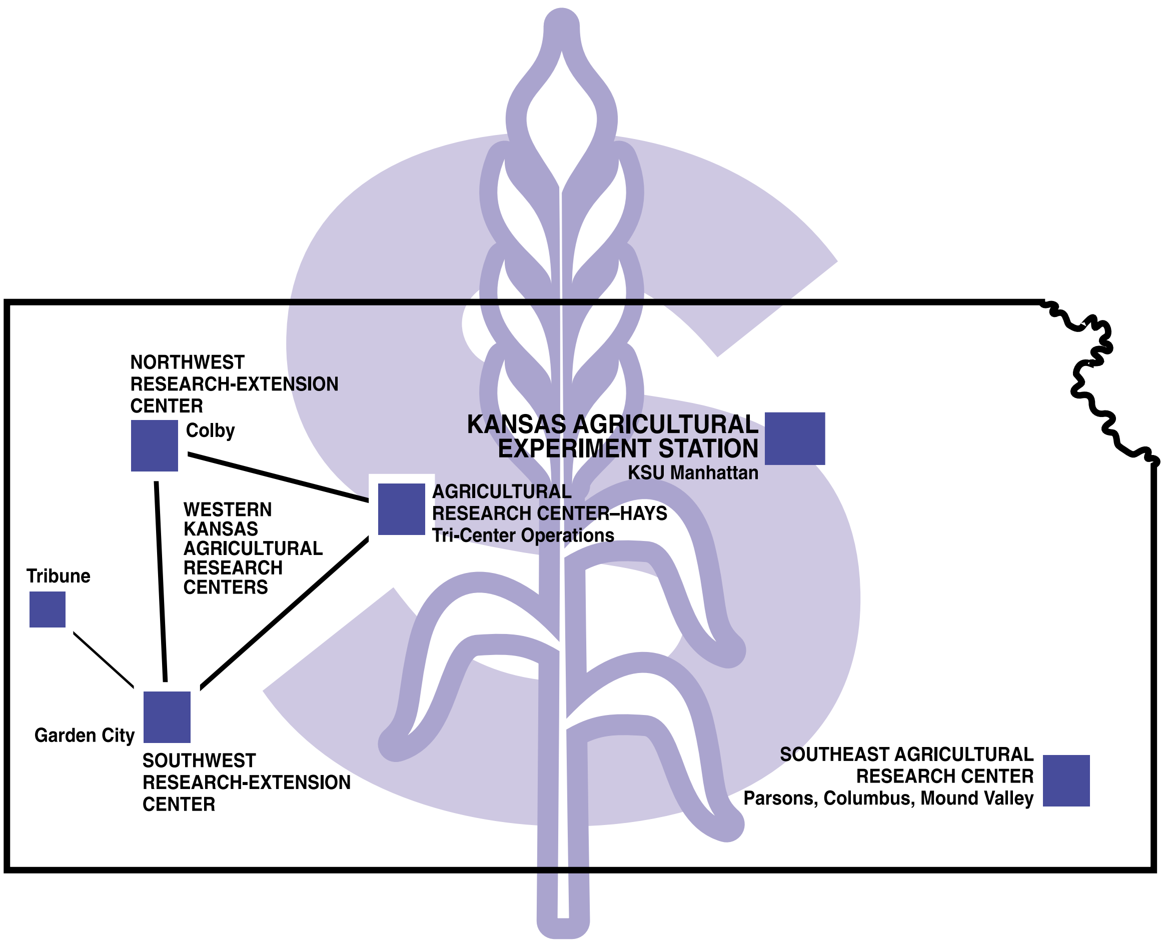
MF-2513

# Economic Issues with Grain Sorghum




## Agricultural Industry Competitiveness

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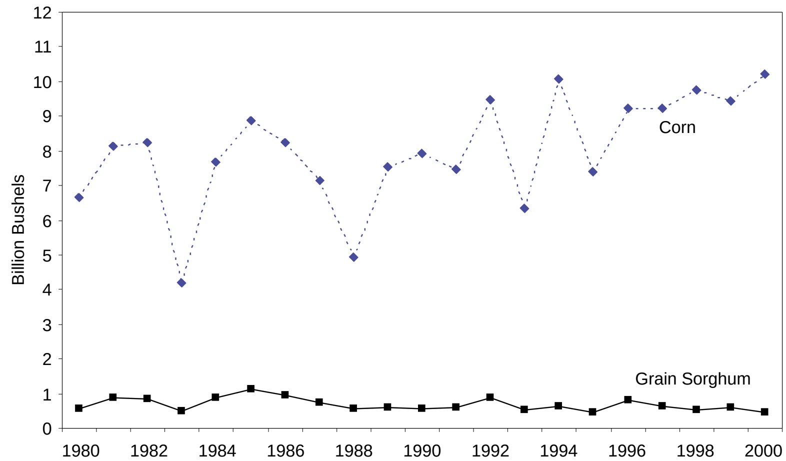
*Kansas State University Agricultural Experiment Station and Cooperative Extension Service*

# Economic Issues with Grain Sorghum

Kansas historically has been a leading producer of grain sorghum. From 1990 to 1999 Kansas was the number one or two grain sorghum producing state in the United States (Kansas Agricultural Statistics). During this time, Kansas accounted for 27.6 to 50.8 percent of the total grain sorghum produced in the United States. Sorghum's growth characteristics and nutrient needs allow it to be a profitable crop in many areas of the state. In recent years, however, corn acreage in Kansas has increased. This is due, in part, to improved corn hybrids and increased irrigation in western Kansas. Sorghum requires less water and nutrient application, making it a less expensive crop to produce, but the yield potential of corn and corn prices relative to sorghum prices have increased the popularity of corn in Kansas. This publication describes how these two crops compare in Kansas and the United States through the past two decades.

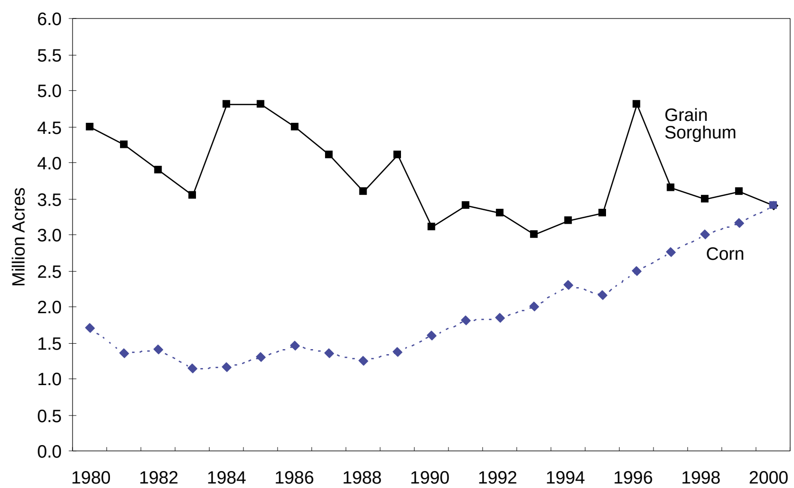
