COMPARATIVE FEEDING VALUE OF SORGHUM GRAIN RECONSTITUTED BY DIFFERENT METHODS FOR DAIRY COWS

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FOR DAIRY COWS

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CHAPTER I

INTRODUCTION

Dairy cows are fed for maximum milk production. High producing cows at the peak of their lactation are usually in a negative energy balance and are forced to utilize body reserves to meet their energy demands. This may depress the peak of production and lower total lactation yield. If bulk fill limits energy intake, increasing the digestibility of the ration components would enhance feed intake and increase milk production.

Sorghum grain is widely used throughout the Southwest as a major component of concentrate mixtures for dairy cows. It has long been recognized that this grain needs to be processed in some manner for optimum digestibility. Several intensive investigations have examined different methods of processing sorghum grain for beef cattle. However, results of these studies are not directly applicable to dairy cows due to differences in ration components, intake levels, and the unique problem of milk composition.

Many dairymen find it advantageous to buy bulk quantities of sorghum grain, and believe that its nutritive value can be greatly enhanced by reconstitution and storage in an oxygen-limiting structure. Since oxygen-limiting structures are quite expensive, adding organic acids to permit high-moisture storage in an aerobic environment might have some merit.

The major objectives of this study were to: 1) investigate the production responses of lactating dairy cows to feeding of sorghum grain finely ground or reconstituted with or without the addition of organic acids, 2) examine storage characteristics of reconstituted sorghum grain preserved with 2% organic acids and 3) evaluate the effect of reconstitution on ration digestibility and rumen volatile fatty acid ratios.

CHAPTER II

LITERATURE REVIEW

Sorghum grain has been bred and selected for years to withstand the weather damage such as heat, drought and wind of the Southwest U.S. Development of sorghum varieties with a dense, hard endosperm and waxy bran cover, extremely resistant to weather conditions and digestion, has resulted. Since mature cattle apparently masticate sorghum grain very little due to its small particle size, rupture of the grain by some processing method is necessary for optimum digestion.

Chemical Composition of Sorghum Grain

Chemically, sorghum grain resembles corn. Protein and oil contents of the whole grain may often be higher than corn, but the germ of sorghum grain contains less oil and more starch than corn germ (Hubbard et al., 1950).

The starch granules of sorghum grain have a slightly larger diameter than those of corn. Normal sorghum starch contains about 25% amylose and 75% amylopectin. Amylose is a linear polymer of glucose units joined by alpha-(1-4) linkages to yield chains of several hundred glucose units whereas amylopectin is a branched chain glucose polymer with alpha-(1-4) and additional alpha-(1-6) branching points. Branches normally contain 20 to 30 glucose units.

Starch content of different varities varies from 70 to 80%. Starch comprises 83% of the endosperm, 13.4% of the germ and 34.6% of the bran (Hubbard et al., 1950).

Ruminant VFA Production

Starch digestion in the ruminant animal involves anaerobic fermentation by the microbial bacteria and protozoa in the rumen. This microbial activity degrades carbohydrates and other constituents of the diet, yielding as end products carbon dioxide, methane and ammonia plus volatile fatty acids (VFA), namely acetic, propionic, butyric and small amounts of other steam volatile acids.

The VFA are absorbed across the rumen epithelium by simple diffusion into the portal blood system (Annison et al., 1957). The absorption rates appear to be enhanced by lowered pH of the rumen (Masson and Phillipson, 1951). The relative rates of absorption of VFA under acidic condition in order of rapidity are butyric, propionic and acetic, with butyric acid being metabolized to beta-hydroxybutyric acid during absorption (Hird and Weidemann, 1964).

Synthesis of glucose from these fatty acids has been under intensive investigation by researchers. Propionate has been generally accepted as a precursor of glucose (Kleiber et al., 1953), the postulated pathway being conversion to propionyl CoA, carboxylation to methylmalonyl CoA, rearrangement into succinyl CoA, oxidation of succinate to oxaloacetate, decarboxylation to phosphoenolpyruvate, and reduction of phosphoenolypyruvate to triose. Two molecules of propionate thereby can be converted into one mole of glucose. Acetate does not contribute to glucose synthesis in the ruminant, and no enzymatic mechanisms which could catalyze such reactions have been reported. Acetate provides the animal energy for body functions or material for lipogensis.

