

THE EFFECT OF GRINDING SEED HEADS
ON THE NUTRITIVE VALUE OF SORGHUM SILAGE

by

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INTRODUCTION

Silage is an economical, nutritious, easily stored feed for ruminants. A variety of legumes, grasses, roots, and combinations of these, are used for silage making. Crop choice depends greatly on the prevailing agronomic factors and the animals' nutritional requirements. Sorghums are preferred in low rainfall regions because of their ability to withstand drought. Over 5.0 million tons of sorghum silage are produced annually on about half a million acres in Kansas. For 1961-62, the area devoted to sorghum crops in India was 43.0 million acres. Most of the crop in India was grown in the medium black soil area receiving an annual rainfall of 10 to 30 inches. Sun-dried stalks of sorghum plants, from which grain has been removed, are used as roughage for cattle in India, but sorghums would be better utilized as silage than as less palatable and less digestible stover.

Investigations on the feeding value of sorghum silage for milk and beef production are few in number and the findings are controversial. Some variation in the results from sorghum silage feeding undoubtedly has been due to variation in quality of the silage fed. Reports of 25% to 50%, and in extreme cases to 90%, passage of whole sorghum seeds in the feces have been made. A comparison of the proximate composition of sorghum silage with other silages indicates that most proximate components were in adequate amounts with the exception of protein.

This investigation was conducted to compare the feeding values of silages made from a nonjuicy, nonsweet, sorghum hybrid

(Dekalb FSIA) and a juicy, sweet, sorghum variety (White Sourless), both ensiled with and without the seed heads being ground.

REVIEW OF LITERATURE

Sorghum had its origin in Africa and Southern Asia and was introduced in the United States as a drought-resistant crop (Boyd, Green, and Chapman, 1961) capable of survival in extremes in weather and adaptable to light and heavy clay soils (Buchanan, 1930). Good, Horlarcher, and Grimes (1921) reported that sorghum was not hurt by frost and had yielded 56.1% more silage per acre than corn. Krishnan (1932) conducted investigations on the stage at which sorghum crops should be harvested for silage. The crops were harvested at "immature," "prime," and "straw" (stover) stages for ensiling. The extent of deviations in dry matter, organic matter, protein, ether extract, volatile acid and non-volatile acid contents of the silages from their respective harvested sorghum crops indicated that the "prime" stage was the best for harvesting sorghum crops for silage. Holt, Riewe, and Cook (1963) concluded that yield, quality, and physical characteristics of forage sorghum are influenced by the stage of maturity of the plants at the time of harvest. They reported that maximum grain and dry matter production of most varieties and hybrids was reached by the milk to soft-dough stages. Brown, Rupel, and Rinn (1963) observed no differences in milk production among groups of cows fed the Tracy Sorghum Silage in the boot, dough or hard-seed stages of maturity.

Evaluation of Sorghum Silage

Investigations on the feed value of sorghum silage fed alone have been attempted rarely because the protein level is too low for adequate nutrition. Jones, Black, and Keating (1927) observed that calves fed sorgho silage instead of sorgho fodder gained 100 lb more at an average daily gain of 2 lb per animal with considerable saving of cottonseed meal and ground milo. Bechtel et al. (1945b) fed lactating cows a sorghum ration consisting of 46% sorghum stover, 31% sorghum silage, and 23% sorghum grain. The authors observed that the 4% fat-corrected milk (FCM) produced with the all-sorghum ration was only 52% of that produced by the same cows on a typical mixed ration during the previous lactation. The cows dried up much sooner and were in poor physical condition; calves born to these cows were lighter in weight than those born to dams on normal rations. The authors concluded that the animals on the all-sorghum ration performed poorly because they received only about 60% of the digestible protein and 80% of the total digestible nutrients needed as minimal requirements for maintenance and milk production. Atkeson et al. (1938) studied the effect of feeding sorghum silage and sorghum grain on milk yield and duration of lactation of three lots of dairy cows, all of which had received balanced rations in the preceding lactation. Animals in Lot 1 were fed chopped and dried sorghum stover ad libitum with 2 lb sorghum silage per 100 lb body weight and a grain mixture having 100 parts of ground Atlas sorgho grain and 1 part of salt. The

ration of cows in Lot 2 was the same as for Lot 1 except that the grain mix had 150 parts ground Atlas sorgho grain, 100 parts cottonseed meal, 5 parts steamed bone meal, and 2.5 parts salt. Cows in Lot 3 received a ration of chopped alfalfa hay ad libitum, sorghum silage as for Lots 1 and 2, and a grain mixture of 400 parts ground Atlas sorgho grain, 200 parts wheat bran, 50 parts cottonseed meal, 6.5 parts steamed bone meal, and 6.5 parts salt. The milk yields were reduced by 51%, 36%, and 7% from those of the previous lactation for the three lots of animals, respectively. Furthermore, the authors observed that the average length of lactation was reduced by 38, 32, and 25 days, respectively.

