Seed Characteristics of Different Sorghum Endosperm Types

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Story in Brief

One corn and four sorghum endosperm types (white-bird resistant, waxy, hetero-yellow and white normal) produced in each of two consecutive crop years were wet milled to determine the starch, gluten, bran and germ and peripheral endosperm cell (PEC) content. Total protein was then determined on the various fractions. The raw, isolated starch was evaluated by an *in vitro* ruminal digestion technique to determine digestibility or availability of the purified starch.

The corn yielded significantly ($P<.05$) more starch than the sorghum endosperm types, while the wet milling by-products (bran and germ, gluten and PEC) were higher in the sorghum grains. The protein content in starch was very low for all endosperm types, but sorghum grains had the highest protein content in the other wet milling fractions. The PEC fraction, which makes up the protein matrix, averaged 5.4 percent higher in protein content for sorghum as compared to corn. Since starch granules are embedded in the protein matrix, the higher protein content of the PEC fraction of sorghums may suggest more total protein matrix. Moreover, there may be a lower solubility of the proteinaceous matrix. Thus, starch would be less easily released in sorghums as compared to corn. This, in addition to a lower starch content, may explain, at least partially, the reduced feeding value of sorghums compared to corn. *In vitro* data on the isolated, purified starch provided evidence that starch alone is not entirely responsible for the lower feeding value of sorghum as differences among the five endosperm types were small and not significant ($P>.05$).

Introduction

The major expense in cattle finishing rations is the cereal grain which supplies the major energy source. Since cereal grains contain much starch, efficiency of starch utilization is of utmost importance.

Previous research has indicated a lower feeding value for sorghum grain as compared to corn or barley, although chemical compositions of the grains are rather similar. This might be partly attributed to plant genetics as past emphasis in sorghum breeding has been on agronomic traits such as drought, bird and insect resistance rather than nutritive value. Thus, sorghum grains are much more variable and usually lower in feeding value than the other

cereal grains. Past research has been largely based upon nondescript or common sorghum varieties. Sorghum grain varieties with superior feeding value likely exist.

The purpose of this study was to compare the grain composition of several varieties of sorghum grain with corn. Moreover, susceptibility of the isolated sorghum starches to ruminal bacterial digestion was determined.

Materials and Methods

Wet milling

Five sorghum varieties in Year I and eight sorghum varieties in Year II were planted on irrigated land at the Perkins Agronomy Research Station. These varieties represented four sorghum endosperm types (white-bird resistant, waxy, hetero-yellow and white normal) each year. In addition, two hybrid corn varieties were planted and managed under similar conditions on irrigated land at the Panhandle Agronomy Research Station.

A 300 g sample of air dried grain was subjected to two steeping solutions consisting of sulfur dioxide and lactic acid for a total of 48 hr after which the solution was drained. The purpose of the steeping solutions was to soften the protein matrix in which the starch is embedded to facilitate the release of starch during the milling process. The milling process consisted of grinding the steeped grain with distilled water in a Waring Blender with the blades reversed to reduce damage to the starch granule. The slurry was then poured over three sieves which separated the grain into four components—bran and germ, gluten, peripheral endosperm cells and a starch and gluten mixture which passed through the sieves. The bran and germ portion represents the seed coat and embryo of the grain, while the gluten and peripheral endosperm cell fraction represents the protein matrix. The starch and gluten mixture was separated by pouring the solution onto a starch table which consisted of a long aluminum trough. The starch, being denser, settled on the table while the lighter gluten flowed off the end of the table when washed with distilled water. The gluten was then separated from the water by centrifuging. The starch was washed with distilled water and allowed to dry to a solid, white cake. It was then scraped off the table and dried in a 40 C oven for 48 hr and weighed. The gluten, bran and germ and peripheral endosperm cell fractions were dried in a 100 C oven for 24 hr and weighed.

In Vitro Ruminal Dry Matter Disappearance of Isolated Starch

A 0.2 g starch sample (dry matter basis) was evaluated for *in vitro* digestion by ruminal microorganisms. Twenty milligrams of urea was added to each tube to elevate the nitrogen level to approximately that found in intact grain. Each tube was inoculated with a mixture of artificial saliva and rumen fluid which was obtained from a fistulated steer being fed a high concentrate diet. *In vitro* dry matter disappearance (IVDMD) was determined for a 24 hr incubation (digestion) period.

Results and Discussion

Wet milling

Table 1 shows how the Year I sorghum varieties were classified into different endosperm types. The sorghum grains were grouped in this way because of the large number of varieties that have been developed, and varieties of a common endosperm type should be more alike than varieties of different endosperm types. This system of classification should allow for a wider application of the data from this study, providing the endosperm type of a variety is known.