**Figure 1**. *U.S. Corn and Sorghum Production, 1980 to 2000*




## U.S. Production Trends

Figure 1 shows total production of corn and sorghum in the United States from 1980 to 2000. Corn production has exceeded 9 billion bushels seven times from 1992 to 2000. Average U.S. corn production increased approximately 30 percent during these two decades. Annual production from 1981 to 1985 averaged slightly more than 7.4 billion bushels, and it rose to nearly 9.6 billion bushels from 1996 to 2000. U.S. sorghum production declined 28 percent from an average of nearly 837 million bushels from 1981 to 1985 to approximately 602 million bushels from 1996 to 2000.

**Figure 2.** *Kansas Corn and Grain Sorghum Planted Acres, 1980 to 2000*




## Kansas Production Trends

From 1980 to 2000 acres planted to grain sorghum in Kansas have been steadily decreasing while acres planted to corn have been increasing significantly (Figure 2). The annual average acres planted to grain sorghum was 4.26 million acres from 1981 to 1985 which decreased to 3.79 million acres (11 percent decrease) in 1996 to 2000. During these same 5-year time periods, acres planted to corn increased from 1.27 million acres to 2.96 million acres (133 percent increase). In 2000 the acres planted to corn equaled those of grain sorghum for the first time in almost 50 years (acres planted to corn and grain sorghum were similar in the 1940s with corn acres typically exceeding sorghum acres prior to 1940).