Efforts at improving the feeding value of sorghum have been made by supplementing the deficiencies which were supposed to have lowered the feeding quality of sorghum silage. Jones and Stangel (1938) observed in their experiments with fattening lambs that calcium-supplemented sorghum silage was consumed in larger quantities and that feed lot gains were comparable to those of lambs fed high quality alfalfa hay. Cox and Connell (1933) reported that lambs ate more silage supplemented with limestone than those which received a ration without limestone supplementation. Some investigations indicated that sorghum silage was deficient in carotene which probably is also a reason for the poor results obtained. Cunningham and Addington (1940) supplemented sorghum silage with Sudan grass pasture. This increased sixfold the content of vitamin A in the milk fat of the cows. Davis, Hathaway, and Trimberger (1943) observed that Guernsey cows fed for two years on sorghum products only, had low milk

yield, incoordination of muscular movements, loss of eyesight, and post-mortem had revealed abnormalities of internal organs, all of which the authors attributed to avitaminosis A.

It was observed by Harrington, Adriance, and Tilson (1890) that the digestibilities of nutrients in sorghum and corn silages were comparable, except that crude protein of sorghum silage was less digestible. Berry and Franke (1961) observed that the efficiency of sorghum silage as cattle feed was enhanced by supplementation with readily available sources of nitrogen such as urea, biuret, or soybean oil meal. Williams, Cannon, and Espe (1943) observed that milk yields of cows were not depressed when sorghum silage was fed after supplementation with soybean oil meal. Morris (1958a), in investigations on use of native grass hay (bush hay) and sorghum silage as drought fodder for sheep and cattle, observed losses in body weight, but when the ration was supplemented with urea, these losses were reduced. In continuation of earlier experiments (1958b), the author fed cattle and sheep sorghum silage supplemented with urea at different levels. Urea supplementation increased the dry matter consumption of sorghum silage and increased the rate of gain. The author concluded that addition of urea to sorghum silage had spared the tissue proteins and increased the digestibility and utilization of silage energy.

Comparison with Other Silages

The value of sorghum silage as a livestock feed has been assessed by trials which were mostly comparative evaluations with

corn, legume, and grass silages. Sorghum silage was observed to be more palatable for cattle than corn silage (LaMaster and Morrow, 1929). In another set of feeding trials with lactating cows, no difference in palatability was observed between mixed sorghum-alfalfa silage and corn silage (Olson, 1939, 1940).

Nevens and Kendall (1954) stated that sorghum silage was lower in feed value than corn silage. They attributed this to the lower dry matter content, poorer digestibility of dry matter, and lesser energy per pound of dry matter of sorghum silage. The digestibility coefficients compared well with corn silage except those for crude protein as was found also in trials conducted by Harrington *et al.* (1890).

Sorghum and corn silages have been compared on the basis of productive efficiencies estimated by lactation and beef-fattening trials. Wilson *et al.* (1891) observed that 2.9 lb of corn fodder, 3.73 lb of corn silage, or 3.86 lb of sorghum silage were consumed for each 1 lb of milk solids. They also reported that 9.61 lb of corn fodder, 13 lb of corn silage, or 13.5 lb of sorghum silage were consumed for each pound of milk fat produced. Cunningham and Reed (1927) reported that corn silage produced 1.5% and 1.68% more milk and 4.3% and 2.94% more butterfat than sorghum silage, respectively, in two lactation trials. They concluded that a ton of sorghum silage possessed 91% and 95.8% of the productive capacity of a ton of corn silage in successive trials. LaMaster and Morrow (1929) noted that, on the basis of total digestible nutrients, sorghum silage was 72.12% and 74.63% as efficient as corn silage for milk and milk fat production,

respectively. Owen et al. (1957) fed corn silage and sorghum silage to lactating cows and found greater yields of FCM from cows receiving corn silage. Williams et al. (1943) reported that yields of milk from cows fed soybean oil meal-supplemented sorghum silage were comparable to those obtained from corn silage-fed cows. The protein supplement added adequate crude protein and total digestible nutrients to sorghum silage.