Milk fat percentages are frequently depressed when dairy cows are fed high concentrate, low forage rations. The lowered milk fat is commonly accompanied by a changed ratio of the volatile fatty acids produced or present in the rumen. Tyznik and Allen (1951) reported that the percentages of ruminal VFA for cows fed normal forage diets were 65% acetic, 20% propionic, and 15% butyric. Feeding a low forage ration consistently decreased the acetic acid level and increased the propionic acid, with and butyric acid remaining relatively constant.

The effects of VFA on the yield and composition of milk were studied by Rook and Balch (1961). When acetic acid was infused into the rumen of lactating cows, increased milk yield and milk fat percent were observed. In contrast, infusion of propionic acid consistently depressed milk fat percentage with little change in milk yield. Butyric acid infusions had no effect on milk yield, but increased milk fat percentages.

Altered VFA ratios in the rumen of animals fed high concentrate diets appear to result from high levels of readily available carbohydrates. Phillipson (1952) observed a high level of lactic acid (70μM/ml) in the rumen of lambs fed a ration of hay, flaked maize, and maize gluten meal. The lactic acid appeared to be fermented largely to propionic acid. Waldo and Schultz (1956) reported that lactic acid appeared in the rumen of Holstein steers after feeding rations of grain plus hay or silage. In addition to altering VFA ratios, the concentration of ruminal lactate may also determine whether a feed will depress the percentage of milk fat.

Digestion of Sorghum Grain

Sorghum is improved more by processing than most other cereal grains. Several different processing methods will increase animal performance and increase digestibility. McNeill et al. (1971) observed increased ruminal digestion of starch in steam flaked and reconstituted sorghum grain when compared to micronized or ground sorghum grain. However, the steers were fed only 4 kg of dry matter daily. Hinman and Johnson (1974) found no significant differences in ruminal digestibility and starch in dry rolled, micronized, steam flaked and ground sorghum grain, although post ruminal digestion of starch in dry rolled grain was significantly less than grain otherwise processed.

Processing Methods

Various methods of processing have been assessed for effects on animal efficiency. Among the most commonly used methods are dry rolling, grinding, and flaking with heat and moisture.

Grinding

Grinding of cereal grains is the oldest and most widely used method of grain processing. Grinding simply disrupts the intact kernel to expose more surface area, thereby rendering the grain more susceptible to water absorption and enzymatic degradation. In terms of equipment and output, grinding is an economically competitive means for processing. But the power requirement to grind sorghum grain increases with decreasing particle size. The power requirement expressed in kilowatt hours per ton, 7.4 when grinding through a 3.2 mm screen size, increases to 14.0 when the screen size is reduced to 1.6 mm. This is an increase of 89% KWH/ton (Hastings and Miller, 1961).

Dry Rolling

Dry rolling, also called cracking, is a common method for preparing grains for feeding to beef cattle. In dry rolling, grain is passed through rollers which are commonly grooved on the surface. The rolled grain may vary in particle size from very fine to coarse, the size being a function of weight, pressure and spacing of the rollers and moisture content and rate of flow of the grain (Wagner et al., 1973).

Micronizing

Micronizing is a type of dry heat processing that does not pop the grain. It is accomplished by heating grain with gas-fired , infra red generators. Microwaves with 3×10^{8} to 3×10^{11} cycles/sec are emitted from the burners. The appearance of the end product resembles that of steam flaked grain.

Steam Flaking

Steam flaking is a newer process, a modification of steam rolling in which treatment specifications and quality control standards are established. Grain is subjected to high pressure steam for sufficient time to raise the moisture level to between 18 and 20%. The temperature of the grain leaving the steam chamber is approximately 100 C. The grain is then passed through the roller mill with a tolerance set between the rollers specific for the grain. For sorghum grain, a tolerance of approximately 0.051 mm is common. For corn, wheat and barley the tolerance between the rollers will depend upon the flatness of the flake desired. Flow rate through the mill is reduced to form a thinner flake. Flaking ruptures the starch granule, a chemical process known as gelatinization.

High Moisture Processing

High moisture processing of grain for cattle feeding is not new. For many years, livestock feeders have soaked grain in water for 12 to 24 hours prior to rolling or grinding. This soaking softens the endosperm and waxy coating and makes feed more palatable. High moisture processes should be divided into two distinct categories: high moisture harvested and reconstituted grains.

Harvesting of grain at a high moisture level and prior to maturity is necessary in certain regions due to weather. Yet milo is physiologically mature at 38 to 40% moisture and is usually harvested at 27 to 30% moisture, so although mature, it is still high in moisture. Dry matter yields are 6-20% greater with high moisture harvest than with dry harvest due to reduced field losses. High moisture harvesting also allows crops to be removed earlier in the fall and eliminates the expense of drying the grain.