Figure 3 shows total production of corn and sorghum in Kansas from 1980 to 2000 and illustrates changes in both crops. During the 1980s, sorghum production exceeded that of corn. Since that time, however, corn production has been higher than sorghum, with the exception of 1996

***Figure 3.*** *Kansas Corn and Grain Sorghum Production, 1980 to 2000*

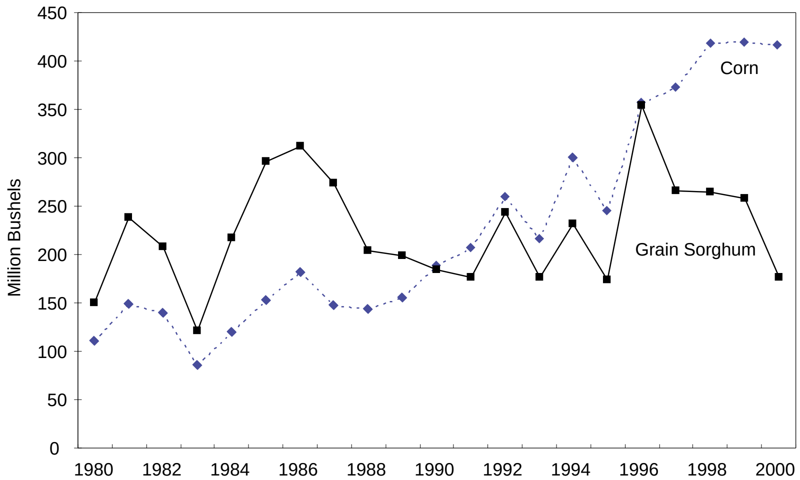
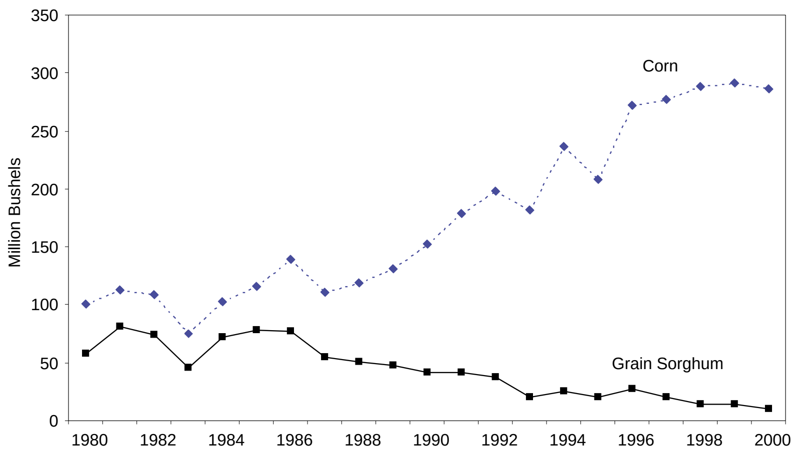



***Figure 4.*** *Kansas Irrigated Corn and Grain Sorghum Production, 1980 to 2000*




when sorghum acreage increased sharply due to a late wheat freeze in western Kansas. Corn production in 2000 reached 416 million bushels, and sorghum production fell to 176.7 million bushels. Even though acres planted to sorghum fell 11 percent from 1981-1985 to 1996-2000, total production of grain sorghum increased 21 percent over this time period due to increasing yields (statewide yields increased 26 percent). Likewise, corn production increased 208 percent over these two 5-year periods due to both increased acres and higher yields (21 percent higher yields).

Figure 4 compares irrigated production of sorghum and corn in Kansas. Much of the irrigated production takes place in western Kansas where the climate typically is drier. Irrigated sorghum production has declined substantially whereas irrigated corn production has increased dramatically over the last 20 years. Production of irrigated grain sorghum averaged over 75 million bushels annually from 1981 to 1985, however that number dropped to about 17 million bushels from 1996 to 2000 (75 percent decrease). During these same time periods, irrigated corn production increased from about 103 million bushels annually to approximately 283 million bushels annually (175 percent increase).