Corn silage induced better weight gains in beef fattening trials than sorghum silage. Gayle and Lloyd (1917) conducted two feeding trials on steers and obtained approximately 0.18 lb greater average daily gain in weight with corn silage than with sorghum silage. These authors equated 1 lb of Goliad corn silage with 1.124 lb of Early Amber sorghum silage and with 1.134 lb of Texas seeded ribbon cane silage for producing weight gain. King (1944) reported that sorghum silage and corn silage yielded similar rates of gain in body weight of steers.

Sorghum silage has been demonstrated to be superior to certain other feeds as roughage for livestock. Lyons (1938) conducted a feeding trial with lactating cows. The author concluded that Atlas sorgo silage was a better roughage than oat silage for milk production. Shealy, Kirk, and Crown (1941) compared the feeding value of Napier grass, sugar cane, and sorghum silages. They concluded that the steers used in the experiment had received a larger proportion of total digestible nutrients (69%) from sorghum silage and a correspondingly smaller proportion (31%) from a concentrate mixture than when the other silages were fed. Brown, Lundquist, and Heath (1962) reported that the

digestibility of sorghum silage nutrients was about 60% whereas for Orchard grass silage it was in the range of 51% to 52%. The sorghum silage was reported also to have produced 3.6 lb more FCM per cow per day on 5.08 lb less dry matter.

Influence of Grain on Nutritive Value

The grain in the silages contributes starch for beneficial fermentation of silage, and the dry matter serves as a conditioner in the fermentation processes. Genter (1960) reported that corn produced twice as much grain and only half as much stalk as sorghum, the leaf content being the same for both crops. Sorghum grain seems to escape mastication and is eliminated in part in feces without being digested. Particles with a density of 1.2 g/cm³, having a volume of 23.4 cm³/thousand particles, each weighing 28.1 mg having a size between 20 and 30 x 10⁻³ cm³, have the most rapid rate of passage in the bovine digestive tract (King and Moore, 1957). Sorghum grain probably has most of these attributes. Consequently, large quantities of seeds are excreted in feces. Thurman, Stallcup, and Reams (1960) concluded that leaves and grain of the sorghum plant were the major contributors of digestible protein. Hence, the inefficiency of sorghum silage might be attributed to the non-availability of a major portion of digestible protein as a result of whole grain lost in feces. Shaw and Norton (1906) reported the fecal losses of whole corn and oats were 22.75% and 12.06%, respectively. Jordan (1950) observed that Norghum sorghum had only 90% of the value of shelled corn, which he explained on the basis of the considerable quantity

of sorghum grain which was excreted in the feces. Fitch and Wolberg (1934) observed that 43% of the seeds in Kansas Orange sorgho silage and 36% of the seeds in Atlas sorgho silage were voided in the feces of dairy cows, but when the silages were fed along with alfalfa hay and a grain mixture, the seeds voided in feces were only 30%.

Reams, Stallcup, and Thurman (1961) studied the factors influencing the qualities of sorghum and corn silages. They observed that a hybrid sorghum, RS 301, which had lightly seeded heads, was as good as Conker 911 and Dixie 82 corn silages in digestibilities of nutrients. These authors reported that Atlas sorgho silage without heads had greater crude fiber digestibility than the sorgho silage with heads.

Brethour and Duitsman (1962a) reported that gains in weights of steers ranked in the same order as the percentages of grain in the sorgho silage but that the digestion coefficients of nutrients were lower with high grain types due to extensive losses of nutrients as undigested seeds. These authors reported an experiment in 1962 in which rolled sorghum grain was fed at levels of 4 lb and 8 lb daily to two lots and none to another lot of steer calves. All the lots received in addition 5 lb of chopped alfalfa hay and ad libitum heavily seeded hybrid sorghum silage. Average daily gains observed were 1.25 lb, 1.75 lb, and 2.06 lb for the lots which received no grain, 4 lb grain, and 8 lb grain, respectively. The first 4 lb of grain exerted more influence on daily gain than did the second.

