

IN VITRO DRY MATTER DISAPPEARANCE AND IN VITRO GAS PRODUCTION OF SORGHUM GRAIN VARIETIES

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Story in Brief

Dwarf Redlan, 1133, Darset and millrun sorghum grain varieties were finely ground prior to determination of composition, in vitro dry matter disappearance and in vitro gas production. Dwarf Redlan is a non-bird resistant sorghum grain with a waxy endosperm. Darset and 1133 are bird resistant-high tannin varieties differing in endosperm, Darset having a normal and 1133 a waxy endosperm. Millrun was a commercially purchased non-bird resistant sorghum with a normal endosperm. In vitro dry matter disappearance was determined to assess differences between sorghum varieties and the inhibitory influence of tannin on rumen microbes. Mean in vitro dry matter disappearance values were lower (36.4%) when rumen fluid was obtained from a heifer consuming Darset (high tannin) sorghum than when obtained from a heifer consuming millrun sorghum (40.9%). Averaged across rumen fluid source, 1133 (35.4%) and Darset (30.9%) bird resistant varieties were less digestible than non-bird resistant Dwarf Redlan (44.3%) and millrun (44.0%). In vitro gas production (12 hours) further suggests that starch in non-bird resistant varieties, Dwarf Redlan (85.1 ml gas/g dry matter) and millrun (77.2), is more available to enzymatic degradation than in bird resistant varieties, 1133 (65.2) and Darset (52.2). A waxy endosperm appears to enhance in vitro dry matter disappearance and in vitro gas production and may offer potential for partially overcoming the detrimental effects of high tannin levels.

(Key Words: Sorghum Grain, Endosperm Type, Dry Matter Disappearance)

Introduction

The importance of sorghum grain as an energy source in feedlot diets should increase as irrigated corn production declines. Declining water tables, increasing costs of irrigation and increasing water demands in the High Plains should make sorghum an increasingly important feed grain. Sorghum grain varieties differ greatly in physical characteristics, digestibility and resulting animal performance. Identification and production of nutritionally improved sorghum varieties will result in improvements in feeding value. The following study was conducted to identify differences in in vitro dry matter disappearance and in vitro gas production of four widely divergent sorghum grain varieties.

Materials and Methods

Dwarf Redlan (Dwf), 1133 and Darset (Dar) pureline sorghum grain

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varieties were grown under dryland conditions at the Perkins Agronomy Experiment Station, Perkins, OK. A fourth, millrun (Mr), was purchased commercially through the OSU feedmill. Origin and genetic background of the Mr were unknown, but appeared representative of that normally purchased on a commercial basis (normal endosperm, non-bird resistant). Observable physical characteristics are listed in Table 1.

Grains were analyzed for dry matter, crude protein, starch, tannin (catechin equivalents/g DM), sodium chloride soluble and pepsin insoluble nitrogen. In vitro dry matter disappearance (IVDMD) was determined using 1 g of grain which had been ground through a 20 mesh (1mm) screen in a laboratory Wiley mill. Ruminant fluid was obtained from two different heifers in each of four replications. One heifer consumed a bird resistant sorghum grain (Dar), the other a non-bird resistant sorghum grain (Mr). Varieties were incubated in each fluid to determine if microbial populations differed in their ability to digest grain due to high tannin diets.

In vitro gas production (IVGP) of the grains was determined by measuring the CO₂ produced when 1 g of grain was incubated with .25 g of commercial baker's yeast and 10ml of a 0.1% (w/v) amyloglucosidase solution at 39 C. Gas production measurements were made hourly from 0 to 6 h and at 12 h after initial incubation. Gas productions at 6 and 12 h are presented.

Results and Discussion

The protein and starch contents of the grains are shown in Table 2. Significant differences ($P < .01$) in protein were noted. Darset (72.1%) contained the least, Mr (78.8%) the greatest, and 1133 (76.4%) and Dwf (77.1%) intermediate amounts of starch. Condensed tannin content of bird resistant grains was greater ($P < .01$) than for non-bird resistant varieties. Sodium chloride soluble nitrogen was highest for non-bird resistant varieties. Moreover, waxy bird resistant 1133 (4.3%) had a greater soluble nitrogen content than normal bird resistant Dar (2.1%). Waxy endosperm may cause an increase in protein solubility,

Table 1. Descriptive characteristics of sorghum grain.

- Endosperm -					
Sorghum variety	Abbreviation	Pericarp color	Color	Starch type	Testa layer ^a
Dwarf					
Redlan	Dwf	red	white	waxy	absent
1133	1133	brown	yellow	waxy	present
Darset	Dar	brown	white	normal	present
Millrun	Mr	mixed	non-descript	normal	absent

^a Presence of a testa layer indicative of high tannin content and bird resistance.

Table 2. Chemical composition of sorghum grain varieties (dry matter basis).

Item (%)	1133	Dar	Dwf	Mr
Crude Protein ^{abcd}	12.0	13.2	12.4	10.3
Starch	76.4	72.1	77.1	78.8
Tannin (cat.eq.1g) ^e	1.24	1.44	0.0	0.0
NaCl soluble protein	4.2	2.1	7.5	7.4
Pepsin insoluble nitrogen ^{bdfg}	18.3	22.0	13.3	13.8

^aInteraction (P<.01).

^bDar vs Mr (P<.01).

^cDwf vs Mr (P<.01).

