Whole Sorghum Grain Stillage for Beef Cattle[1]

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Summary

Trials were conducted to evaluate the storing, handling, and feeding of whole sorghum grain stillage from a farm-scale still. Stillage varied in dry matter among batches and had to be agitated to keep solids suspended. Whole stillage kept for 10 days to 2 weeks, even during warm weather, with mold growth occurring only on the surface. However, when stillage was mixed with either grain or forage, it spoiled rapidly and required close bunk management.

Although whole stillage was still palatable to cattle after 2 weeks, intakes were best when it was less than 3 days old. When whole stillage was fed freechoice, cattle could not consume enough dry matter to maintain weight.

Steers fed whole stillage at 50% (as-fed basis) of a growing ration consumed more dry matter, gained faster, and were more efficient than those fed 0, 32, or 68% stillage.

Feeding decanted stillage (10.5% dry matter) as a protein supplement in finishing rations gave poorer rate and efficiency of gains than did soybean meal or urea.

Introduction

When cereal grains are fermented, starch, which makes up about two-thirds of grain dry matter, is converted to alcohol and carbon dioxide. Thus, fermenting the starch results in a three-fold increase in the remaining nutrients.

The residue after distillation, commonly called "stillage," contains only 5 to 10% dry matter and has a relatively short storage life. The recovery of stillage can contribute a significant economic return to grain alcohol production. However, drying stillage is not economical for farm-scale units, and dumping the effluent into rivers or streams can damage the environment.

Several universities have shown that the protein in commercial dried distillers' feeds is well used by growing cattle. Our objectives were to evaluate methods of feeding whole stillage to beef cattle. Stillage was obtained from a farm-scale still at approximately 14-day intervals and stored in a polyethylene tank at the feeding site. A flow diagram and outline of the alcohol-production process is shown in Figure 1.

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Experimental Procedures and Results

Chemical analyses of the stillage are shown in Table 12.1. Dry matter content averaged 7.5% (5.4 to 8.3 percent). Crude protein averaged 33% on a dry matter basis and ranged from 26 to 35%.

Trial 1: Stillage Fed Free-Choice. Twenty mixed breed yearling steers averaging 809 lb were randomly assigned (10 steers/treatment) to free choice stillage with or without access to drinking water. Steers, housed in individual stalls, were fed stillage in polyethylene troughs twice daily. All received 5 lb of longstem grass hay once daily and had free access to a salt block. The trial lasted 16 days (May 13 to May 29, 1981). The steers were not pre-adapted to stillage.

Steer performances are shown in Table 12.2. Stillage intakes were quite variable among all steers. Average daily stillage intake peaked at 115 lb on day 11, after delivery of fresh stillage on day 10. Steers without drinking water adapted to the stillage somewhat faster than did those with water; but by the end of the trial, intakes were about equal.

Fed whole stillage in this manner, steers consumed only 1.26% of their body weight as dry matter and all 20 lost weight. Poor performances were likely due to the extremely high moisture content and high acidity of the stillage. Steers looked emanciated by day 4, but no serious digestive problems occurred.

Trial 2: Stillage in Growing Rations. Sixty-four Hereford and Hereford x Simmental steers averaging 653 lb were fed growing rations for 56 days (April 24 to June 19, 1981). Four pens of four steers each were randomly assigned by blocks to each of four rations: 1) control; 2) 32% stillage; 3) 50% stillage; and 4) 68% stillage (as-fed basis).

All rations contained a fixed percentage of roughage and supplement on a dry matter basis. As stillage dry matter was added to the control ration, the same amount of milo dry matter was removed, and soybean meal and minerals in the corresponding supplement were replaced with milo to compensate for stillage protein and minerals. Water was added to the control ration so that its moisture content would equal that of the 32% stillage ration. Ration and the supplement compositions and ration proximate analyses are presented in Table 12.3.

Roughages were ground in a tub grinder through a 2-inch screen. Milo was coarsely rolled. Stillage was agitated in the holding tank before each feeding. All rations were mixed once but fed twice daily.

Steers were fed a fixed amount of corn silage for three feedings, then weighed individually after 16 hr without feed or water at the start and again at the end of the trial. That was to remove the effect of fill differences due to different moisture levels in the rations.