Brethour and Duitsman (1962b) reported that the loss of nutrients by the passage of undigested seeds in feces might be curtailed by ensiling the sorghum crop at milk stage before the seed coat hardens. Such a crop would favor easy mastication and disintegration of seeds in the digestive tract. The authors recorded poor consumption of silage and small gains in weight of the experimental animals.

Hybrid sorghum crops with lightly seeded heads were used for making sorghum silage to prevent loss of undigested seeds in feces. Boren et al. (1961) ensiled two high-grain nonsweet and two low-to-medium grain semi-sweet sorghums and fed them to beef heifer calves. They observed that the two high-grain yielding varieties (Hegari, Dekalb FSIA) produced greater gains, 0.2 lb and 0.11 lb per animal per day, respectively, than the two low-to-medium grain varieties (Lindsey 115F, Axtell). These differences were not statistically significant, however.

Effect of Grinding Seed Heads

The grain in sorghum silage contributes to the energy value of the silage, but the fecal losses of unmasticated grain tend to nullify much of this contribution. Attempts at reducing the fecal loss of silage grain were made by ensiling the sorghum after grinding the heads. Boren et al. (1962) conducted feeding investigations with control and ground silages both made from each of a heavily seeded fertile sorghum and a lightly seeded sterile sorghum. Control silage was established by the conventional

method of silage preparation using the chopped whole plant. Ground silage was made by ensiling the chopped stalks of the sorghum evenly mixed with heads ground in a hammermill. Highly significant differences were obtained in average daily gains in the body weights of the heifers. The animals fed the fertile (heavily seeded) control silage gained the most and consumed the most silage. Lots which received fertile (heavily seeded) ground-head silage and sterile (lightly seeded) control silage made similar gains. The total dry matter intake and pounds of feed consumed for 100 lb of body weight gain were closely correlated with the average daily gain. In later studies, these authors (1963) observed no significant differences in gains among groups of heifer calves fed silages made with and without grinding the seed heads.

Olson and Wallis (1938) fed whole, medium, and fine ground corn to cows along with alfalfa hay. The results indicated that coefficients of digestion for entire ration was higher for fine ground than medium ground and whole corn rations.

The beneficial effects of grinding sorghum grain have been demonstrated by feeding trials. Darnell and Copeland (1936) fed dairy cows grain mixtures which had 60% milo, as ground or whole. They observed that cows fed the ground grain consistently yielded more milk than those that received unground milo. In both lots there were inconsistent trends in body weight gains. The authors estimated that the productive energy value of 100 lb of ground milo grain was 2.13 therms greater than that of unground milo. Black, Jones, and Keating (1937) compared the fattening effect

of feeding various forms of milo grain to steers and observed that ground milo caused greater daily gain: 1.93 lb, with a consumption rate of 682 lb of total digestible nutrients per 100 lb of gain in body weight; whereas, animals fed on unground milo gained 1.86 lb daily with a consumption rate of 789 lb of total digestible nutrients per 100 lb of gain in body weight. Jones et al. (1937) conducted feeding trials during three years and reported that 18%, 13%, and 4% greater gains, respectively, were recorded for beef cattle fed ground milo grain rather than unground grain. They found that feeding ground milo grain brought about more efficient gains in weight among the beef calves with a saving of 20%, 16%, and 12% in grain for every 100 lb gain in these three years, respectively. The ground milo heads had 69.7 therms of productive energy per 100 lb of grain, 20% greater than that of unground milo heads. Atkeson and Beck (1942) investigated the advantages of feeding dairy cows ground Atlas sorghum grain. They estimated that only 10.7% of the grain in the silage was recovered from feces; whereas, the recoveries from feces of cows fed whole grain was 42%; for coarsely ground grain, 4.8%; and for finely ground grain, 1.5%. The authors recommended coarse grinding of sorghum grain for lowering fecal losses of unmasticated and undigested seeds. Bechtel et al. (1945a) observed that there were no associative trends between proximate composition of feces and the percentage of undigested seeds in feces. Brethour and Duitsman (1962c) reported an experiment in which high moisture sorghum grain harvested in the hard dough stage (36% moisture) was ensiled as ground or whole grain and fed to

steers. The daily gain in weight was 2.76 lb for the former with lesser feed consumption, and 2.39 lb for the latter with greater feed consumption.

