

FINAL REPORT

Project: Nutritional Characteristics of Sorghum Differing in Bushel  
Weight and Seed Size.

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## Introduction

Sorghum that has been stressed during seed development may result in grain that tests below 54 lb/bu when harvested. Lack of moisture and freezing temperatures before seed maturity are stresses that may result in light weight sorghum. Possible nutritional differences as well as processing and flaking difficulties have been attributed to light weight sorghum used in rations for feedlot cattle. Within the past 10 years and especially during the last 5 years, the occurrence of small, seed within harvested sorghum has become more evident. The cause of small seed is not known, although it is thought to be the result of interaction among physiological, pathological, genetic and environmental factors. Yield reductions of 2 to 20% annually, due to small seed have been estimated. Some hybrids have more small seed than others. Seed size reductions (both diameter and weight) of about 50% are common. Small seed present harvesting and processing problems, and possible nutritional differences.

The objectives of this study were to:

- 1) determine the nutritional characteristics of sorghum of different seed size and bushel weight by in vitro techniques, including crude protein, starch availability, gross energy, gelatinization and crude fiber;
- 2) determine the effect of processing on sorghum of different seed size and bushel weight; and to
- 3) determine the distribution of different sizes of seed in samples of sorghum.

## Experimental Procedure

Sorghum of different bushel weights were obtained from northern Kansas (light weight due to early frost), the Oklahoma Panhandle, the Texas Panhandle and from the Texas High Plains. Each sample of grain was processed by a laboratory scale, steam-pressure flaking technique developed by Sherrod and Summers at the Texas Tech University Center at Amarillo, Pantex. In addition, samples of grain were micronized using a laboratory scale microwave processor and roller technique developed by Hinders at Producers Grain Corporation, Amarillo, Texas. Only whole, cleaned sorghum was processed. The processed samples were passed through the same Wiley mill screen (20 mesh) prior to laboratory analysis. Samples of sorghum were separated into small, medium and large seed sizes by using a sieve screen size of 2.8 mm. The different sizes of seed were processed and prepared for laboratory analysis in the same manner as for sorghum of different bushel weights.

Laboratory analyses conducted on the sorghum samples were starch availability (measuring in vitro yeast gas yield from starch digestion of beta-amylglucosidase), crude protein, ether extract, gelatinization (measured as mg maltose/g of sample), crude fiber, ash and gross energy (kcal/g using a bomb calorimeter). Bushel weights of sorghum samples were verified by weighing 100 cc of sorghum from each sample.

## Results

The effect of bushel weight upon the nutritional value of sorghum is summarized in table 1. Analysis of variance was conducted to determine significant differences for parameters measured among the sorghums varying in bushel weight. Significantly lower values ( $P < .01$ ) were detected for starch availability and gelatinization of steam pressure flaked sorghum weighing under 40 lb/bu versus sorghum weighing over 40 lb/bu. No significant differences ( $P > .05$ ) were detected among sorghum samples of different bushel weights for % crude protein, % ether extract, gross energy (kcal/g), % ash and % dry matter. A significant linear difference ( $P < .01$ ) was detected for % crude fiber among the different weight sorghum samples, indicating that % crude fiber increased as bushel weight decreased.

Correlation coefficients ( $r$ ) were determined between all the parameters, using each nutritional or energy variable as X with each of the other variables as Y. A low, but significant correlation ( $P < .01$ ) of  $r = .42$  was detected between bushel weight and steam pressure flaked gas production (indicator of starch availability). A significant correlation ( $P < .01$ ) of  $r = 0.85$  was determined between steam pressure flaked gas production and degree of gelatinization. The correlation coefficient between bushel weight and crude fiber was significant ( $r = .77$ ;  $P < .01$ ).