The production from non-irrigated sorghum and corn in Kansas is compared in Figure 5. Production of non-irrigated sorghum has declined slightly in the last three years, however, this is following a substantially large production level in 1996, when a late freeze injured the wheat crop in western Kansas. While Figure 5 shows there has been a steady increase in non-irrigated corn production in the last 5 to 10 years, there is still twice as many bushels of grain sorghum produced on non-irrigated acres than there are of corn. Production of grain sorghum on non-irrigated acres averaged about 146 million bushels annually from 1981 to 1985 and increased to 249 million bushels from 1996 to 2000 (70 percent increase). During these same time periods, non-irrigated corn production increased from about 26 million bushels annually to approximately 114 million bushels annually (339% increase). Thus, while the gap between non-irrigated production of grain sorghum and corn is narrowing, it is clear that grain sorghum is still a very important crop in Kansas on non-irrigated acres.

## Food Uses of Grain Sorghum

In the United States, grain sorghum is considered by most to be a feed grain. More than 90 percent of all sorghum consumed in the United States is used for livestock feed. However, globally, humans consume approximately 50 percent of the sorghum produced. It is a staple in human diets in the Middle East, India, and Africa where the climate is very arid, and grains such as wheat and rice will not grow.

Sorghum is somewhat drought tolerant and can be grown in these areas.

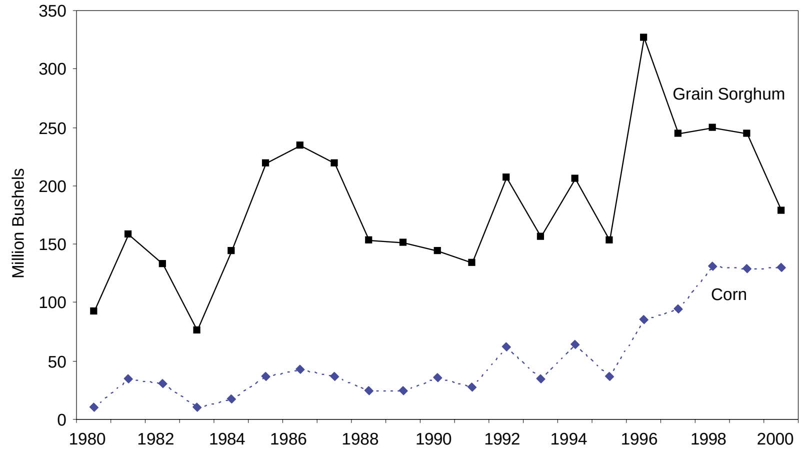
Food use of grain sorghum in the United States is an extremely small market. This has mainly been due to the presence of phenolic acid and tannins, which impart a bitter and astringent flavor to flour made from sorghum. Sorghum also lacks gluten, limiting its application in the food industry. However, new white sorghum hybrids have been developed in recent years. The new hybrids do not contain the phenolic acid or the bitter taste. These new, food grade white hybrids consist of white berries and a tan plant versus a purple or reddish plant. This allows for flour that is clean in appearance. A Texas-based company is currently milling and marketing white sorghum flour products. The flour can be used to make products including breakfast cereals, breads, pastries, beer, ethnic foods, and a fry coating for meats or vegetables. The grain still lacks a gluten component. However, this can be an advantage: People who are gluten intolerant can consume products made with the gluten-free sorghum flour.

## Industrial Uses of Grain Sorghum

Currently four plants produce ethanol in Kansas. The plants — in Atchison, Colwich, Garden City, and Leoti — produce approximately 57 million gallons of ethanol per year, including both beverage alcohol and fuel ethanol. Beverage alcohol requires extensive refining to remove impurities from crude ethanol, and fuel ethanol requires dehydration to remove all water. Beverage alcohol is marketed to distillers such as Seagram's, Jim Beam, and McCormick. Fuel ethanol is marketed to most major oil companies and refineries as well as some local blenders. Transportation is a major cost for ethanol plants, with local markets being served via truck and more distant markets typically being served via rail.

To produce ethanol, these plants use more than 20 million bushels of feedstock. The major feedstock for ethanol production in Kansas is grain sorghum, which makes these plants somewhat unique. Other feedstock sources include corn and wheat. Kansas's ethanol plants typically obtain grain from within a 100- to 200-mile radius of the plant. Sorghum is both purchased from country elevators and directly from producers who have on-farm storage. Grain is purchased using many of the same considerations as an elevator. Some added importance is given to foreign material and aflatoxin presence. Aflatoxin is an important issue because much of the distiller's dried grains, a by-product of ethanol production, is used in livestock rations at feed yards and dairies and thus the presence of aflatoxin could have health implications.

