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R. Smith

K. Bolsen

J. Hoover

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Whole-plant grain sorghum silages for growing cattle

Abstract

Four trails were conducted to determine the effects of processing (rolling before feeding, with rolls set to break 95% of the kernels) and stage of maturity at harvest on the nutritive value of whole-crop grain sorghum silages for growing cattle. Rolling mid-dough silages did not improve feeding value. However, rolling at later maturity stages increased cattle gains and feed efficiencies, with the more mature, hard-grain silages giving the greatest response. Only starch digestibility was consistently affected (increased) by processing. Silage dry matter (DM) intake tended to increase, but feed efficiencies tended to decrease with advancing maturity. Neither average daily gains nor DM digestibilities were affected by stage of maturity at harvest. However, starch and crude protein (CP) digestibilities were highest for the late-dough silage in one trial and for the early-dough silage in another. Dry matter content and DM recovery from the silos increased and silage CP content decreased with advancing maturity.

Keywords

Cattlemen's Day, 1986; Kansas Agricultural Experiment Station contribution; no. 86-320-S; Report of progress (Kansas State University. Agricultural Experiment Station and Cooperative Extension Service); 494; Beef; Grain sorghum silage; Growing cattle

Whole-plant Grain Sorghum Silages for Growing Cattle

Russell Smith, Keith Bolsen, and Jim Hoover

Summary

Four trials were conducted to determine the effects of processing (rolling before feeding, with rolls set to break 95% of the kernels) and stage of maturity at harvest on the nutritive value of whole-crop grain sorghum silages for growing cattle. Rolling mid-dough silages did not improve feeding value. However, rolling at later maturity stages increased cattle gains and feed efficiencies, with the more mature, hard-grain silages giving the greatest response. Only starch digestibility was consistently affected (increased) by processing. Silage dry matter (DM) intake tended to increase, but feed efficiences tended to decrease with advancing maturity. Neither average daily gains nor DM digestibilities were affected by stage of maturity at harvest. However, starch and crude protein (CP) digestibilities were highest for the late-dough silage in one trial and for the early-dough silage in another. Dry matter content and DM recovery from the silos increased and silage CP content decreased with advancing maturity.

Introduction

Work at Texas A and M has shown that feeding whole-plant grain sorghum silage can increase beef production per acre by almost 28% compared with feeding only the grain. However, if the silage is fed straight from the silo, much of the grain may escape digestion. The effect of processing (rolling) the silage to break the kernel has been studied at Kansas State University in each of the past three years (Reports of Progress 427, 448, and 470), but results have been inconsistent. Last year's report (470) showed that the benefit from processing probably depended on the amount and maturity of the grain; higher grain yielding, more mature grain sorghum silages responded most to processing.

This trial measured the response to processing grain sorghum silages harvested at early- and late-dough and hard-grain stages of maturity. The results from our first three trials are also presented for comparison.

Experimental Procedures

Summarized in Table 39.1 are the harvest dates, maturities, and dry matter contents at harvest for the grain sorghum hybrid used in this year's trial (Trial 4) as well as those used in the three previous years (Trials 1, 2, and 3).

All hybrids were direct-cut using a Field Queen forage harvester, and about 80 to 85% of the sorghum kernels were whole when ensiled. The mid-dough silages in Trials 1 and 2 were made in 16 x 50 ft concrete stave silos. In Trial 3, the late-dough material was ensiled in a 14 x 60 ft concrete stave and the hard-grain stage in a 14 x 40 ft Harvestore®. Storage structures used in Trial 4 were the 14 x

60 ft concrete stave silos for the early- and late-dough stage materials and the 14 x 40 ft Harvestore® for the hard-grain stage.

Trial 1. The whole-plant silage made in 1981 was either processed through a roller mill prior to feeding to break 95% of the kernels or fed without processing. Sixteen steer and heifer calves (four pens of four calves per ration) were allotted by weight to the two silage rations. Silages were full-fed with 2.0 lb of supplement per calf daily (as-fed basis). Rations were formulated to provide 12.5% crude protein (CP) on a DM basis, 150 mg of monensin per calf daily, and equal amounts of calcium, phosphorus, and vitamin A. The growing trial was 84 days (January 20 to April 20, 1982).

Trial 2. The whole-plant silage made in 1982 was fed with or without processing (as described in Trial 1) to 16 steer calves, four pens of four calves per ration. Rations were formulated and fed as presented in Trial 1. The growing trial was 56 days, November 20, 1982 to January 15, 1983.