The effect of seed size upon the nutritional value of sorghum is presented in tables 2 and 3. Small size seed contained a significantly lower % crude protein than large size seed ( $P < .01$ ). A tendency was detected for small size seed to weigh less per bushel than large seed ( $P < .10$ ). A significant correlation was determined between steam pressure flaked gas production versus gelatinization ( $r = .78$ ;  $P < .01$ ).

The distribution of seed sizes among various samples of sorghum were determined. At Texas Tech, Krieg (personal communication) summarized 3 years of data involving 8 hybrid varieties of sorghum, 12 different levels of nitrogen fertilization at 3 or 4 locations (depending upon year) and found these relationships:

- a) amount of small seed on a single head of sorghum = 10-12%;
- b) harvesting loss of these small seeds was between 75 and 80% or about 8-9% of the total seeds on a head; and the
- c) amount of small seed left in the total quantity of sorghum harvested would be about 20-25% of the small seed or approximately 2-3% of the total sorghum being shipped to market.

In the present study, a sample of sorghum observed to contain an above average proportion of small seeds, was screened into different seed sizes using a 2.8 mm sieve size screen and the results are shown in table 3. About 7% of the total seed was small seed. Combining both sources of information, less than 7% small size seed would be expected in any given quantity of sorghum.

## Discussion

This study indicates that sorghum weighing 40 lb/bu or more is not nutritionally different from 56 lb/bu sorghum. These data were determined by in vitro techniques and one could suggest that the measurements taken to indicate nutritional value were not refined enough to detect real differences in sorghum weighing less than 56 lb/bu. Some consulting feedlot nutritionists (Plains Nutrition Council, Inc. Personal communication, March 5, 1975) indicated that there might be little nutritional difference in light weight sorghum, if properly processed; however, they strongly argued that it is nearly impossible to completely and properly steam process flake sorghum of light weight and/or sorghum of small seed size. Attempts were made to carefully standardize and maintain processing technique in this study, which suggests that differences in efficiency of utilization of improperly steam process flaked sorghum observed under feedlot conditions is a result of roller mill management. This seems to be a valid statement, but equally valid is the rebuttal that to properly steam process flake light weight and/or small seed sorghum, the cost of slowing down the movement of steamed sorghum through the rollers in order to flake each seed would be increased. Another point mentioned at the Plains Nutrition Council meeting on March 5 was that some sorghum is dark colored, requiring additional steaming time to reach the desired degree of gelatinization, and this increases the cost of processing.

It has been stated that care was taken to insure that each steam pressure processed seed was flaked for this study. However, the light weight sorghum weighing under 40 lb/bu had a different texture during flaking, resulting in a flake that attached to the grooved rolls in many instances. In addition, the flakes appeared to be crumbly, with less integrity when compared to the flakes of sorghum weighing over 40 lb/bu.

Another interesting point was made by Mike Gatzman, feedlot manager at Smyer, Texas, suggesting that even if the light weight and/or small seed sorghum is properly processed, one will experience a lower digestibility of the sorghum due to a higher crude fiber content. The data in this report support the theory that crude fiber could be involved (since it is highly correlated with bushel weight); but the starch availability test and gelatinization technique detected differences only when sorghum weighed less than 40 lb/bu. The techniques used in this study may not have been sensitive enough to detect the effect of crude fiber in lowering digestibility of sorghum weighing more than 40 lb/bu. Further research is warranted in this area.

Based upon seed size distribution studies, it appears that less small seed sorghum escapes flaking than most observers suspect.

The literature supports the results of this study. Dudley Arnett (Garden City Branch of the Kansas Experiment Station) obtained the data shown in tables 4 and 5 which show no differences in steer and lamb feedlot performance when light weight sorghum was used. However, sorghum for the steer study was dry rolled, and sheep are known to chew feed thoroughly; both conditions would be expected to reduce differences due to processing, resulting in similar feedlot performance regardless of the bushel weight of the sorghum.

