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Test weight affects the milling characteristics of grain sorghum

Abstract

As test weight was reduced from normal to intermediate (i.e., from 58 to 52 lb/bu), little change occurred in milling characteristics of grain sorghum. However, as test weight was decreased from intermediate to light (52 to 39 lb/bu), production rate slowed and cost of grinding increased dramatically. Decreasing screen opening size from 8/64 in to 3/64 in also decreased production rates and increased electrical energy costs, with these effects much more pronounced in light test-weight sorghum.; Swine Day, Manhattan, KS, November 16, 1995

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TEST WEIGHT AFFECTS THE MILLING CHARACTERISTICS OF GRAIN SORGHUM

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Summary

As test weight was reduced from normal to intermediate (i.e., from 58 to 52 lb/bu), little change occurred in milling characteristics of grain sorghum. However, as test weight was decreased from intermediate to light (52 to 39 lb/bu), production rate slowed and cost of grinding increased dramatically. Decreasing screen opening size from 8/64 in to 3/64 in also decreased production rates and increased electrical energy costs, with these effects much more pronounced in light test-weight sorghum.

(Key Words: Sorghum, Test Weight, Grinding.)

Introduction

Grain sorghum production in Kansas during the 1993 crop year was 176.4 million bushels. Thus, grain sorghum is an important crop for both grain farmers and livestock feeders in our state. Data gathered by the Kansas Department of Agriculture suggested that more than 30% of the sorghum produced in Kansas was given a discount because of excessive moisture and nearly 10% was discounted for light test weight during good cropping years. Test weight of sorghum grains is affected by genetics, environment, and cultural practices. In particular, late planting, cool growing season, and early frost result in light test weight, and all three of the factors occurred this year in Kansas.

Data generated at KSU during the past 4 years suggested that the feeding value of sorghum with test weight as low as 35 lb/bu was only 10 to 12% lower than that of normal test-weight sorghum. This reduction in feeding value of light sorghum is in sharp contrast with the 30 to 50% discount in price some farmers have reported. Very little information is available about milling characteristics that might help a producer decide whether or not to use light test-weight sorghum in diets for pigs. Thus, an experiment was conducted to determine the milling characteristics of sorghum grain varying widely in test weight.

Procedures

Grain sorghums with test weights of 58, 52, and 39 lb/bu were obtained from grain producers in the state of Kansas. Three replications (random samples) of each test weight were ground in a 1.5 horsepower Bliss hammermill (Model ELT-9506-TF) equipped with screens having openings of 8/64, 6/64, 4/64, and 3/64 in. The motor load of the hammermill was constant at 75% of capacity during milling, so that production rates and electrical energy consumption could be measured. Net electrical energy was calculated as the difference between total electrical energy used during grinding and electrical energy used to spin the hammer rotor while no sorghum was being ground. Samples were obtained after grinding to allow determination of the geometric mean particle size (Dgw), log normal geometric standard deviation (Sgw), and apparent bulk density (lb/ft^3).

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All data were analyzed as a completely randomized design with a 3 × 4 factorial arrangement of treatments. Main effects were test weight (58, 52, and 39 lb/bu) and screen size (8/64, 6/64, 4/64, and 3/64 in) used to mill the grain. Polynomial regression was used to characterize the response of milling characteristics as test weight and screen size were decreased and to identify any interactions among the test weight and screen size treatments.

Results and Discussion

Each lot of grain sorghum was characterized with an official grade (Table 1). Minimal differences occurred for dockage, foreign matter, and broken kernels as test weight was decreased from 58 to 52 lb/bu. However, marked differences between the 52 and 39 lb/bu sorghums occurred for dockage, foreign matter, and broken/foreign matter content.

Although the same screens were used to grind all three sorghums, as test weight was decreased, there was a trend for the 39 lb/bu sorghum to have greater particle size than the 58 and 52 lb/bu sorghums (quadratic trend, $P<.08$). Also, a marked decrease in production rate and increases in total and net energy consumption occurred during grinding, as test weight was decreased from 52 lb/bu to 39 lb/bu (quadratic, $P<.01$). The decreased desirability for milling the 39 lb/bu test weight sorghum results from its relatively high fiber content (glumes, stalks, etc.) compared to the 52 and 58 lb/bu sorghums. Indeed, the difficulty in grinding the fibrous 39/lb/bu sorghum resulted in a total grinding cost of $2.23/ton compared to values of $.94/ton and $.85/ton for the 58 and 52 lb/bu test-weight sorghums, respectively.

Because feed manufacturers use equipment that is based on volumetric capacity (mixers, bins, etc.), any changes in ground grain bulk density could affect the performance of the mixer (i.e., mix uniformity), storage capacity of bulk bins, and production rate through grinders. Linear decreases in bulk density of the whole and ground grain occurred as test weight was decreased ($P<.01$), but most of the effect actually occurred as test weight was decreased from 52 to 39 lb/bu (quadratic, $P<.01$).