Trial 3. Each of the two whole-plant silages made in 1983 was fed with and without processing as described in Trial 1. In the growth trial, the four silage rations were fed to 20 steers, four pens of five steers per ration. Silages were full-fed with 2.0 lb of supplement per steer daily (as-fed basis). Rations were formulated to provide 12.0% CP (DM basis), 200 mg monensin per calf daily, and equal amounts of calcium, phosphorus, and vitamin A. The growing trial lasted 84 days, December 15, 1983 to March 9, 1984.

Twenty steers, similar to those used in the growth trial, were individually fed the same four silage rations in a digestion trial, using chromic oxide as a marker. The trial consisted of a 14-day adaptation period followed by a 7-day fecal collection period.

Dry matter losses during fermentation, storage, and feedout were measured by accurately weighing and sampling all loads of fresh crop ensiled and subsequently weighing and sampling all silage removed.

Further details of procedures for Trials 1, 2, and 3 are in the Reports of Progress 427, 448, and 470, respectively.

Trial 4. In 1984, DeKalb DK-42Y, a homozygous, yellow endosperm, grain sorghum, was harvested for whole-plant silage at three stages of kernel development: early-dough, late-dough, and hard-grain. The sorghum was from fields with two planting dates (May 25 and June 19), so approximately the same amount of material for each stage of maturity was harvested from plots of each planting date. In-silo DM losses were determined for each silage.

Six silage rations were compared. Each of the three silages was processed through a roller mill prior to feeding and also fed without processing. The roller mill was a Roskamp® model K, with two 9 x 18 inch rolls, each having 10 corregations per inch. Forty-eight heifer and 48 steer calves (avg. initial wt., 553 and 623 lb, respectively) were allotted by weight and previous rate of gain to the six rations (two pens of four heifers and two pens of four steers per ration). Silages were full-fed twice daily with 2.0 lb of supplement per calf daily (as-fed basis). Rations were formulated to provide 12.0% CP for heifers or 11.0% CP for steers (DM basis), 200 mg of Rumensin® per calf daily, and equal amounts of calcium, phosphorus, and vitamin A. All calves received hormonal implants at the start of the 84-day growing trial (February 15 to May 10, 1985).

Calves were weighed on two consecutive days at the beginning and end of the trial, after 16 hr without feed or water. To minimize fill effects, all calves were fed a forage sorghum silage ration at 1.75% of body weight (DM basis) for 1 week before the trial began.

Samples of each silage were taken twice weekly. Feed intake was recorded daily for each pen and the quantity of silage fed adjusted daily to assure that fresh feed was always in the bunks. Feed not consumed was removed, weighed, and discarded as necessary.

After completion of the growing trial, 30 of the steers were individually fed the same six silage rations to determine apparent digestibility. Other digestion trial procedures were similar to those used in Trial 3.

Results and Discussion

Chemical analyses and DM recoveries of the five silages fed in Trials 3 and 4 are shown in Table 39.2. Good preservation was obtained for silages at all stages of maturity. In Trial 3, DM recovery was higher for the hard-grain stage silage than for the late-dough silage. Likewise, DM recovery in Trial 4 increased from the early-dough to the hard-grain stage silage. As maturity advanced, DM content increased and the extent of fermentation decreased, as indicated by the increasing pH values and decreasing fermentation acids. There was a decrease in CP, ammonia-nitrogen, and cellulose and an increase in hot water insoluble-nitrogen as maturity increased. No consistent trends were observed in other fiber constituents, indicating that variation among years might have more effect on silage composition than stage of maturity at harvest.

Trials 1 and 2. Performance by calves fed the processed and nonprocessed mid-dough grain sorghum silages is shown in Table 39.3. Processing the silages prior to feeding did not significantly improve cattle performance in either trial. In Trial 1, calves receiving processed silage consumed 4% more DM and gained 6% faster, but in Trial 2 processing gave just the opposite response, with calves receiving nonprocessed silage consuming 4% more DM and gaining slightly faster.

Trial 3. Performance by steers fed the two grain sorghum silages is shown in Table 39.4. For the late-dough harvested silage, processing increased gain by 11% ($P<.05$) and improved feed efficiency by 12% ($P<.10$), but did not affect DM intake. For the hard-grain harvested silage, processing increased gain by 16% ($P<.05$) and improved feed efficiency by 9.6% ($P<.10$). Although not statistically significant, DM intake was increased from 19.86 to 20.82 pounds from processing the later harvested silage.