Hale (Arizona - personal correspondence) stated that they could establish no relationship between bushel weight and nutritive value of sorghum in their early work. He did indicate that this was not to say that there was no effect, but that usual feeding and digestion techniques may not define the difference. He felt that bushel weight is probably not as important in feeding as commonly believed (referring to trash-free sorghum).

California and Arizona research with barley of 30-32, 40 and 48 lb/bu weights detected no differences in steer performance, although the 32 lb/bu barley at Arizona had no definitive control treatment (Hale - personal communication).

Thornton, Goodrich and Meiske (1969) at Minnesota reported work with corn of light bushel weights and could detect no differences in apparent digestibility (table 6), although crude fiber percentages followed the trends stated for sorghum in the present study (table 7).

The following calculations were made to give one view of the reduction in value of sorghum due to low bushel weight. Using the equation of Porter, Albin and Sherrod (1974) involving the gas production technique to estimate DE (digestible energy), these values were obtained.

Equation:  $Y = 3.13 + 0.075X$   
 Where  $Y = \text{kcal DE/g of grain dry matter}$   
 and  $X = \text{ml gas/hr/g grain dry matter}$

Bushel wt. (from study)	ml gas (from study)	Calculations
53	19.5	$3.13 + 1.46 = 4.59 \text{ kcal DE/g}$
35	10.8	$3.13 + 0.81 = 3.94 \text{ kcal DE/g}$

thus: DE reduction = 14%

Using the Southwest Scale of Grain Premiums and Discounts, the following calculations were made.

Given: \$5.00/cwt for sorghum and a 35 lb/bu weight, the discount would be \$0.80/cwt, resulting in a 16% reduction in price.

A summary of project % price reductions is given in table 8, using the Southwest Scale for Sorghum Premiums and Discounts. This system appears to reflect realistic judgment in assessing steam process flaking difficulties associated with light weight sorghum and/or sorghum with small size seeds to be used in cattle feedlot rations when sorghum prices are \$4.00/cwt or higher.

### Conclusions

1. No significant nutritional or energy differences were detect<sup>ed</sup> among samples of sorghum weighing above 40 lb/bu.
2. Sorghum with small size seed contained a significantly lower crude protein percentage and a lighter bushel weight than sorghum of large size seed.
3. Properly processed sorghum weighing under 40 lb/bushel should have a reduced energy value of 14%.
4. Sorghum with decreasing bushel weights is significantly correlated with an increasing crude fiber percentage.
5. Whole sorghum of small size seed makes up a small percentage (<7%) of the total amount of grain in the mixed ration.

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Table 1. Effect of Bushel Weight Upon Various Nutritional Parameters of Sorghum

Number of samples	Bushel weight, lb.	Crude protein %	Starch availability <sup>a</sup>	Gelatinization (mg maltose/g)	Gross energy (kcal/g)	Crude fiber, %
9	30, 37	11.5	10.8 ± 1.5 <sup>b, c</sup>	271 ± 63 <sup>c</sup>	4.405	3.21
20	45, 48	12.5	19.3 ± 3.2	428 ± 74	4.423	2.88
41	50	11.1	20.8 ± 5.5	451 ± 64	4.381	2.75
39	52	10.8	19.3 ± 3.2	417 ± 75	4.353	2.47
34	54	10.3	19.7 ± 3.3	445 ± 67	4.380	2.13
38	56,58,60	11.0	18.2 ± 3.0	422 ± 82	4.364	1.82

<sup>a</sup> Estimated as ml gas produced/hr/g of grain dry matter.

<sup>b</sup> Standard deviation.

<sup>c</sup> Significantly lower ( $P < .01$ ) from the other parameters for bushel weights.