Effect on Milk Production

No reports of investigations planned to evaluate the effects of feeding sorghum silage on the composition of milk were found. Riddet et al. (1942) observed that plane of nutrition had no constant effect on milk fat percentage, but that subnormal planes of nutrition had depressed the solids-not-fat by 0.3 to 0.5 percentage units. Larson (1958) noted that the amino acid composition of milk protein was not altered by starvation or by overabundant feeding and also that high milk fat percentage is associated with high percentage of milk protein. Leroy (1949) noted a decrease in milk fat percentage when insufficient protein and energy were consumed by cattle. The author observed that if less than 350 g digestible lipids were consumed by a lactating animal daily, the milk yield and milk fat were decreased. Jarl (1949) concluded that the fat content of the ration consumed by a cow and the iodine number of the milk fat were closely correlated. Rook and Line (1962) observed that level of protein in the ration had no effect on the level of fat, solids-not-fat, lactose, and true protein contents of milk, but influenced ($P < 0.001$) the non-protein nitrogen content of milk and, as a result, the total nitrogen content varied significantly ($P < 0.05$) with the level of protein fed. Cows on spring pasture produce milk having lower percentage solids-not-fat due to a relative

increase of propionic acid over that of acetic in rumen (Bath, Rook, and Rowland, 1962). Powell (1939) investigated the effects of feeding normal and ground roughages of equal fiber content on the fat and solids-not-fat composition of milk, and observed that these were lowered by as much as 60% with ground roughage feeding. Richardson and Folger (1950) confirmed earlier findings of linearity between solids-not-fat and fat percentages of milk, and observed that the linearity exists within narrow limits of change in fat percentage. Brown (1959) concluded that milk of satisfactory quality was produced by cows fed a ration consisting solely of good quality silage and that the addition of concentrates to silage increased the daily total dry matter consumption per cow, daily milk yield, percentage solids-not-fat in milk, and weight gain, but no significant change in milk fat percentage was found.

PROCEDURE

Lactation Trial

A lactation trial was conducted with 12 Holstein cows (Table 1) using three replicates of a 4 x 4 Latin square design. A two-week standardization period was used to accustom the cows to the ration. The amount of grain mixture to be fed each cow was calculated from the data obtained during the standardization period, assuming 0.17 therm net energy per pound of silage, 0.79 therm net energy per pound grain mixture, and 0.34 therm energy per pound FCM. The grain mixture consisted of 7 parts ground

TABLE 1
Experimental subjects - lactation trial

Replicate	Cow	Standardization period		Date of calving
		Body weight (lb)	FCM (lb/day)	
I	A 100	1221	50.4	10/26/62
	183 B	1370	47.8	8/31/62
	143 C	1517	62.1	11/28/62
	160 C	1572	49.3	11/ 1/62
II	A 102	1260	35.5	10/ 6/62
	198 C	1117	43.8	9/26/62
	199 C	1134	39.7	11/19/62
	103 D	1058	35.0	10/31/62
III	A 109	1158	47.0	10/15/62
	A 110	1228	44.1	11/22/62
	177 C	1223	44.3	10/19/62
	101 D	1184	50.5	11/13/62

yellow corn, 5 parts soybean oil meal, 1% salt, and 1% dicalcium phosphate. The grain mixture allotted was reduced every week, assuming a 2% decline in the FCM yield per week. The cows received silage slightly in excess of consumption so that some silage was weighed back and the silage consumption was on

ad libitum basis. The grain mixture and silage were weighed out once daily but were fed in approximately equal portions twice daily. Water and salt were available at all times.

The lactation trial was conducted in four periods, each period being of 21 days duration. Of these, the initial 14 days constituted the transition period and the final 7 days were for data collection. The daily silage and grain consumptions and milk yields were recorded for each cow. The animals were weighed on two successive days at the end of each period and their average weights were used for calculations. Composite milk samples obtained from the milkings at seven-day intervals were analyzed for milk fat percentage by Babcock's method, and ash, protein, and total solids by AOAC techniques. The FCM for every 7 days were calculated, employing the butterfat value obtained from the composite milk sample of the seventh day. The average FCM for the last 7 days in a period and the butterfat, protein, ash, solids-not-fat, and total solids percentages estimated from the milk sample of the last day in a period were used in the calculations.

Digestion Trial

Digestibility of the four silages and rate of passage of undigested whole seeds were estimated using four yearling Holstein steers (Table 2) in a 4 x 4 Latin square design. The silage and soybean oil meal (2 lb) were weighed out once daily, but were fed in two approximately equal portions.