Apparent digestibility coefficients of the four silage rations are shown in Table 39.5. For the late-dough silage, processing increased DM digestibility by 15% ($P<.05$) and starch digestibility by 22% ($P<.05$). For the hard-grain silage, DM digestibility was increased by only 5%, but starch digestibility was improved by 22% (P<.05). Fiber digestibility were not affected by processing.

Trial 4. Performance by steers and heifers fed the six grain sorghum silage rations is shown in Table 39.6. Both stage of maturity and processing significantly affected cattle performance. For the unprocessed silages, gain and feed efficiency tended to decrease but DM intake increased as maturity advanced. The responses to processing increased with increasing maturity. Processing improved gain by only 4.5% and feed efficiency by only 3% in the early-dough silage, gain by 12% and efficiency by 7% in the late-dough silage, and gain by 23% and efficiency by 12% in the hard-grain silage.

Results from the digestion trial are shown in Table 39.7. The effect of processing on apparent digestibilities was not as pronounced as in Trial 3, with only starch digestibility being significantly affected by processing. Dry matter digestibility was not significantly affected by stage of maturity at harvest, although it tended to decrease with advancing maturity. Digestibilities of starch and CP were highest (P<.05) for the early-dough stage silages, but similar for the late-dough and hard-grain stage silages. Fiber digestibilities generally increased from the early- to late-dough stage silages, then declined at the hard-grain stage.

Table 39.1. Grain Sorghum Hybrids, Harvest Dates, and Maturities and Dry Matter Contents at Harvest

Year, Trial, and Hybrid	Harvest Date	Maturity at Harvest	% DM at Harvest
1981 (Trial 1)			
Ferry-Morse 81	Sept. 16-17	Mid-dough	37.0
1982 (Trial 2)			
DeKalb E 67	Sept. 20	Mid-dough	36.6
1983 (Trial 3)			
DeKalb DK-42Y	Aug. 28-30	Late-dough	42.1
DeKalb DK-42Y	Sept. 15-16	Hard-grain	50.8
1984 (Trial 4)			
DeKalb DK-42Y	Aug. 23 & Sept. 17	Early-dough	32.6
DeKalb DK-42Y	Sept. 4 & Sept. 26	Late-dough	41.3
DeKalb DK-42Y	Sept. 12 & Oct. 12	Hard-grain	54.2

Table 39.2. Chemical Analyses and Dry Matter Recoveries for the Grain Sorghum Silages Fed in Trials 3 and 4

Item	Trial 3 Late-dough	Trial 3 Hard-grain	Trial 4 Early-dough	Trial 4 Late-dough	Trial 4 Hard-grain
Silage DM,%	42.3	50.9	31.9	42.3	56.2
DM Recovery, % of the DM Ensiled	96.7	97.9	87.0	92.2	94.1
pH	4.19	4.34	3.85	4.13	4.39
	% of the Silage DM				
Lactic Acid	5.92	4.56	5.49	3.58	2.57
Acetic Acid	1.54	1.22	3.00	2.04	1.42
Butyric Acid	<.01	<.01	.07	.08	.05
Total Fermentation Acids	7.48	5.81	8.7	5.8	4.2
Acid Detergent Fiber	23.3	23.1	26.6	26.5	21.9
Neutral Detergent Fiber	40.1	45.2	44.8	41.7	41.9
Lignin	3.8	4.0	4.3	4.4	3.6
Cellulose	17.3	16.6	19.6	18.7	16.2
Crude Protein	10.9	10.1	10.6	9.8	9.9
	% of the Total Nitrogen				
Ammonia-nitrogen	6.5	5.0	9.8	6.1	5.2
Hot Water Insoluble-nitrogen	46.7	56.3	33.4	47.3	62.4
Acid Detergent-nitrogen	11.1	13.3	—	—	—

Table 39.3. Performance by Calves Fed the Grain Sorghum Silage Rations in Trials 1 and 2

Item	Trial 1 Nonproc	Trial 1 Proc	Trial 2 Nonproc	Trial 2 Proc
Silage DM, %	36.3		35.9	
Silage CP, %	9.3		9.5	
No. of Calves	16	16	16	16
Initial Wt., lb	412	416	453	452
Avg. Daily Gain, lb	2.19	2.32	2.12	2.07
Avg. Daily Feed, lb[1]	15.11	15.75	15.01	14.45
Feed/lb of Gain	6.88	6.80	7.09	7.02

[1] 100% dry matter basis.