As screen size opening was decreased from 8/64 to 3/64 in, geometric mean particle size (Dgw) was decreased from 759 to 366 microns (linear, $P<.01$) and variation of particle size (Sgw) decreased from 2.11 to 1.97. However, production rate decreased from 535 lb/h to 115 lb/h as screen size was decreased ($P<.01$), and total electrical cost of grinding was increased by $1.92/ton.

Thus, both decreasing test weight and using screens with smaller openings tend to decrease production rate and increase milling costs. However, the effects of test weight and screen size were not independent, as indicated by several noteworthy interactions. The most important of these interactions indicated that decreased throughput and increased milling costs from using small screen openings were greatly affected by 39 lb/bu sorghum vs the 52 and 58 lb/bu sorghums (test weight by screen size interaction, $P<.01$).

In conclusion, our data suggest that grain sorghum test weight as low as 52 lb/bu has no effect on mill throughput, energy consumption, or energy costs for grinding when compared to normal test-weight sorghum. In contrast, the use of sorghum with a test weight of 39 lb/bu reduced mill throughput from 297 to 166 lb/h and increased grinding costs from $.41 to $2.33/ton. Thus, increased milling costs should be considered along with potential reductions in growth performance in making a decision about use of low test-weight sorghum.

Table 1. Characteristics of the Whole Grain[a]

	Test weight, lb/bu		
Item	58	52	39
Grade	#1 white	# 4 white	Sample
Test weight, lb/bu	58.0	51.5	38.5
Dockage, %	0.00	0.00	1.00
Foreign matter, %	0.3	0.4	6.5
Broken/foreign matter, %	1.3	1.5	14.5

[a] Official grain grades were determined by an FGIS inspector.

Table 2. Effects of Test Weight and Screen Size on Grain Sorghum Processing Characteristics

	Test weight, lb/bu												
	58				52				39				
Item Screen size, in:	8/64	6/64	4/64	3/64	8/64	6/64	4/64	3/64	8/64	6/64	4/64	3/64	CV
Milled grain characteristics													
Geometric mean particle size, microns	775	536	401	361	739	534	402	321	762	595	430	416	10.6
Log normal standard deviation	2.13	2.17	2.05	2.00	2.12	2.17	2.01	2.00	2.06	2.02	1.98	1.90	3.0
Production characteristics													
Production rate, lb/h	581.0	300.1	165.2	141.5	642.6	360.0	173.0	151.0	383.2	155.6	72.8	53.0	9.8
Electrical energy consumption, kWh/ton													
Total	4.57	8.67	15.4	18.17	4.00	7.33	14.63	16.73	6.70	16.47	35.67	52.60	16.6
Net[a]	1.17	2.06	3.73	4.57	1.03	1.87	3.47	4.00	1.70	4.00	9.23	15.83	27.6
Electrical energy grinding costs, $/ton[b]													
Total	.37	.69	1.23	1.45	.32	.59	1.17	1.34	.54	1.32	2.85	4.21	16.6
Net	.09	.17	.30	.37	.08	.15	.28	.32	.14	.32	.74	1.27	27.6
Apparent bulk density, lb/ft^3													
Whole grain	46.93	48.43	48.42	48.88	42.93	42.27	41.47	42.15	30.03	29.27	31.40	29.23	3.7
Ground grain	41.78	41.45	40.72	39.23	38.63	37.77	36.63	36.38	27.42	28.25	30.33	29.37	2.4
Difference	-5.15	-6.98	-7.70	-9.65	-4.30	-4.50	-4.84	-5.77	-2.62	-1.02	-1.07	0.14	23.5

[a] Difference between total grinding amps and empty amps.
[b] Calculation based on $.08/kWh for electrical energy cost.

Table 3. Probability Table

	Test weight		Screen size			Two-way interactions					
Item	Linear (1)	Quadratic (2)	Linear (3)	Quadratic (4)	Cubic (5)	1 × 3	1 × 4	1 × 5	2 × 3	2 × 4	2 × 5
Geometric mean particle size	-[a]	.08	.01	.01	-	-	-	-	-	-	-
Log normal standard deviation	.01	.11	.01	-	.07	-	-	-	-	-	-
Production rate	.01	.01	.01	.01	-	.01	-	-	-	-	-
Total energy consumption	.01	.01	.01	-	.04	.01	.08	-	.01	-	-
Net energy consumption	.01	.01	.01	-	-	.01	.04	-	.01	-	-
Total grinding cost	.01	.01	.01	-	.04	.01	.08	-	.01	-	-
Net grinding cost	.01	.01	.01	-	-	.01	.04	-	.01	-	-
Whole grain density	.01	.01	-	-	-	-	-	.10	-	-	-
Ground grain density	.01	.01	.05	-	-	.01	-	-	.02	.10	-
Difference in density	.01	-	.03	-	-	.01	-	-	-	-	-

[a] Dash indicates $P > .11$.