Steer performances are shown in Table 12.4. Daily gain from 50% stillage was greater ($P<.05$) than that from the control or the 32% stillage but similar to that from the 68% stillage. Feed intakes and efficiencies were not significantly different, but the 50% and the 68% stillage were 10 and 8%

more efficient, respectively, than the control ration. We concluded that stillage dry matter can successfully replace milo as an energy source and soybean meal as a supplemental protein source for growing steers.

Trial 3: Stillage in Finishing Rations. The 64 steers from trial 2 were used in an 84-day finishing trial (June 19 to September 13, 1981). Pens were re-allotted randomly, one pen from each previous ration, to four protein treatments: 1) soybean meal; 2) urea; 3) stillage; and 4) stillage plus urea.

Rations were 85% concentrate and 15% drought-stressed corn silage (dry matter basis). Steers were brought to full-feed within 10 days. The composition of the rations and the supplements and the proximate analyses of the mixed rations are given in Table 12.5.

All steers received 300 mg of Rumensin daily. Stillage moisture was reduced as follows: stillage was agitated within the holding tank, then the amount needed for the next day was pumped into two 55-gallon drums with siphoning ports about one-third the distance down from the top. After stillage had settled 24 hr; the thin slurry (top one-third) was removed. Dry matter of the thin phase was 1.5 to 2.0%; that in the remaining stillage was 10.5%. Rations were mixed once but fed twice daily.

Final weights from trial 2 were used as the initial weight in this trial. At the end, steers were weighed individually after 16 hr without feed or water. Final weights were adjusted to a 61.5% dressing percentage.

Performance data are shown in Table 12.6. Steers fed soybean meal gained 10% faster and 9% more efficiently ($P<.05$) than did those fed stillage as supplemental protein. Urea or stillage plus urea produced faster and more efficient gains than did stillage alone, but no rations containing stillage or urea performed as well as soybean meal. Dry matter intakes were not significantly different among treatments.

No significant differences were observed in dressing percentages.

Alcohol-production Process

1. One hundred bushels of milo was finely ground (1/4-inch screen) in a portable grinder-mixer.

2. A slurry (mash) was made in the cook tank by adding 12 gallons of preheated water per bushel of grain.

3. Live steam was added to bring the slurry temperature up to 130°F. Then a carbohydrase enzyme (taka-therm) was added to convert the starch to sugars (dextrins). The slurry was then heated with steam to 200°F and held there for 45 min. Agitation was continuous.

4. Another 8 gallons of water per bushel was added to cool the mash to 130°F. After the temperature had stabilized, amylase (an enzyme) was added to break the dextrins down to simple sugars (glucose). This process took about 6 hr.

5. The mash was then cooled to 80°F by passing it through a tube-in-shell heat exchanger.

6. The mash was transferred to the fermenting tank, inoculated with yeast, and allowed to ferment 72 hr. Glucose was converted to alcohol.

7. The mash was transferred to the beer column. Steam was added at the bottom of the beer still to vaporize the alcohol. The temperature at the top of the column was maintained at 190° to 200°F.

8. The uncondensed alcohol vapors were passed to the rectifier column. The temperature at the top of the rectifier column was controlled at 170°F by reflux (i.e., by pumping a portion of condensed product back into the column top).

9. The vapors from the rectifier column were condensed in a water-cooled condenser and the product flowed either into the reflux tank or into a product-storage tank.

10. Whole stillage was recovered from the bottom of the columns and was pumped directly to a transfer tank.

Cook tank	make-up
Grain sorghum	100 bushels (600 gallon)-displacement
Make-up	1200 gallon
Cooling water	800 gallon
Condensed steam	267 gallon
Total	2067 gallon

Recovery volume	
Whole stillage	2700 gallon
Alcohol (180 proof)	167 gallon
Total volume	2867 gallon