Table 39.4. Performance by Steers Fed the Four Grain Sorghum Silage Rations in Trial 3

Item	Late-dough Nonproc	Late-dough Proc	Hard-grain Nonproc	Hard-grain Proc
No. of Calves	20	20	20	20
Initial Wt., lb	573	570	569	570
Avg. Daily Gain, lb	2.25[b]	2.50[a]	2.11[b]	2.45[a]
Avg. Daily Feed, lb[1]	19.41[d]	19.37[d]	19.86[cd]	20.82[c]
Feed/lb of Gain	8.68[d]	7.75[c]	9.44[e]	8.53[d]

[a,b]Means with different superscripts differ ($P<.05$).
[c,d,e]Means with different superscripts differ ($P<.10$).
[1]100% dry matter basis.

Table 39.5. Dry Matter Intake and Apparent Nutrient Digestibility of the Four Grain Sorghum Silage Rations in Trial 3

Item	Late-dough Nonproc	Late-dough Proc	Hard-grain Nonproc	Hard-grain Proc
No. of Steers	5	5	5	5
Initial Wt., lb	572	554	557	576
Avg. Daily Feed, lb[1]	18.7	20.3	17.3	18.0
	Digestibility, %			
Dry Matter	53.8[b]	61.9[a]	55.1[ab]	57.9[ab]
Starch	65.0[b]	79.0[a]	50.8[c]	65.5[b]
Crude Protein	42.8[ab]	51.6[a]	38.3[b]	42.6[ab]
Neutral Detergent Fiber	52.5	55.1	60.6	60.2
Acid Detergent Fiber	49.5	50.0	55.9	56.1
Hemicellulose	56.6	61.0	66.2	65.1
Cellulose	60.2	59.0	62.5	63.0
Crude Fiber	58.9	58.6	65.4	64.4

[a,b,c]Means with different superscripts differ ($P<.05$).

[1]100% dry matter basis.

Table 39.6. Performance by Heifers and Steers Fed the Six Grain Sorghum Silage Rations in Trial 4

Item	Early-dough		Late-dough		Hard-grain	
	Nonproc	Proc	Nonproc	Proc	Nonproc	Proc
No. of Calves	16	16	16	16	16	16
Initial Wt., lb	579	595	593	584	596	580
Avg Daily Gain, lb	2.40^{bc}	2.51^{abc}	2.37^{bc}	2.66^{ab}	2.27^{c}	2.79^{a}
Avg. Daily Feed, lb[1]	18.4^{b}	18.6^{b}	18.5^{b}	19.3^{b}	19.5^{b}	21.3^{a}
Feed/lb of Gain[1]	7.75^{a}	7.52^{a}	7.98^{a}	7.42^{a}	8.78^{b}	7.76^{a}

[a,b,c]Means with different superscripts differ ($P<.05$).

[1]100% dry matter basis.

Table 39.7. Dry Matter Intake and Apparent Nutrient Digestibility of the Six Grain Sorghum Silage Rations in Trial 4

Item	Early-dough		Late-dough		Hard-grain	
	Nonproc	Proc	Nonproc	Proc	Nonproc	Proc
No. of Steers	4	4	4	4	4	4
Initial Wt., lb	891	876	884	878	869	856
Avg. Daily Feed, lb[1]	19.6	18.4	19.2	20.0	21.9	21.0
	Digestibility, %					
Dry Matter	54.3	55.9	53.7$_{f}$	53.9	51.6$_{f}$	54.3
Starch	86.1^{cd}	91.5^{c}	71.4^{f}	76.7^{e}	68.2^{f}	82.3^{de}
Crude Protein	49.1^{cd}	50.8^{c}	39.7^{e}	39.6^{e}	43.0^{de}	39.3^{e}
Neutral Detergent Fiber	39.7^{cd}	40.8^{cd}	49.6^{c}	45.6^{cd}	41.2^{cd}	38.^{d}
Acid Detergent Fiber	36.5^{cd}	39.5^{cd}	44.2^{c}	41.0^{cd}	38.4^{cd}	33.0^{d}
Hemicellulose	44.1^{cd}	42.8^{d}	55.9^{c}	51.0^{cd}	44.6^{cd}	45.7^{cd}
Cellulose	47.0^{cd}	51.0^{cd}	58.1^{c}	55.0^{c}	50.3^{cd}	42.8^{d}
Crude Fiber	46.4^{d}	49.2^{cd}	57.1^{c}	49.5^{cd}	52.6^{cd}	44.9^{d}

[a,b]Means with different superscripts differ ($P<.10$).

[c,d,e,f]Means with different superscripts differ ($P<.05$).

[1]100% dry matter basis.