Reconstitution involves the addition of water to air-dry mature grain to a moisture level of 25 to 30%. The main objective of reconstituting is to enhance the digestibility of the grain for ruminant animals.

High moisture harvested or reconstituted grain may be stored in a trench silo as a ground product or in oxygen-limited silos as ground or whole grain. Wagner et al. (1973) indicated that high moisture sorghum grain stored in whole form and processed prior to feeding was superior to high moisture sorghum stored in the ground form. Reconstituted sorghum grain should be at 30% moisture and stored for twenty days prior to feeding to maximize animal performance (Wagner et al., 1973).

Particle size of reconstituted and reground sorghum grain declines with storage time (Florence and Riggs, 1968). Grain ground after twenty days of storage had the finest particle size. All the grain after storage, regardless of length of time after reconstitution, had a much finer particle size than the dry grain. *In vitro* dry matter disappearance was more rapid for the first 12 hours with reconstituted sorghum grain at 30% moisture than with the dry grain. McNeill et al. (1971) reported reconstituted and steam flaked sorghum grains had equivalent ruminal and postruminal digestibilities, both being superior to ground or micronized grains.

Acid Preservation

Acid preservatives are used for storage of high moisture grains in an aerobic environment. The acid preservative (usually propionic acid, acetic acid or a mixture) kills the fungi or molds in grain and prevents mold growth. It also kills the kernel, stopping respiration and other biological activity in the grain. The amount used varies with the grain moisture content and the specific acid. Residual organic acids have subsequent nutritional value for ruminants being the same acids produced in the rumen.

Equally important with treatment rate is treatment thoroughness. Every kernel needs to be thoroughly coated for preservation and areas of untreated grain should be avoided. To treat grain properly, the producer must know the moisture content and the flow rate of the grain passing through the treatment system.

Lane et al. (1973) reported that high moisture sorghum grain at 30% was effectively preserved for at least 21 days by treatment with either 1 or 3% acetic acid.

Performance Studies With Beef Cattle

Wagner et al. (1973) summarized a series of beef cattle studies involving grinding, dry rolling, steam flaking and reconstitution of sorghum grain. Based on five experiments, ground and dry rolled sorghum grain gave equal cattle gain and feed efficiencies. Based on 10 experiments, fine grinding sorghum grain improved feed efficiency by 5% over coarse grinding. Cattle fed very finely ground sorghum grain had 6.9% improved feed efficiency over cattle fed finely ground grain. In 11 trials, steam processing sorghum grain improved gain by 10% and feed efficiency by 7% over dry rolling. Based on 10 trials, high moisture harvesting and reconstituting sorghum grain improved feed efficiency by 10 and 9% respectively, over dry rolling. In contrast, Harpster et al. (1975) reported that digestibility of dry matter, energy and crude fiber of corn and sorghum grains by lambs was not influenced by ensiling with or without organic acids as compared with dry rolling.

Performance Studies With Dairy Cattle

The results from beef cattle studies are not directly applicable to dairy cattle due to differences in ration components and the unique problem of milk composition. Most of the improvements in feed efficiency in beef cattle experiments were observed when more extensive processing treatments were compared to dry rolling or coarse grinding. It is not feasible to use finely ground grain as a control in beef cattle studies because feed intake problems are often encountered when finishing cattle are fed very finely ground grain. Due to higher forage to concentrate ratios for dairy cattle, very finely ground grain causes no feed intake problems. So when comparing very fine grinding to various processing methods, there would be less advantage for dairy than for beef cattle.

Corn

High moisture grain for dairy cattle has been primarily early harvested and ensiled rather than reconstituted corn grain. Zogg et al. (1961) reported that gross efficiency of dry matter utilization by dairy cows increased from 22 to 32% when cows were fed high moisture ensiled corn rather than dry corn. McCaffree and Merrill (1968) reported that milk production by dairy cows fed high moisture ensiled corn was greater than that of cows fed either dry shelled corn or a multi-ingredient pelleted concentrate mixture. Cows fed high moisture corn consumed 1.9 kg/day less forage than cows fed dry corn. There were no significant differences in grain intake. Consequently, the concentrate to forage ratio increased by 25% when high moisture corn was fed. This increased the concentrate to forage ratio and decreased fiber in the ration, which might reduce milk fat percentage. In contrast, Jones (1972) reported that actual and fat-corrected milk, percent protein and percent milk fat were the same when cows were fed high moisture shelled corn at 33.5% moisture treated with 1.5% propionic acid as when fed dry shelled corn or dry ear corn. Similar results were reported by MacLeod et al. (1973) who treated high moisture shelled corn with 1.15%

of a 60:40 mixture of acetic-propionic acids or 95% propionic acid. Clark et al. (1975) compared the production of cows fed high moisture corn with and without the addition of 1.1% propionic acid with that of cows fed ground shelled dry corn. There were no significant differences in dry matter intake, milk yield, or percentage of milk fat and non-fat solids. However, rolling the whole corn of each individual treatment prior to feeding increased milk yield, 4% fat-corrected milk production and non-fat solids content of the milk.