***Figure 5.*** *Kansas Non-irrigated Corn and Grain Sorghum Production, 1980 to 2000*




Kansas is a leader in sorghum production, making the crop a dependable feedstock supply for ethanol producers located in the state. Corn and sorghum are nearly equal producers of ethanol on a per-bushel basis. At most plants, both grains consistently produce approximately 2.75 gallons of ethanol per bushel of grain. One commodity does not appear to hold a distinct advantage over the other in terms of production. Therefore, ethanol producers use the least expensive grain and, for Kansas, that is often sorghum.

It has been suggested that sorghum may hold a slight advantage over corn regarding plant cleanliness, product purity, and beverage quality. Sorghum contains less oil than corn, which allows a cleaner ethanol production process. Also, in the final processing steps, sorghum ethanol tends to be easier to purify. In beverage alcohol, sulfur can be a potential problem with ethanol produced from corn but not from sorghum. The sulfur imparts an off flavor or odor to the beverage alcohol, leading to potential quality problems.

## Grain Sorghum Breeding Research

The major focus of current breeding programs is increased yield potential. Many studies are directed toward chinch bug and green bug resistance. Continual research on resistance is necessary because the insects have adapted and developed new biotypes to which current varieties no longer have resistance. Along with insect resistance, many breeding programs include resistance to plant diseases such as *Fusarium* stalk rot, charcoal rot, sooty stripe, and ergot.

Drought tolerance is another breeding issue. A large amount of grain sorghum is grown in areas that are drought susceptible, and most is grown without irrigation. Sorghum grows in these conditions; however, increasing drought tolerance has the potential to further increase yields.

Another area of study focusing on increased yield is grain fill duration. This portion of the growth cycle of sorghum determines the size of the plant's berries. By shortening the plant's vegetative growth stage and lengthening the grain fill duration, breeders hope to keep the same total life cycle timing. Breeding programs are using varieties from Africa, which have a long grain fill duration, and combining them with domestic varieties, which have shorter durations. The resulting plants have medium-length grain fill duration and produce larger berries potentially increasing yields.

Kansas State University and Texas A&M University have expanded sorghum research programs to include sorghum biotechnology research. The goals of the programs are to improve stress tolerance, yield, and grain quality by using molecular genetics, plant breeding, plant physiology, plant pathology, entomology, and other related fields. At the current time, much of this research is in its early stages.

## Feed Milling and Livestock Feeding Research

Much of the sorghum research in feed milling and livestock feeding focuses on different milling and feed preparation techniques and how the resulting products affect feed use and digestion in livestock. The processing method used for sorghum plays a major role in its effectiveness as a feed. The chemical components of sorghum and corn are similar and suggest that the two grains should have comparable feeding values. However, the starch and protein in sorghum are more difficult to digest than those in corn. Processing serves to break the seed coat, reduce particle size, and increase surface area, making the grain more digestible. Sorghum processing results in improvements in feeding value because more starch is digested.

The feed processing methods employed include grinding, dry rolling, and steam flaking. Many studies in this area evaluate the feeding efficiency of various processing methods for sorghum. Often these same studies compare sorghum results to similarly processed corn because the two grains are substitutes as feed grains. Following is a review of some examples of sorghum research for cattle, swine, and poultry.

### *Cattle Research*

Two popular processing methods for cattle feed in Kansas are dry rolling and steam flaking. When comparing dry

***Table 1.*** *Comparison of Processing Systems for Grain Sorghum Fed to Beef Cattle*

| Processing Method | Dry Rolled | Flaked | % of Dry Rolled |
|---|---|---|---|
| Dry Matter Intake, lb | 16.8 | 16.0 | 95% |
| Daily Gain, lb | 2.56 | 2.76 | 108% |
| Feed/Gain | 6.57 | 5.80 | 88% |

Source: Stock and Mader

ground or rolled sorghum to similarly processed corn it has been shown that the sorghum has a relative feed value of 85 to 95 percent of corn. Steam flaking sorghum improves its feeding value compared to dry rolling. Table 1 shows the results of a feeding study in Arizona comparing dry rolled to steam flaked sorghum. This shows that steam flaking improved daily gain and feed efficiency. Daily gain increased by 7.8 percent from 2.56 pounds to 2.76 pounds per day. Dry matter intake was reduced by 0.8 pounds or 4.8 percent. Feeding efficiency (feed/gain) improved by 11.7 percent, decreasing from 6.57 to 5.80 pounds of feed per pound of gain.