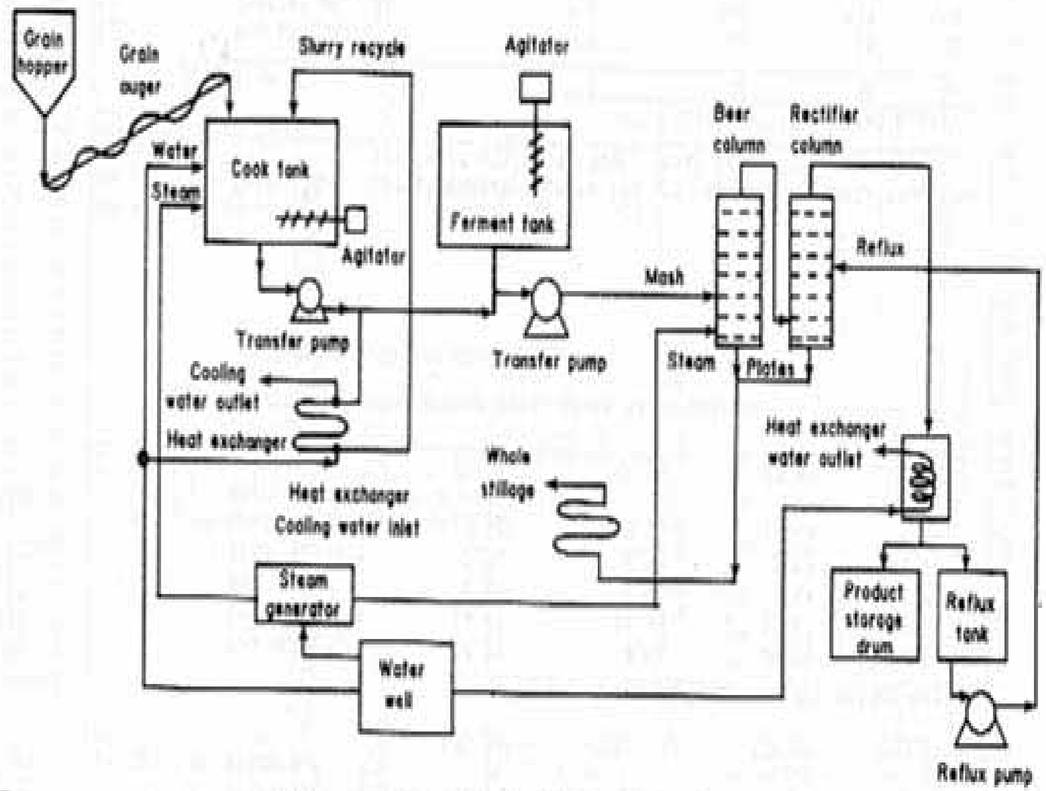

Figure 1. Alcohol Production Process

Table 12.1. Chemical composition of whole sorghum grain stillage[1]

Item	Dry analysis[2] Range	Average
Dry matter	5.40 - 8.3	7.5
Crude protein	26.0 - 35.0	33.2
Ash	4.3 - 5.2	5.0
Ether extract	11.7 - 12.7	12.2
Crude fiber	5.9 - 6.8	6.2
Nitrogen-free extract	41.4 - 45.4	43.4
Hemicellulose*	23.6 - 30.2	26.3
Cellulose*	17.2 - 26.3	20.2
Lignin*	6.5 - 9.5	8.1
Calcium	.11 - .12	.115
Phosphorus	.61 - .72	.67
Sodium	.028- .032	.030
Magnesium	.31 - .35	.322
	Wet analysis[3]	
pH	3.90 - 4.10	4.05
Lactate, % (w/v)	.27 - .42	.31
Acetate, % (w/v)	.02 - .42	.18
Ethanol, % (v/v)	.5 - 3.2	1.9

[1]Values presented are from five distillations (three samples/distillation).

[2]Expressed as a % of stillage dry matter.

[3]Expressed as a % of stillage volume.

*Van Soest analysis.

Table 12.2. Performance by steers fed whole stillage, trial 1[1]

Item	With water	Without water
No. of steers	10	10
Initial wt., lb	824	794
Final wt., lb	800	783
Avg. total weight change, lb	-24	-11
Avg. daily feed intake, lb as-fed[2]		
prairie hay	5.0 (4.5)	5.0 (4.5)
stillage[3]	71.8 (5.4)	76.8 (5.8)
total	76.8 (9.9)	81.8 (10.3)

[1]16-day trial.

[2]Value in parenthesis: feed intake on a 100% dry matter basis.

[3]Stillage: 7.5% dry matter.