Sorghum Grain

At the Oklahoma State Agricultural Experiment Station, several different methods of processing sorghum grain for dairy cattle have been tested.

Bush et al. (1973) reported that very fine as compared to coarse grinding of sorghum grain increased milk yield. Yield increased as particle size decreased to approximately 300 microns geometric mean diameter. No significant differences existed in feed intake, percent fat and total solids, or molar percentages of rumen volatile fatty acids. Although moisture content and flow rate may also contribute to particle size, sorghum grain ground through a 1.6 mm screen appears sufficiently fine to maximize utilization by dairy cows.

Dry heating plus steaming or simply steaming in addition to very fine grinding did not improve the nutritive value compared to very fine grinding only of sorghum grain for lactating dairy cows (Bush et al., 1964). In a later study (Bush et al., 1972), steam rolling as compared to fine grinding of sorghum grain produced no significant differences in milk yield, non-fat solids percent or solids-corrected milk. However, a significant depression in percent milkfat was observed with the finely ground grain.

Pressure cooking and expanding to gelatinize the starch fraction of sorghum grain, compared to fine grinding only, did not improve its nutritive value for lactating dairy cows. Milk yield of cows fed finely ground sorghum grain was significantly greater than that of cows fed the expanded grain. However, again slight depression in milk fat percentage was observed among cows fed finely ground sorghum grain. Compared to fine grinding, micronizing sorghum grain to produce varying degrees of starch gelatinization did not improve feeding value (Bush et al., 1973, 1974).

Helm (1970) reported significant depressions in total milk and percent milk fat produced by lactating cows fed reconstituted sorghum grain as compared to air dry grain. Bade et al. (1973) reconstituted sorghum grain to 30% moisture and stored it either anaerobically or treated with 2% acetic acid for comparison with dry control grain. No significant differences were observed in the yield of 4% fat corrected milk; however, the reconstituted grain stored anaerobically depressed milk fat percent. Molar percentage of ruminal acetic acid was significantly lower in the rumen of cows fed the reconstituted grain stored anaerobically. They suggested that the 2% acetic acid addition to the corn was sufficient to maintain ruminal acetic acid level and milk fat percentage. Digestion coefficients did not differ with treatment. An increase in the efficiency of actual milk yield was observed for the cows fed the anaerobically stored reconstituted grain, but when calculated on a fat corrected milk basis, the difference was minimal. Cummings and Peterson (1973) observed no difference in the yield of 4% fat corrected milk or milk fat percentages of cows fed high moisture sorghum grain preserved with 1.0 to 1.2% organic acids (Chemstor) and those fed grain dried to 10 to 13% moisture.

The objectives of this experiment were to (1) compare the production responses of lactating dairy cows fed sorghum grain reconstituted with and without the addition of organic acids with that of cows fed dry, very finely ground grain, (2) examine the storage characteristics of sorghum grain reconstituted with the addition of organic acids and (3) determine the effect of reconstitution on ration digestibility.

CHAPTER III

EXPERIMENTAL PROCEDURE

Thirty lactating dairy cows consisting of 15 Ayrshires and 15 Holsteins, 3-6 weeks postcalving, were selected from the University dairy herd. All were adjusted to a ration containing a 50:50 dry matter ratio of high quality alfalfa hay to a concentrate mixture and were "challenge" fed for a 2-3 week adjustment period to establish maximum milk production. Feed allowances were calculated at the end of the adjustment period to meet NRC requirements considering milk yield, percent milkfat, body weight and lactation number. The total dry matter intake for each cow was reduced by 10% at the end of each comparison period during the experiment.

The cows were assigned to six treatment sequences in a switchback design as described by Lucas (1956). The trial consisted of three 6-wk periods, with the first 2 wk of each period allowed for changeover from one ration to another. The thirty cows were assigned to 10 blocks based upon breed, calving date and lactation number.