^d1133 vs Dar (P<.01).

^e1133 & Dar vs Dwf & Mr (P<.01).

^fInteraction (P<.01).

^g1133 vs Dwf (P<.01).

resulting in increased starch availability. Pepsin insoluble nitrogen (PIN) content was greater (P<.01) for Dar (22.0%) than 1133 (18.3%). Within waxy and normal varieties, the bird resistant 1133 contained more (P<.01) PIN than Dwf and Dar more (P<.01) than Mr. Condensed tannins may be responsible for or related to the increased PIN.

Sorghum varieties incubated in ruminal fluid from heifers fed a bird resistant sorghum tended to result in lower IVDM than when the same varieties were incubated in fluid obtained from a heifer fed Mr (Figure 1; Table 3). Rumen microbes appeared to be inhibited by high tannin levels. IVDM (averaged across fluid source), within bird resistance, was lower (P<.01) for normal Dar (30.9%) than waxy 1133 (35.4%). The branched nature of amylopectin present in waxy endosperm appears to facilitate a greater starch availability. Additionally, IVDM for waxy Dwf (non-bird resistant) was greater (P<.01) than waxy 1133 (bird resistant). Within normal varieties, Mr (44.0%) had a greater (P<.01) IVDM than Dar (30.9%). Condensed tannins and greater PIN appear to limit digestion of bird resistant varieties.

IVGP measured at 6 and 12 h showed similar results; therefore, only data obtained at 12 h is discussed. Bird resistant varieties, 1133 (65.2 ml gas/g DM) and Dar (52.2) produced less (P<.01) CO₂ than non-bird resistant varieties, Dwf (85.1) and Mr (77.2). Tannins and/or protein insolubility of bird resistant varieties appeared to limit enzymatic starch liberation resulting in lower gas production. Tannin may also adversely affect the yeast, inhibiting fermentation of free glucose into CO₂ and water. Varieties with a waxy endosperm (1133 and Dwf) produced more (P<.01) CO₂ than their bird resistant or non-bird resistant normal (Dar and Mr) counterparts. This further suggests that grains with waxy endosperm have greater starch availability. Moreover, the waxy trait appears to offset part of the negative influence of the bird resistant characteristic. Greater starch availability may result from increased protein solubility and/or the higher amylopectin content in waxy types.

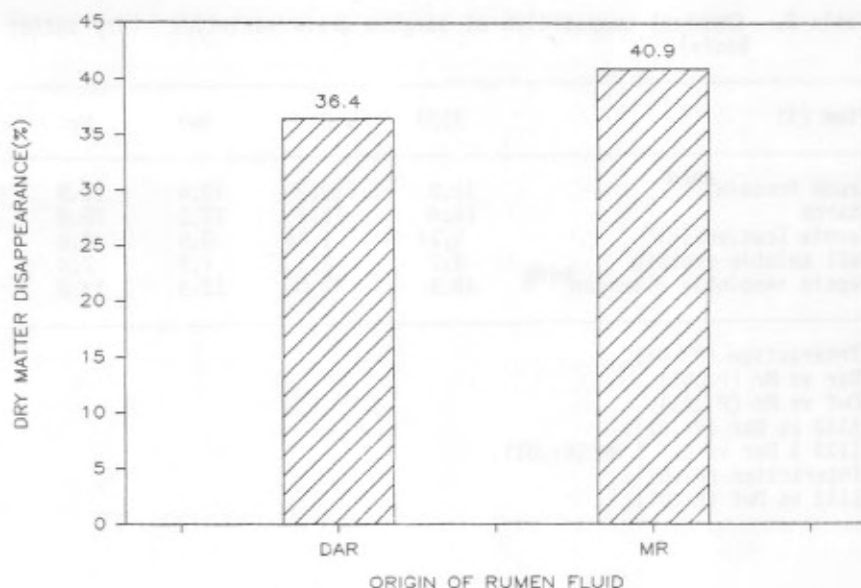


Figure 1. Comparison of fluid sources.

Table 3. IVDMD & IVGP of sorghum grain varieties.

Item	1133	Dar	Dwf	Mr
IVDMD (% averaged across variety & w/n fluid) ^a		36.4		40.9
IVDMD (% averaged across fluid) ^{b,c,d,e}	35.4	30.9	44.3	44.0
IVGP (ml gas/g DM)				
6h ^{f,g}	48.4	37.5	64.9	53.5
12h ^{f,g}	65.2	52.2	85.1	77.2

^aDar fluid vs Mr fluid (.10 P<.25).

^bInteraction (P<.05).

^c1133 vs Dar (P<.01).

^d1133 vs Dwf (P<.01).

^eDar vs Mr (P<.01).

^f1133 & Dar vs Dwf & Mr (P<.01).

^g1133 & Dwf vs Dar & Mr (P<.01).

The bird resistant characteristic decreased both IVDMD and IVGP. Rumen bacteria appeared to be inhibited by high tannin levels under conditions of this study. Waxy endosperm may offer a useful method of partially overcoming some of the detrimental effects of the bird resistant characteristic. However, IVDMD and IVGP for 1133 (bird resistant, waxy) were still below the values obtained with the non-bird resistant sorghum grain varieties. Further study to identify the specific characteristics of bird resistant sorghum grain responsible for decreased IVDMD and IVGP and combinations of bird resistant and waxy traits may be beneficial in future improvement of sorghum grain.