Table 2. Effect of Seed Size Upon Various Nutritional Parameters of Sorghum<sup>a</sup>

Seed Size	Bushel weight, lb.	Crude Protein, %	Gross energy (kcal/g)	Starch Availability <sup>b</sup>	Gelatinization (mg maltose/g)
Small	52 ± 4 <sup>c,d</sup>	10.4 ± .8 <sup>e</sup>	4.35 ± .08	20.7 ± 1.4	460 ± 61
Large	56 ± 4	11.1 ± .6	4.37 ± .06	20.2 ± 1.8	453 ± 68
Mixture	54 ± 4	10.9 ± .7	4.39 ± .05	20.3 ± 1.9	459 ± 59

<sup>a</sup> Six samples of sorghum separated into different sizes using a 2.8 mm sieve screen.

<sup>b</sup> Estimated as ml gas produced/hr/g of grain dry matter.

<sup>c</sup> Standard deviation.

<sup>d</sup> Small seed lighter than large seed ( $P < .10$ ).

<sup>e</sup> Small seed lower than large seed ( $P < .01$ )

Table 3. Distribution of Sorghum

Seed Sizes (one sample)					
Seed Size	Bushel Weight	% of Mixture	% Crude Protein	Gas Production	Gelatinization
Small	46	7.3	11.7	18.7	374
Med.	55	44.4	11.7	21.3	448
Large	58	40.9	12.0	20.6	419
Mixture	55	100.0	11.4	18.8	427

Table 4. Feedlot Performance of Steers Consuming Light Weight Sorghum<sup>a,b</sup>

<u>Item (lb)</u>	<u>Bushe1 Weights</u>	
	<u>45 1b</u>	<u>58 1b</u>
Feed	22.9	23.4
Gain	3.2	3.2
Feed/Gain	7.2	7.4

<sup>a</sup>  
22 steers

Arnett- Garden City

<sup>b</sup>

Information provided by Dr. Larry Corah, Kansas State University, Manhattan.

Table 5. Feedlot Performance of Lambs Consuming Light Weight Sorghum  
at Two Concentrate: Roughage Ratios<sup>a,b</sup>

Bu wt. Conc: Roughage	Bushel Weights					
	35		45		58	
	40:60	80:20	40:60	80:20	40:60	80:20
<u>Performance (lb)</u>						
Feed	5.0	3.9	4.7	3.7	4.5	3.4
Gain	0.7	0.5	0.6	0.5	0.6	0.5
Feed/Gain	7.5	7.5	7.5	7.5	8.0	7.3

<sup>a</sup>288 lambs

Arnett - Garden City

<sup>b</sup>

Information provided by Dr. Larry Corah, Kansas State University, Manhattan.

Table 6. Apparent Digestion Coefficients for Corn of Different Bushel Weights<sup>a</sup>

<u>Digestion Coefficients</u>	<u>lb/bu</u>			
	<u>35</u>	<u>47</u>	<u>55</u>	<u>58</u>
CP, %	84	80	80	85
EE, %	77	83	88	92
GE, %	88	90	91	94
OM, %	90	92	93	95
TDN, % of DM	91	94	97	99
DE, kcal/g	4.03	4.07	4.18	4.28

<sup>a</sup> Information provided by Dr. Larry Corah, Kansas State University, Manhattan.

Thornton, Goodrich,  
Meiske (1969)

Table 7. Composition of Corn of Varying Bushel Weights<sup>a</sup>

Item	lb/bu		
	35.2	46.1	57.8
CP, %	11.7	10.5	11.0
EE, %	2.9	3.1	4.7
CF, %	3.5	2.7	2.2
Ash, %	2.0	1.8	1.4
NFE, %	80	82	81
GE, kcal/g	4.44	4.43	4.48

Thornton, Goodrich,  
Meiske (1969)

<sup>a</sup> Information provided by Dr. Larry Corah, Kansas State University, Manhattan.

Table 8. Sorghum Price Fluctuations and % Discounts for Sorghum

Sorghum (\$/cwt)	% Reduction in Price	
	45 lb/bu (-30¢/cwt)	35 lb/bu (-80¢/cwt)
6.00	5	13
5.00	6	16
4.00	7	20
3.00	10	26
2.00	15	40