The wet milling composition of the Year I grains is shown in Table 2. Corn consisted of 64.9 percent starch and was significantly ($P<.05$) higher than any of the sorghum endosperm types, which averaged 57 percent starch. The wet milling by-products (bran and germ, gluten and peripheral endosperm cells) were higher in the sorghum grains than in the corn. Though not significant, there was a trend for the waxy sorghum endosperm type to be higher in starch and lower in bran and germ and peripheral endosperm cells than the other sorghum endosperm types. Since the sorghum endosperm types contained an average of 7.9 percent less starch than the corn, this can explain (at least partially) why sorghum grains may be somewhat lower in feeding value than corn.

The protein content of the various wet milling fractions is shown in Table 3 for the Year I crop. Starch contains only very minute quantities of protein while the other fractions are considerably higher. The protein content of the corn bran and germ (9.9 percent) was much lower than the sorghum endosperm types which averaged 16.8 percent. The peripheral endosperm cell fraction of sorghum grains contained 5.4 percent more protein than the corn. Since the peripheral endosperm cell fraction makes up the protein matrix, the increased protein found in this fraction may be related to the quantity and solubility of the protein matrix and the subsequent release of the starch granules.

In the Year II crop, the same endosperm types were represented. The only variety changes were in the corn and waxy endosperm types. The corns consisted of Northrup King and Pioneer while the waxy endosperm type consisted of 73BCT 1126, 73BCT 1133-2, 73BCT 1122-2 and Dwarf Redlan varieties. The wet milling data for the Year II crop showed the same trends observed in the first crop.

IVDMD of isolated starch

The 24 hr IVDMD values on the Year I raw, isolated starches, grouped according to endosperm type, are shown in Figure 1. Although differences in dry matter digestibilities were small and not significant ($P>.05$) among endosperm types, waxy starch was slightly more digestible (60.8 percent) than the others (avg. 57.8 percent). The same trend was observed in the second

Table 1. Year 1 sorghum variety classification

Variety	Endosperm type classification
Pioneer corn 3149	Corn
Pioneer corn 3306	Corn
Darset (bird resistant)	White-BR
Soft endo	White-normal
Redlan normal	White-normal
OK 612	Hetero-yellow
Dwarf redlan	Waxy

Table 2. Wet milling compositional characteristics of grains[a] (Year I)

	Percentage			
Endosperm type	Starch	Bran and germ	PEC[b]	Gluten
Corn	64.9[a]	15.0[a]	1.1[a]	7.7[a]
Waxy	59.5[b]	16.0[a,b]	3.0[b]	10.9[b,c]
White-BR	54.9[c]	17.7[b,c]	4.4[c]	12.2[d]
Hetero-yellow	58.9[b]	16.4[a,b]	5.1[c]	10.6[b]
White-normal	54.9[c]	18.4[c]	5.1[c]	11.6[c,d]

[a]Dry matter basis.
[b]Peripheral endosperm cells.
[a,b,c,d]Means in a column with different superscripts are significantly different ($P<.05$).

Table 3. Protein content[a] of wet milling fractions (Year I)

	Percentage			
Endosperm	Starch	Bran and germ	Peripheral endosperm cells	Gluten
Corn	.30	9.90	18.76	47.69
White-BR	.31	16.41	23.80	37.63
Waxy	.23	17.12	27.32	51.61
Hetero-yellow	.36	16.48	20.42	46.32
White normal	.36	17.20	25.15	49.06

[a]Dry matter basis.
[b]Protein content of the whole grain is: 9.56% (corn), 12.80% (white-BR), 13.12% (waxy), 12.90% (hetero-yellow), 14.26% (white-normal).

crop. This data suggests that starch type alone cannot account for much of the difference in corn and sorghum digestibilites. Gas production data (susceptibility of starch to purified enzyme attack) provides additional evidence in that the waxy sorghum starch was more susceptible to enzymatic attack than the other endosperm types.

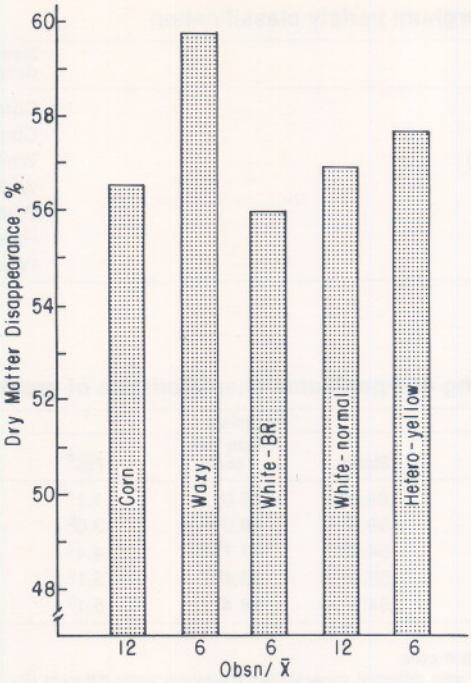

Figure 1. 24 Hour IVDMD of Raw, Isolated Starch (Year I Crop)

The lower feeding value of sorghum grains as compared to corn seems to be related to a lower starch content and the chemical and/or structural composition of the protein matrix which surrounds the starch granules. Once the sorghum starch is released from the proteinaceous matrix, it appears to be rather comparable in value to raw, isolated corn starch.