Ration Preparation and Storage

Sorghum grain comprised 80% of the concentrate mixture (Table 1) on a dry matter basis. This was fed in a 50:50 dry weight ratio with high quality alfalfa hay. The sorghum grain was processed in three

TABLE I

CONCENTRATE MIXTURE

Ingredient	Kg/Ton	Percent
Sorghum Grain	800	80.0
Soybean Meal (44%)	100	10.0
Barley, Crimped	55	5.5
Dried Molasses	30	3.0
Dicalcium Phosphate	10	1.0
Salt	5	0.5
	1,000	100.0

ways: a) finely ground, to approximately 400 microns geometric mean diameter, b) reconstituted to 30% moisture content, and c) reconstituted to 28% moisture content with 2% organic acids (Chemstor) added. The grain reconstituted with water was stored in sealed, double-layer .10 mm thickness polyethylene bags to provide an anaerobic environment for a minimum of 3 weeks. The reconstituted grain treated with 2% organic acids was stored aerobically on an open concrete barn floor for a minimum of 3 weeks prior to feeding. The finely ground control grain was mixed to form the complete concentrate mixture and stored in a metal grain bin. The reconstituted sorghum grain, with and without the addition of 2% organic acids, was stored as whole grain and rolled daily prior to feeding with the exception of weekends when enough grain was rolled on Friday for the weekend feedings. Representative samples of the reconstituted sorghum grain were taken at the time of reconstitution, and samples of the dry grain were taken at the time of grinding. The samples were analyzed for dry matter percentage and adjustments were made in allowances to equalize grain dry matter intakes.

Equal concentrate intakes were attained by allowing 80% of the concentrate mixture as sorghum grain dry matter. The cows receiving the reconstituted treatments were fed 20% of the concentrate mixture as protein supplement at the time of feeding. The protein supplement contained the same ingredients as the control ration other than sorghum grain (Table I). The final ration mixture, containing a 50:50 dry matter ratio of forage to concentrate, had an estimated net energy of lactation value of 1.65 Mcal/kg dry matter.

TABLE II

CHEMICAL ANALYSIS OF RATION

Item	Alfalfa Hay	SE	Concentrate Mix[a]	SE
	%		%	
Dry Matter	86.8	1.60	87.6	1.33
Crude Protein[b]	18.1	1.70	13.5	0.72
Organic Matter[b]	92.52	---	95.87	----
Ash[b]	7.48	0.65	4.13	0.22

[a]Control ration

[b]Dry matter basis

Management of Cows

The cows were milked at 5:30 am and 5:00 pm daily. One-half of the concentrate allotment was fed one hour prior to each milking in a stanchion barn with individual feeding stalls. Following milking, the animals were moved to one of two outside lots where they remained for periods other than feeding and milking. At 1:00 pm the cows were placed in individual tie stalls in a loafing barn adjacent to the outside lots. For a period of two hours the animals were allowed to consume their daily allotment of hay. Any cow that did not consume the entire allotment of hay at the scheduled time was returned to the stall the following morning at 8:00 am for an opportunity to consume it. Weighbacks of hay and concentrate were made daily following the morning feeding.

Collection of Data

Body weights of the cows were taken on three successive days, at the beginning of the trial and on the last three days of each period. Three-day weights were taken and averaged to correct for fluctuations in body weight due to water fill. The weights were recorded prior to milking and the milk yield for that milking was subtracted.

Milk weights were recorded twice daily throughout the trial, with samples collected at four consecutive milkings each week for percent milkfat and total solids analysis. Milkfat percentages were determined, after compositing the samples from four consecutive milkings, by the Babcock method. Analysis of total solids was made by placing 3 ml of milk in an aluminum dish and drying for four hours at 100 C in a forced air oven.

Representative samples of the concentrate mixture were collected at the end of each week, dry matter determinations made, and stored in a freezer until the termination of the trial. The baled alfalfa hay was sampled every two weeks using a Pennsylvania State hay sampler. The hay samples were also analyzed for dry matter and stored in a freezer until the end of the trial. The weekly concentrate samples and biweekly hay samples collected throughout the trial were composited for each period and analyzed for dry matter, protein and ash content. Dry matter was determined by allowing a one gram sample to dry in a heated oven at 100 C for 24 hours. The percent nitrogen was determined by the Kjeldahl method and multiplied by the constant 6.25.