Several studies compared the feeding value of steam flaked corn to steam flaked sorghum. Tables 2 and 3 show selected results of these studies. The first study consisted of 200 heifers fed a finishing diet of 15 percent corn silage, 8 percent supplement, and 77 percent flaked corn, flaked sorghum, or a combination of the two. Heifers fed a ration containing all flaked sorghum for the grain fraction had the lowest daily feed intake, lowest daily gain, and poorest feed efficiency (feed/gain). The daily gain of 2.22 pounds per day was 86 percent of the group fed flaked corn. Similarly, for the two groups, the feed efficiency of 7.87 pounds of feed/pound of gain for those fed flaked sorghum was 117 percent of the group fed flaked corn. (**Remember:** Feed efficiency is defined as pounds of feed per pound of gain, therefore a higher value is associated with lower efficiency. For example, the 117 percent in Table 2 represents a lower efficiency for sorghum relative to corn.) The group of heifers fed a combination of 75 percent flaked corn and 25 percent flaked sorghum yielded the highest daily gain and had the highest daily feed intake, suggesting a complimentary effect of the two grains.

The second study consisted of 306 finishing steers fed a ration of 10 percent corn silage, 7.5 percent soybean meal, 4 percent beef tallow, 4 percent supplement, and 74.5 percent steam flaked sorghum or steam flaked corn. This study yielded similar results to that of the heifers but the steers performed slightly better on the sorghum ration. The daily gain of 4.09 pounds for the steers fed a ration containing flaked sorghum was 93 percent of the steers fed flaked corn. The two groups showed similar daily feed intakes of 22.7 pounds for those fed flaked corn and 22.9 pounds for those fed flaked sorghum. The feed efficiency of 5.63 pounds of feed per pound of gain for the flaked sorghum group was 109 percent the efficiency of those fed flaked corn.

### *Swine Research*

Popular processing methods for the production of swine feed are roller milling and hammer milling. Both serve to reduce particle size to allow for easier and more complete digestion. For swine, the particle size plays an important role in swine growth performance. Table 4 summarizes the results of a study consisting of 192 weanling pigs fed from a weight of 15 to

***Table 2.*** *Effect of Feeding Flaked Corn and Flaked Sorghum Singly or in Combination on Finishing Cattle Performance*

| %Corn: %Sorghum | 100:0 | 75:25 | 50:50 | 25:75 | 0:100 | 0:100/100:0 |
|---|---|---|---|---|---|---|
| Dry Matter Intake, lb | 17.34 | 17.89 | 17.73 | 17.63 | 17.30 | |
| Daily Gain, lb | 2.59 | 2.65 | 2.46 | 2.40 | 2.22 | 86% |
| Feed/Gain | 6.71 | 6.79 | 7.38 | 7.38 | 7.87 | 117% |

Source: Kreikemeier, Kuhl and Eck

***Table 3.*** *Feedlot Performance of Cattle Fed Various Grain Diets*

| | Steam Flaked Corn | Steam Flaked Sorghum | % of Corn |
|---|---|---|---|
| Dry Matter Intake, lb | 22.7 | 22.9 | |
| Daily Gain, lb | 4.40 | 4.09 | 93% |
| Feed/Gain | 5.17 | 5.63 | 109% |

Source: Huck et al.

**Table 4.** *Effect of Particle Size of Corn- and Sorghum-Based Diets on Starter Pig Performance*

| Mill Type | Grain | Mean Particle Size Diameter (microns) | Average Daily Gain (lbs.) | Daily Feed Intake (lbs.) | Feed/ Gain |
|---|---|---|---|---|---|
| Hammer mill | Corn | 624 | 1.00 | 1.72 | 1.70 |
| | Sorghum | 539 | 0.96 | 1.72 | 1.78 |
| | % of Corn | | 96% | 100% | 105% |
| | Corn | 877 | 0.99 | 1.77 | 1.78 |
| | Sorghum | 722 | 1.00 | 1.79 | 1.79 |
| | % of Corn | | 101% | 101% | 100% |
| Roller Mill | Corn | 822 | 1.02 | 1.85 | 1.81 |
| | Sorghum | 885 | 1.00 | 1.91 | 1.92 |
| | % of Corn | | 103% | 103% | 106% |
| | Corn | 1147 | 1.04 | 2.00 | 1.92 |
| | Sorghum | 1217 | 0.94 | 1.82 | 1.94 |
| | % of Corn | | 90% | 91% | 101% |