The digestibility trial started with an initial 2-week preliminary period in which steers were accustomed to the silages.

TABLE 2
Experimental subjects - digestion trial

Steer	Age	Body weight	
		Initial	Final
	(mo)	(lb)	
21 B	12	653	735
38 B	12	782	832
186 D	13	800	853
189 D	12	725	788

The experiment was conducted in four periods, each of 21 days duration. The steers were confined in stanchions for the initial 14 days of a period but were transferred to metabolism cages for the last 7 days of each period. The steers were accustomed to the metabolism cages for the first two days, and on the evening of the second day, feces collection was started. The total wet feces collected were weighed and a 3% sample was frozen in a polyethylene bag. Collection and subsequent freezing of feces samples were made similarly on five consecutive days in each period. The samples of feces were thawed at room temperature without moisture loss, thoroughly mixed, and two subsamples were taken. These two samples were weighed separately; then one of them was dried in a forced air oven at 160 F for dry matter estimation and the other was used for estimating the proportion

of whole seeds in the feces. The seeds were separated by washing the weighed sample of feces in a metal sieve and floating the lighter debris out in a dish of water, thus isolating the heavier whole seeds. The separated whole seeds also were dried in the forced air oven. The dry matter percentage of feces and the percentage of dry matter of whole seed voided in the feces were calculated. The dried feces samples were ground and used for energy determination and proximate analysis. The steers were weighed at the start and finish of the digestion trial.

Samples of silages were collected every third day. The grain mixture and soybean oil meal used in lactation and digestion trials, respectively, were sampled at the beginning and middle of each period. All samples were weighed and dried in a forced air oven at 160 F for dry matter estimation. Alternate silage samples were used for estimation of whole seed content. A sample of 400 whole dry seeds of each variety was weighed and volume determined by displacement of water in a 10 cc graduated cylinder, and from these values, weight, volume, and density of 1000 whole seeds were estimated. The remainder of the silage samples were pooled by periods for proximate analysis. Samples of the soybean oil meal and the grain mixture were also subjected to proximate analysis. Samples of milk, silage, grain mixture, soybean oil meal, and feces were analyzed by the Chemical Service Laboratory.

Data obtained from lactation and digestion trials were analyzed for variance and the means were compared by the Fisher's

least significant difference technique (Snedecor, 1956).

RESULTS

Analyses of dry matter, proximate nutrients, and energy content of the feeds are presented in Table 3.

TABLE 3

Dry matter, proximate composition, and energy content of feeds

Feeds	Dry matter	Crude protein*	Ether extract*	Crude fiber*	Ash*	Nitrogen free extract*	Gross energy**,**
Silage							
White Sourless control	29.7	5.1	2.5	20.9	6.7	64.8	4378
White Sourless ground	27.8	4.5	2.2	24.3	7.0	62.0	4393
Dekalb FSIA control	32.7	4.7	1.8	22.4	7.4	63.7	4363
Dekalb FSIA ground	31.8	5.1	1.7	22.2	7.0	64.0	4384
Grain mixture	86.7	21.1	3.7	3.7	4.3	67.2	4631
Soybean oil meal	89.0	44.6	1.9	5.2	6.9	41.4	4785

* Dry basis.

** Each energy value is an average of 12 estimations by bomb calorimeter.

Lactation Trial

Average dry matter consumptions by variety of silage and process are presented in Table 4. Dry matter consumption of control silage was greater than that of ground silage but no significant difference was noted between varieties.

TABLE 4
Dry matter consumption per cow

Silage	Daily dry matter consumption per animal		
	Silage	Grain	Total
	(lb)		
Process			
Control	24.8 ^A	12.0	36.8
Ground	22.6 ^B	12.0	34.6
Variety			
Sourless	23.6	12.0	35.6
FSIA	23.8	12.0	35.8

A,B Values differ significantly ($P < 0.01$).

Averages of daily FCM and energy yields, relative productive efficiency, and changes in body weight are presented in Table 5. Daily yields of FCM and milk energy were influenced neither by processing nor variety of silage fed to cows. Processing but not variety had a significant effect on body weight gain. Animals

gained body weight on control silages but lost weight on ground silages.