Digestibility of Ration Components

During the last 12 days of each period, 15 g of chromic oxide was added to the concentrate mixture at each feeding to serve as an external marker for determining the digestibility of ration components. Fecal samples were collected during the last five days of each period, composited for each individual cow and subjected to the same chemical analysis as prescribed for feed collections. Samples collected in the morning and afternoon were composited separately. To correct for diurnal variations in chromic oxide excretion, fecal samples were collected every four hours for two days from six randomly selected cows during each period. Chromium determination were made by the method described by Williams et al. (1962) using the atomic absorption spectrophotometer. Digestibility coefficients for each nutrient in the rations were determined using the following formula:

$$\% \text{ Digestibility} = 100 - (100 \times \frac{\% \text{ Cr. Feed}}{\% \text{ Cr. Feces}} \times \frac{\% \text{ Nutrient Feces}}{\% \text{ Nutrient Feed}}) .$$

Rumen VFA

Rumen samples were taken during the last week of each period by passing a tube down the esophagus to the rumen. A hand pump was used to extract approximately 300 ml of rumen liquor into an Erlenmeyer flask. The extracted sample was immediately strained through double layer cheesecloth and 2 ml of mercuric chloride was added to 200 ml of strained fluid to inhibit bacterial action. The samples were centrifuged at 12,000 X g for 5-10 minutes and the resulting supernatant was stored in a freezer for later VFA analysis. Volatile fatty acid (VFA) analysis of samples was obtained by the procedure of Erwin et al. (1961) with a Bendix Series 2500 gas chromatograph.

In Vitro Dry Matter Digestibility

In vitro dry matter disappearance of the sorghum grain, reconstituted with and without the addition of organic acids or dry grain finely ground was conducted at the end of the experimental trial, using procedures outlined by Johnson (1969). Fifteen ml of artificial saliva and 10 ml of rumen fluid from a donor steer were added to .4 gm of finely ground grain in a previously tared test tube. These test tubes were incubated at 39 C for the prescribed time, dried at 100 C for 24 hr, reweighed, and percent dry matter disappearance calculated.

Particle size of the dry control grain was determined at the end of the trial by the method described by Ensor et al. (1970).

CHAPTER IV

RESULTS AND DISCUSSION

Feed Intake and Production Data

Reconstituting the sorghum grain had no significant effect (P>.05) on feed dry matter intakes (Table III). No pattern of concentrate or hay refusal was observed for cows receiving different treatments in different periods. This was in agreement with Forsythe et al. (1972) who observed no difference in feed intake by lactating cows fed high moisture corn preserved with propionic acid.

Bade et al. (1973) observed no difference in total feed intake due to feeding dairy cows reconstituted sorghum grain, although an alteration from the 40:60 ratio of forage to concentrate was observed. Cows fed reconstituted grain consumed more (P<.05) hay and less (P<.05) concentrate than cows fed the dry grain ration. McCaffree and Merrill (1968) and Palmquist and Conrad (1970), reported a decrease in total dry matter intake and forage dry matter intake of cows fed high-moisture corn as compared to those fed dry corn.

Actual milk yield of cows fed reconstituted grain was quite similar to that of cows fed finely ground sorghum grain (Table III). Milk yield was slightly lower for the cows fed high moisture grain stored anaerobically, however, these differences were nonsignificant (P>.05). Cummings and Peterson (1973) reported similar results with high moisture

TABLE III

RESPONSES OF COWS FED SORGHUM GRAIN PROCESSED BY DIFFERENT METHODS

Item	Ration			
	Finely Ground	H_2O Recon.	Acid Recon.	SEM
Feed DM Intake				
Hay kg/day	6.95	7.26	6.90	1.060
Grain kg/day	7.03	7.35	7.04	1.500
Milk Production				
Yield kg/day	18.21	18.16	18.25	0.015
Fat Test, %	3.75[a]	3.81[b]	3.74[a]	0.002
Non-Fat Solids	8.91	8.94	8.95	0.003
Feed Efficiency				
Milk/total feed DM	1.29	1.27	1.28	0.010
Milk/net feed DM	2.33	2.37	2.52	0.120
SCM/net feed DM	2.25	2.31	2.48	0.014
Weight change, kg/6 wk.	-3.6	0.6	11.0	3.730

[ab]Means in a column which do not have the same superscript are significantly different ($P < .05$).

sorghum grain; however, Bade et al. (1973) reported a significant increase in actual milk production by cows fed water reconstituted sorghum grain as compared to cows fed acid treated and dry rolled grain.

On a solids corrected milk basis, there were no significant differences (P>.05) among any of the three experimental sorghum grain treatments. Similar results were reported by Bade et al. (1973) and Cummings and Peterson (1973) comparing high moisture sorghum grain with and without the addition of organic acids to a dry control grain fed to lactating dairy cows, using fat corrected milk as the criterion. Palmquist and Conrad (1970), McCaffree and Merrill (1968) and Jones (1972), all had similar results with high moisture corn grain.

