EFFECT OF WEATHERING ON FERMENTATION CHARACTERISTICS OF SORGHUM

by

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DEDICATION

The author wishes to dedicate this paper to her parents, Harry and Charlotte Witt, and her sister, Judy, who have always been there to offer encouragement. Also a special dedication to all the farmers in the Gulf Coast area who suffered the phenomenon of weathered grain in 1976.

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ABSTRACT

An *in vitro* fermentation trial was conducted to compare nutrient disappearance and end product production of weathered and nonweathered sorghum. Grain of one line was harvested before and after the rains, cleaned and processed and incubated for 12 hr with rumen fluid from a steer fed a high concentrate ration. Treatments compared consisted of weathered *vs* nonweathered, large (.841 mm) *vs* small (.210 mm) particles and addition of cellulose vs control tubes. Nutrient disappearance was not affected by weathering but was increased in tubes containing the small rather than large particles. Total volatile fatty acid concentrations were higher in weathered grain ($P<.05$) and in incubation tubes containing the smaller particle size ($P<.01$). The ratio of acetate: propionate followed similar patterns indicating that the effect of weathering was associated with the smaller particle size of weathered grain. Addition of cellulose had no effect on dry matter disappearance or volatile fatty acid production.

Introduction

Grain sorghum is the principal row crop of the Gulf Coast area. With the easy access to the port of Corpus Christi, a large amount of this sorghum is exported overseas. Because of its quality, this grain has commanded a premium price in Asia and Africa where it is the chief food staple. Of the sorghum remaining in the United States about 10% of it is consumed by livestock. Grain sorghum is especially important in

the fattening of cattle in feedlots. Cattle are capable of utilizing the energy of sorghum to convert the low quality protein of plant tissue to the high quality protein found in beef.

In a normal year by planting sorghum in late February or early March it can be harvested before the summer rainy season. Harvesting usually occurs during the hot, dry month of July when only one to two inches of rain is expected to fall. During 1976, however, wide deviations from the normal pattern of rainfall occurred. In the early months of the year there was no effective rainfall. Thus farmers delayed planting to wait for adequate soil moisture. Below normal seasonal temperatures in May and June also delayed grain sorghum maturation. Consequently, when nearly seven times the average monthly rain fell from July 5 to 17, approximately three-fourths of the grain was still in the field. This prolonged rainfall, high humidity, high temperatures and alternate periods of wetting and drying, before and after the grain matured, all contributed to produce the phenomenon of weather damaged sorghum.

When the weather damaged grain sorghum occured in 1976 there was virtually no previous research on the subject. Therefore a "crash program" of laboratory studies and feeding trials was initiated. Experiments conducted on this weathered sorghum by Lichtenwalner (1978) determined that the chemical composition was very similar to the normal, nonweathered sorghum except for a significant increase in the ash content (table 1). The protein, fat, fiber, and nitrogen free extract percentage, were approximately the same.

The physical characteristics of weathered and nonweathered sorghum were also determined by Lichtenwalner, 1978 (table 2). Bushel weight

TABLE 1. EFFECT OF WEATHERING ON CHEMICAL COMPOSITION OF SORGHUM GRAIN

GRAIN	NUTRIENT, %					
	MOISTURE	PROTEIN	FAT	FIBER	ASH	NFE
Non-Weathered	13.9	10.7	3.1	2.3	1.7	82.3
Weathered	12.5	10.5	3.0	2.4	1.9	82.4
Weathered, % of Non-Weathered						
Percent	90.2	97.7	96.5	103.5	109.0	100.1
Std. Deviation	9.2	6.8	11.0	13.4	9.6	1.2

TABLE 2. PHYSICAL EFFECTS OF WEATHERED GRAIN

ITEM	NON-WEATHERED	WEATHERED
Bushel wt., lbs.	58.0	42.0
% trash	1.3	7.2
% fines	trace	3.8
Particle size, *as is* grain, % retained		
Sieve # 5	trace	1.6
10	20.1	5.4
20	70.2	75.9
30+	8.7	17.1
Particle size, micronized grain, % retained		
Sieve # 5	20.2	22.1
10	62.8	45.5
20	9.8	18.0
30+	6.3	11.6

was greatly decreased for the weathered sorghum. This was one of the major factors causing reduced yields with weathered sorghum. There was a high percentage of trash or foreign matter in the weathered sorghum. Due to the harvester's desire to maximize yields, the combine speeds were reduced and more trash in the sorghum resulted. The nonweathered sorghum did not have any fines or cracked kernels present. The weathered sorghum, however, had a significant increase in the percentage of fine or small particles. Molds were also found on the weathered sorghum, along with a large amount of sprouting or seed germination. Weathered sorghum is also characterized by a dark, discolored appearance.

Performance trials on heifers were conducted by Wiltbank and Riggs, 1978 (table 3). Calves were fed rations of nonweathered, weathered and a 50:50 mixture of the two grains. Feed intake and gain were very similar for the nonweathered and weathered sorghum. Heifers fed weathered grain did not convert feed to gain as efficiently as heifers fed normal sorghum. Interestingly, the mixture produced the greatest feed intake and rate of gain. However, these heifers converted feed to gain less efficiently than either of the other groups.