Source: Goodband, Tokach and Nelssen

18 pounds up to a final weight of about 51 pounds. Both corn and sorghum grains were ground to a course or fine particle size using a hammer mill or roller mill. These results show that for both corn and sorghum, feed efficiency (feed/gain) was better for those animals fed hammer milled feed. Direct comparisons between corn and sorghum are difficult because of differing particle sizes of the resultant feeds. However, when comparing similar particle sizes and milling techniques, sorghum feed efficiency ranged from about 100 to 104 percent of corn feed efficiency. Additional information can be found in K-State Research and Extension publication MF-2050 *The Effects of Diet Particle Size on Animal Performance.*

The results in the study above are similar to those in several studies comparing growth performance of hogs fed sorghum versus corn diets. Table 5 shows a compilation of results from university studies done for both nursery and grow/ finish hogs. The average rate of gain for sorghum-fed hogs as a percent of those fed corn diets was 98 percent and the average feed efficiency was 95 percent. Here, efficiency is defined as gain per pound of feed as opposed to feed per pound of gain.

### Poultry Research

Grains are processed much the same for poultry feed as they are for swine feed. Again, particle size plays an important role in the digestibility of the feed. Table 6 shows the gain and feed conversion of 1,720 broilers fed yellow corn, low-tannin sorghum (LTS), or high-tannin sorghum (HTS) in ground or rolled form. The data show that both ground and rolled corn and LTS performed nearly equal in this study, with corn being slightly better. As ex-

**Table 5.** *Nutritional Value of Sorghum Relative to Corn for Swine*

| Investigator | Stage of Growth | Rate of Gain % of Corn | Efficiency of Gain % of Corn |
|---|---|---|---|
| White et al. (1983) | Nursery | 90 | 94 |
| Combs et al. (1980) | Nursery | 98 | 91 |
| Hamilton et al. (1979) | Nursery | 106 | 99 |
| Hines and Koch (1971) | Nursery | 92 | 95 |
| Cromwell et al (1985) | Grow/Finish | 99 | 96 |
| Myer (1982) | Grow/Finish | 106 | 95 |
| Danielson et al. (1978) | Grow/Finish | 97 | 95 |
| Tribble (1975) | Grow/Finish | 96 | 96 |
| Average | | 98 | 95 |

Source: Hancock and Bramel-Cox

***Table 6.*** *Feed Efficiency and Daily Gain for Broilers Fed Corn and Grain Sorghum (1 to 21 days)*

| | Feed Form | Yellow Corn | LTS | HTS |
|---|---|---|---|---|
| Gain (grams) | Ground | 521 | 510 | 440 |
| | Rolled | 488 | 462 | 420 |
| Feed/Gain | Ground | 1.49 | 1.54 | 1.71 |
| | Rolled | 1.55 | 1.61 | 1.75 |

Source: Douglas et al.

***Table 7.*** *Feed Efficiency and Daily Gain for Chicks Fed Corn and Grain Sorghum*

| | Corn | LD1 Sorghum | LD2 Sorghum | HD1 Sorghum | HD2 Sorghum |
|---|---|---|---|---|---|
| Gain, lb | 1.06 | 1.00 | 1.02 | 1.04 | 1.06 |
| Gain, % of Corn | | 94% | 96% | 98% | 100% |
| Feed/Gain | 1.53 | 1.61 | 1.57 | 1.56 | 1.53 |
| Feed/Gain, % of Corn | | 105% | 103% | 102% | 100% |

Source: Healy et al.

pected, the HTS performed well below that of both corn and LTS.