Milk produced by cows fed water reconstituted grain had significantly higher (P<.05) fat content than that of the other two groups, but the difference was not of a large enough magnitude to be of practical importance. Fat depression was not observed due to feeding water reconsituted sorghum grain. In contrast, McCaffree and Merrill (1968) and Palmquist and Conrad (1970) observed milk fat depression in cows fed high moisture corn and Bade et al. (1973), in cows fed high moisture sorghum grain. These differences in results may be due to different control rations and forage to concentrate ratios rather than feeding of high moisture grain.

Non-fat solid percentages was not influenced by treatment (P>.05). Similar results were reported by Bade et al. (1973) and Jones (1972).

Gross feed efficiency, expressed as a ratio of milk/total dry feed consumed (Table III) was not affected by treatments (P>.05). Net feed efficiency was calculated as the ratio of milk yield to feed available for milk production. Feed available for milk production was the feed consumed minus the amount required for maintenance and the amount required for body weight change. The net efficiency of milk yield was not significantly different (P>.05) among treatments. Jones (1971) and Forsythe et al. (1972) obtained similar results from feeding lactating dairy cows high moisture corn grain with propionic acid used as a chemical preservative. In contrast, Bade et al. (1973) observed a 5% increase in net feed efficiency of cows fed high moisture sorghum grain stored anaerobically.

Solids-corrected milk was calculated to express milk yield on an equivalent energy basis. Reconstituting sorghum grain with and without the addition of acids had no significant effect (P>.05) on the net efficiency of producing solids corrected milk when fed to lactating dairy cows. These results are consistent with the net efficiency of actual milk yield, since no appreciable differences were observed in milk fat percentage. Likewise Bade et al. (1973) did not find any differences in net feed efficiency when milk yield was expressed as 4% fat corrected milk.

Bush et al. (1973) reported finely ground sorghum grain to be 7 to 9% higher in feeding value than coarsely ground sorghum grain. Consequently, reconstituted grain would be expected to have 7 to 9% higher feeding value than coarsely ground or dry rolled sorghum grain. This higher efficiency is comparable to that found in beef cattle studies where coarsely ground or dry rolled grain has been used as the control grain.

Digestibility Data

In vitro, dry milo was digested more slowly (P<.05) for the first

3 hrs. than the reconstituted grain (Table VI). No appreciable differences existed at 12 hours of digestion; however, after 24 hours the acid-treated sorghum grain was less completely digested ($P<.05$) than the water reconstituted or dry sorghum grain. In contrast, Lane et al. (1973) reported dry sorghum grain to be significantly less digested ($P<.05$) after 24 hours of digestion than reconstituted sorghum grain with and without the addition of acid preservative.

Dry matter, protein or organic matter digestibilities (Table IV) were not different among rations ($P>.05$). This agrees with results of Bade et al. (1973); however, McGinty et al. (1966), reported significant increases ($P<.05$) in the digestibility of dry matter, organic matter, nonprotein organic matter and protein digestibility of reconstituted sorghum grain fed to yearling bulls as compared to dry control grain.

TABLE IV

DIGESTIBILITY COEFFICIENTS OF RATION COMPONENTS

Component	Ration Treatments			SE
	Control	H_2O Recon.	Acid Recon.	
Dry Matter	63.44	64.93	62.82	1.28
Organic Matter	65.89	67.84	65.13	1.50
Protein	61.47	63.94	62.29	1.16

VFA DATA

Total volatile fatty acid concentration in rumen fluid of cows was not affected by treatment (P>.05) although the acetic to propionic ratio tended to be slightly higher in rumen fluid from cows fed water reconstituted grain. This slightly higher ratio is commensurate with the slight increase in milk fat percentage for the water reconstituted group. In contrast, Bade et al. (1973) found a significant decrease (P<.05) in the molar percentage of acetic acid in cows fed water reconstituted sorghum grain which was consistent with a significant depression (P<.05) in milkfat percentage. Differences in results at the two stations may be due to differences in ratio of forage to concentrates fed. Bade et al. (1973) fed a 40:60 ratio of forage to concentrates. Moreover, the data support the hypothesis that lower levels of acetic acid and higher levels of propionic acid depress milk fat percentage and are directly related to the ratio of forage to concentrate fed.

Total concentration, expressed in Table V as micromoles per milliliter of rumen fluid, was rather low, probably due to water consumption before sampling. On the evening before two sampling dates, the lot watering device was frozen, leaving the cows without access to water for approximately an eight-hour period until the morning feeding, after which larger water intakes might be expected.