In another *in vivo* trial using ruminally fistulated steers fed weathered and nonweathered sorghum, volatile fattly acid (VFA) concentrations in the rumen were studied (Lichtenwalner, 1978). The nonweathered sorghum produced the typical acetate:propionate ratio. However, the weathered sorghum caused an increase in the C_2:C_3 ratio indicating a shift toward increased acetate production. Identification and isolation of factors responsible for the increased acetate production would benefical. to the dairy industry to help overcome the depression in fat content of

TABLE 3

PERFORMANCE OF HEIFER CALVES FED WEATHERED AND/OR NONWEATHERED GRAIN

Item	GRAIN		
	100% Nonweathered	50:50	100% Weathered
Feed intake, lb/day	15.40	17.10	15.70
Gain, lb/day	2.04	2.16	2.00
Feed efficiency, lb/feed/lb gain	7.59	7.93	7.85

the milk which typically occurs during the hot summer months. The purpose of this research project was to determine if the shift in VFA production was due to some mycotoxin present on the weathered sorghum or if it was due to a faster rate of passage associated with the smaller particles of weathered sorghum.

Experimental Procedure

An *in vitro* trial was conducted using rumen fluid collected from a ruminally fistulated steer fed a high concentrate ration. One variety of sorghum which had been harvested before and after the rain was obtained from the Texas Agricultural Experiment Station at Corpus Christi. This sorghum was ground and two distinct particle sizes of .841 mm and .210 mm were collected by sieving. Since the sorghum had been cleaned previously, Solkafloc was added as a treatment variable to increase the fiber content and simulate the trash present in weathered sorghum. Therefore, the three treatments studied were weathered *vs* nonweathered, small particles (.210) *vs* large particles (.841), and the addition of cellulose in the form of Solkafloc. Whole grains were rolled prior to the fermentation trial.

To each fermentation tube were added: a) .2 g of either the grain or a 95:5 mixture of grain and Solkafloc, b) 15 ml of McDougall's buffer (McDougall, 1948) and c) 10 ml of strained rumen fluid, triplicate tubes of each treatment were prepared. Tubes were gassed with carbon dioxide, sealed and incubated at 37 C. Tubes were sampled at 0, 3, 6, 9, and 12 hrs. of fermentation. Gas production was determined by inserting a 50 cc syringe into the fermentation tubes. Volatile fatty acid concentrations were determined by gas-liquid chromatography (Erwin *et al.*, 1961). Dry

matter disappearance was determined by differences between initial and final dry weight. Starch content was measured (Lamar, 1973) on initial and final samples and disappearance calculated. Differences between treatment means was statiscally determined by analysis of variance (Li, 1964).

Results

There were no significant differences in gas production between the nonweathered and weathered sorghum. Starch digestibility and dry matter disappearance were also very similar. However, the smaller particles had significantly ($P<.01$) greater gas production when compared to the large particles. There was also significantly more starch digestibility and dry matter disappearance with the smaller particles. Addition of solkafloc had no significant effect on gas production. Although dry matter disappearance decreased when solkafloc was added to the substrates, starch digestibility was significantly increased. This was due to the preferential digestion of starch when cellulose was added (table 4).

Total volatile fatty acid concentrations and the acetate:propionate ratio were affected by source of grain. Substrates of weathered grain had higher ($P<.05$) levels of volatile fatty acids and also a greater proportion of propionic acid than substrates containing normal sorghum. This is opposite to the shift seen in the _in vivo_ trials. The smaller particles also produced more ($P<.01$) propionic acid which is to be expected due to the larger amount of surface area. The addition of cellulose did not affect the total VFA production or the acetate:propionate ratio (table 5).

Discussion

The phenomenon of weathering causes a decrease in particle size and

TABLE 4.

EFFECT OF GRAIN TREATMENT, PARTICLE SIZE AND ADDED CELLULOSE ON DIGESTIBILITY AND GAS PRODUCTION

Item	Digestibility, %		Gas Production
	Dry Matter	Starch	ml/g
Grain Treatment			
Nonweathered	21.9	37.1	13.5
Weathered	21.1	39.8	14.0
Particle Size, mm[a]			
.841	13.8	32.5	9.8
.210	29.2	44.4	17.8
Cellulose[b]			
-	23.3	33.6	14.3
+	19.7	43.3	13.3

[a]Difference between particle size means significant ($P<.01$).
[b]Starch digestibility significantly ($P<.01$) greater in flasks with added cellulose.

TABLE 5.

EFFECT OF GRAIN TREATMENT, PARTICLE SIZE AND ADDED CELLULOSE ON VOLATILE FATTY ACIDS

Item	Total VFA mm/l	Acetate:Propionate
Grain Treatment[a]		
Nonweathered	110.7	1.67
Weathered	119.1	1.52
Particle Size, mm[b]		
.841	96.9	1.74
.210	132.9	1.44
Cellulose		
-	119.3	1.60
+	110.4	1.58

[a]Differences between means significant ($P<.05$).
[b]Differences between means significant ($P<.01$).

smaller particles are more digestible than larger particles. This may explain the increased rate of gain in animals fed mixtures of weathered and nonweathered grain. The increased levels of propionic acid produced by the fermentation of weathered sorghum may also be due to the smaller particle size of weathered sorghum. Apparently, the increased production of acetic acid seen in the *in vivo* trial was due to a rate of passage phenomemon and not a mycotoxin effect. Presumably, the smaller particles passed out of the rumen thereby resulting in a higher concentration of the larger, more fibrous, particles which are, inherently, acetate producers. In the *in vitro* trial, no passage or absorption was possible and so levels of propionic acid were greater because of the smaller particles associated with the weathered grain. Since post-ruminal utilization of nutrients is inherently more efficient than ruminal fermentation (Black, 1971), this research suggests that reducing the particle size may be an effective way of improving nutrient utilization by ruminants.

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