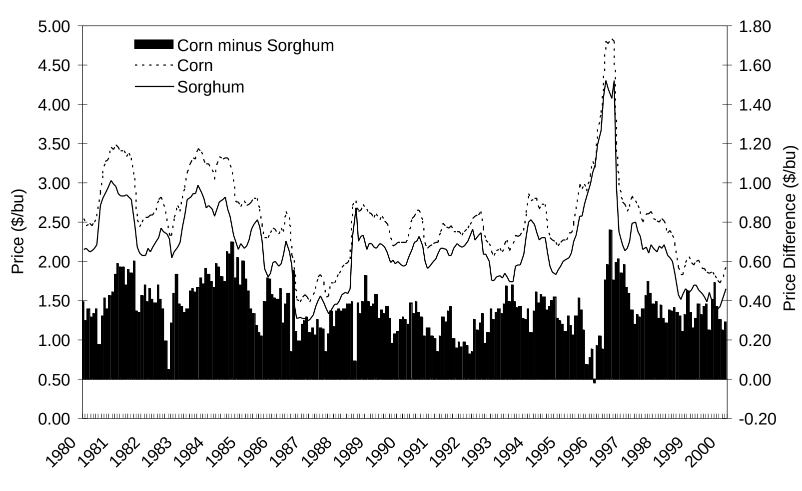
Table 7 shows results of a study comparing growth performance of 288 chicks fed a ration with differing grain components. The types of grain used were corn, two low digestibility sorghums (LD1 and LD2), and two high digestibility sorghums (HD1 and HD2). The digestibility of the sorghums was determined through lab analysis of the individual grains. As expected, LD1 and LD2 did not perform as well as HD1, HD2, or corn in gain or feed efficiency (feed/gain). When comparing HD1, HD2 and corn, the sorghums performed equal to or just slightly below corn in both gain and efficiency.

## Price of Sorghum vs. Corn in Kansas

The price of sorghum in Kansas is generally discounted relative to the price of corn on a per-bushel basis. Figure 6 illustrates monthly price levels in Kansas for corn and sorghum and the price difference (corn minus sorghum) between the two crops from 1980 through 2000. The graph indicates that the prices of the two crops move together as would be expected since both crops have similar growing seasons and end users and are thus close substitutes. The average price difference (corn minus sorghum) for the time period was a 36 cents per bushel premium for corn. On a percentage basis (i.e., ratio of sorghum price to corn price), grain sorghum prices averaged 86 percent of corn prices. The price ratio exhibits a normal distribution, with a standard deviation of 4 percent. This indicates that, although the price difference appears to contain large variation, sorghum price would be expected to be within a range of 82 to 90 percent (86%, ± 4%) of the price of corn 68 percent of the time. The relative prices of corn and sorghum are influenced by supply and demand for both crops in a given region. The fact that prices received for sorghum are often below that of corn indicates that corn is the preferred grain and has a higher value for many end users.

The feeding studies discussed previously provide an explanation for some of the price difference between corn and sorghum. Sorghum is used mainly as a

***Figure 6.*** *Monthly Kansas Corn and Grain Sorghum Prices, 1980 to 2000*



livestock feed in Kansas and it typically does not perform as well as corn (i.e., lower average daily gain and higher feed/gain). As long as this is true, sorghum will be considered an inferior crop when compared to corn for animal feeding purposes and thus will be valued at a lower price. While breeding programs have improved sorghum agronomically, less emphasis has been placed on improving the feeding value of the grain. This is a recognized weakness and steps are being taken to improve the quality and image of grain sorghum. Research funded by the Kansas Grain Sorghum Commission has increased awareness of the situation and developed goals for sorghum breeders and producers, placing importance on the improvement of grain sorghum as a whole.

## Value Added Grain Sorghum

In recent years, the term "value added" or "value enhanced" has been used in conjunction with many agricultural commodities. Adding value to a commodity, such as sorghum, is accomplished through improving the nutritional content of the grain or processing in such a way that the end products have increased value to the end user. This allows the products to be marketed to a specific group.

A survey of grain elevators and seed dealers across Kansas was conducted to determine the extent of value added programs that are in place or are planned for the near future as they pertain to grain sorghum. The results of the survey indicated that currently there is little being done in an attempt to make sorghum a value added crop. Also, there was no indication that those surveyed felt that any substantial steps will be taken in the near future. This suggests that research on increased yields and improving feed value are likely to be the most important focuses for grain sorghum research.

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**Luther Hamman**
Former MS Graduate Research Assistant
Department of Agricultural Economics

**Kevin C. Dhuyvetter**
Extension Agricultural Economist, Farm Management
Department of Agricultural Economics

**Michael Boland**
Assistant Professor
Department of Agricultural Economics

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**Kansas State University Agricultural Experiment Station and Cooperative Extension Service**

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