In this study, the organic acid treatment mixture (Chemstor) contained 80% propionic and 20% acetic acids. The contribution to the total acetate and propionate production in the rumen should have been approximately 2.7% and 15% respectively. However, volatile fatty acid analysis of the extracted rumen liquor revealed no significant differ-

TABLE V

TOTAL AND MOLAR PERCENTAGES OF VOLATILE FATTY ACIDS

Ration	Total Conc. Micromoles/ ml.	Acetic	Propionic	Isobutyric	Butyric	Isovaleric	Valeric	Caproic	Acetic/ Prop.
Control	48.36	66.76	16.32	1.18	12.14	1.95	1.07	.53	4.09
H_2O Recon.	48.22	67.47	15.31	1.17	12.90	1.94	.91	.56	4.40
Acid Recon.	46.68	67.29	15.85	1.17	12.22	1.90	.99	.50	4.25
SEM	5.37	1.11	1.40	0.01	0.60	0.12	0.01	0.01	1.84

ences in acetic and propionic acid ratios. As acetate:propionate ratios were unchanged, it is not possible to determine whether or not the addition of organic acids to high moisture grain has an additive effect on acetate to propionate levels in the rumen or milkfat synthesis.

TABLE VI

PERCENT _IN VITRO_ DRY MATTER DISAPPEARANCE

Processing Method	Hour 3	12	24
Control	5.79[a]	23.75	47.06[a]
H_2O Recon.	9.32[b]	25.29	41.63[a]
Acid Recon.	9.31[b]	25.33	34.82[b]
SE	1.66	0.73	5.07

[ab]Means in a column which do not have the same superscript are significantly different ($P<.05$).

ECONOMIC VALUE

The economic merit of high-moisture grain has a large number of inputs, allowing one to estimate only roughly its economic value. Since sorghum grain is physiologically mature at 38 to 40% moisture, no additional dry matter will accumulate as the grain dries. Harvesting losses of dry matter range from 6 to 20% when grain is allowed to dry in the field. If the average yield of dry sorghum grain at 14% moisture is estimated at 4375 kg/hectare, one could increase his yield by early harvesting by 262.5 to 875 kg/hectare. Assuming sorghum grain to be valued at $107/metric ton or $468/hectare, an increase in yield of 6 to 20% would result in increased profit by $28.09 to $93.60/hectare.

Since organic acid preservation produced grain of nutritive value equal to reconstituted grain stored anaerobically or dry finely ground sorghum grain, it must be considered as an alternative method of storage for high moisture grains. Organic acids, propionic or acetic plus propionic, cost approximately 66¢ to 77¢/kg. If sorghum grain at 30% moisture were treated with 2% organic acids, the chemical cost would range from 1.3¢ to 1.5¢/kg. of grain and storage facilities should be very low in cost. Storage cost per bushel in a glass-lined silo is approximately 75¢/kg when dry matter losses are not included in either storage method. So preservation with organic acid costs about twice that of glass-lined silo storage, but it offers greater flexibility. Dry matter losses were estimated by Bogle (1976) but are not included because of different levels of acid treatment. Organic acids even at a low percentage corrode metal storage containers which will increase the storage cost to some extent. These factors would alter the previous calculated values.

CHAPTER V

SUMMARY

Thirty cows, 8-9 weeks postpartem were fed a 50:50 dry matter ratio of forage to concentrate in a switchback design, to compare production responses of lactating dairy cows fed: a) dry very finely ground sorghum grain, b) sorghum grain reconstituted to 30% moisture stored anaerobically, and c) sorghum grain reconstituted to 28% moisture plus 2% organic acids (Chemstor). The response criteria were milk yield and composition, body weight changes, digestibility of the ration components, and rumen VFA ratios.

Neither of the reconstituted treatments affected feed intake, milk yield, volatile fatty acid percentages or digestibility of the ration components. A small increase was observed in milkfat percentage by cows fed sorghum grain reconstituted with water and stored anaerobically. This difference was too small to be of practical importance, and it was concluded that no important change in milkfat depression should be expected due to reconstitution of sorghum grain.

The reconstituted sorghum grain preserved with 2% organic acids showed no visible signs of mold growth after an extended period of storage.

Since grain preserved by addition of organic acids was equal in feeding value to high moisture sorghum grain stored anaerobically or to a dry control grain ground very fine, it may be considered as an alter-

native method of storage of high moisture grain to be fed to dairy cows.

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