Table 12.3. Composition of growing rations and supplements, trial 2

Ingredients	Ration (%, as-mixed basis)* 1	2	3	4
Alfalfa	14.3 (20.3)	14.3 (20.6)	11.1 (20.7)	7.5 (20.2)
Wheat straw	17.9 (25.4)	17.9 (25.7)	13.9 (26.0)	9.4 (25.3)
Milo	32.0 (44.3)	28.6 (40.0)	19.4 (35.4)	11.3 (29.7)
Water	28.6 --	-- --	-- --	-- --
Stillage[1]	-- --	32.2 (3.8)	50.0 (7.6)	68.0 (14.8)
Supplement	7.2 (10.0)	7.0 (9.9)	5.6 (10.3)	3.8 (10.0)
	100.0	100.0	100.0	100.0
	Supplement (%, as-mixed basis)			
Soybean meal	72.70	53.30	33.84	--
Milo	20.80	40.55	60.55	94.75
Salt	5.00	5.00	5.00	5.00
Dicalcium phosphate	1.25	.90	.36	--
Vitamin A	.25	.25	.25	.25
	100.00	100.00	100.00	100.00
	Ration proximate analyses (%, dry matter basis)			
Dry matter, %	64.13	64.00	48.70	33.50
Crude protein	14.67	14.33	13.67	14.22
Ash	6.82	6.59	6.99	6.60
Ether extract	2.28	2.38	2.67	4.10
Crude fiber	17.62	19.15	18.84	17.84
Nitrogen-free extract	58.62	57.55	57.81	57.24

*Percent on a dry matter basis given in parenthesis.

[1]Stillage: 7.5% dry matter.

Table 12.4. Performance by steers fed growing rations containing four levels of whole stillage, trial 2[1]

Item	Stillage[2] (%, as-fed basis) 0	32	50	68
No. of steers	16	16	16	16
Initial wt., lb	656	648	654	654
Final wt., lb	792	775	811	797
Avg. daily gain, lb	2.43[b]	2.24[b]	2.80[a]	2.54[ab]
Avg. daily feed intake, lb[3]	21.84	22.67	23.20	21.54
Feed/lb of gain, lb[3]	9.15	10.09	8.32	8.48

[1]56-day trial.

[2]Stillage: 7.5% dry matter

[3]100% dry matter basis.

[a,b]Means on same line with different superscripts differ significantly ($P<.05$).

Table 12.5. Composition of finishing rations and supplements, trial 3

Ingredient	Soybean meal	Urea	Stillage	Stillage[1] + urea
	Ration (%, as-mixed basis)*			
Milo	64.7 (80.7)	64.7 (80.7)	41.2 (73.1)	53.7 (77.9)
Corn silage	31.2 (14.2	31.2 (14.2)	22.5 (14.5)	27.2 (14.3)
Stillage[2]	--	--	33.3 (7.1)	15.6 (2.7)
Supplement	4.1 (5.1)	4.1 (5.1)	3.0 (5.3)	3.5 (5.1)
	Supplement (%, as-mixed basis)			
Soybean meal	73.80	--	--	--
Milo	--	62.93	73.80	67.33
Urea	--	10.57	--	6.47
Trace mineral salt	10.00	10.00	10.00	10.00
Limestone	15.60	15.90	15.60	15.60
Vitamin A premix	.23	.23	.23	.23
Vitamin D premix	.04	.04	.04	.04
Rumensin premix	.33	.33	.33	.33
	100.00	100.00	100.00	100.00
	Ration proximate analyses (%, dry matter basis)			
Dry matter, %	70.81	70.52	50.47	61.25
Crude protein	12.32	12.48	12.08	12.48
Ash	4.51	4.32	4.67	4.81
Ether extract	2.31	2.28	2.74	2.54
Crude fiber	5.24	4.84	5.59	5.14
Nitrogen-free extract	75.62	76.08	74.92	75.03

*Percent on a dry matter basis given in parenthesis.

[1]Urea supplied 50% of the supplemental nitrogen.

[2]Stillage: 10.5% dry matter.

Table 12.6. Performance by finishing steers fed the four sources of supplemental protein, trial 3[1]

Item	Soybean meal	Urea	Stillage[2]	Stillage + urea
No. of steers	16	16	16	16
Initial wt., lb	802	784	791	797
Final wt., lb	1083	1056	1048	1060
Avg. daily gain, lb	3.27	3.16	2.99	3.07
Avg. daily feed intake, lb[3]	24.25	24.30	24.09	24.30
Feed/lb of gain, lb[3]	7.44[a]	7.68[ab]	8.10[b]	8.00[ab]

[1]86-day trial.

[2]Stillage: 10.5% dry matter.

[3]100% dry matter basis.

[a,b]Means on the same line with different superscripts differ significantly ($P<.05$).