TABLE 5

Milk yields, milk energy yields; therms of milk energy per unit of metabolic body size; changes in body weight

Silage	FCM	Milk energy		Change in body weight
	(lb/day)	(Therm/day*)	(Therm/W ^{0.73})	(lb/day)
Process				
Control	39.1	13.1	0.126	+0.97 ^A
Ground	39.1	12.8	0.123	-0.06 ^B
Variety				
Sourless	39.6	13.1	0.127	+0.32
FSIA	38.7	12.7	0.123	+0.59

^{A,B} Values differ significantly ($P < 0.01$).

* Estimated by using the energy contents of fat, protein, and carbohydrates in milk to be as 4287 kcal/lb, 2563 kcal/lb, and 1860 kcal/lb, respectively.

Dry matter consumption per pound FCM and per therm milk energy are summarized in Table 6. Efficiencies of FCM and milk energy production were significantly influenced ($P < 0.01$) by silage processing and to a lesser extent by silage variety ($P < 0.05$). Ground silages were more efficiently used than controls, and Sourless than FSIA. Neither silage variety nor

TABLE 6

Silage dry matter consumption per pound FCM
and per therm milk by process and variety

Silage	Dry matter consumption			
	Silage		Total	
	Per lb FCM	Per therm milk	Per lb FCM	Per therm milk
	(lb)			
Process				
Control	0.66 ^B	2.0 ^B	0.97 ^B	3.0
Ground	0.60 ^A	1.8 ^A	0.91 ^A	2.8
Variety				
Sourless	0.61 ^a	1.9 ^a	0.92 ^a	2.8
FSIA	0.64 ^b	2.0 ^b	0.96 ^b	3.0

A,B Values differ significantly ($P < 0.01$); a,b ($P < 0.05$).

processing significantly affected the total dry matter intake per therm of milk energy. Grinding the seed heads increased the efficiencies of FCM and milk energy production to a greater extent ($P < 0.05$) for Sourless than FSIA silage (Table 7), as indicated by significant interaction between methods of processing and varieties of silages.

Average milk composition is presented in Table 8 by process and variety. Milk composition was independent of silage variety. Milk fat percentage was significantly less ($P < 0.05$) from cows

TABLE 7

Silage dry matter consumption per pound FCM
and per therm milk energy by silages

Silage	Silage dry matter intake	
	Per lb FCM	Per therm milk
	(lb)	
Sourless control	0.66 ^c	2.0 ^b
Sourless ground	0.57 ^a	1.7 ^a
FSIA control	0.66 ^{b,c}	2.0 ^b
FSIA ground	0.63 ^b	1.9 ^b

a, b, c Values in same column with different suffixes are significantly different ($P < 0.05$).

TABLE 8

Milk composition by process and variety

Silage	Fat	Protein	Solids-not-fat	Total solids
(%)				
Process				
Control	3.9 ^a	3.05	8.5	12.4
Ground	3.7 ^b	3.09	8.6	12.3
Variety				
Sourless	3.8	3.06	8.5	12.3
FSIA	3.8	3.08	8.6	12.4

a, b Values differ significantly ($P < 0.05$).

fed the ground silages due mostly to differences between the two FSIA silages. This difference in fat percentage is reflected in the significant difference in total solids percentages between the FSIA silages (Table 9).

TABLE 9
Composition of milk by silages

Silage	Fat	Solids-not-fat	Total solids
		(%)	
Sourless control	3.83	8.47	12.31 ^B
Sourless ground	3.72	8.62	12.34 ^B
FSIA control	3.88	8.58	12.47 ^A
FSIA ground	3.66	8.59	12.25 ^C

A,B,C Values with different suffixes are significantly different ($P < 0.01$).

Digestion Trial

Average dry matter consumption by steers is presented in Table 10. Differences in silage dry matter consumption were significant and were dependent on the moisture content of the silages since all steers were fed the same weight of silage.

The steers gained in body weight at an average rate of 0.73 lb per day during the digestion trial (Table 2).

Apparent digestion coefficients by process and variety of silage are presented in Table 11. Dry matter, nitrogen free

TABLE 10

Daily dry matter consumption per steer by silages

Silage	Dry matter intake per steer (lb/day)
Sourless control	12.3 ^b
Sourless ground	11.4 ^b
FSIA control	13.4 ^a
FSIA ground	12.1 ^b

^{a, b} Values with different suffixes are significantly different ($P < 0.05$).

TABLE 11

Apparent digestion coefficients by process and variety

Silage	Dry matter	Crude protein	Ether extract	Nitrogen		Energy
				Crude fiber	free extract	
(%)						
Process						
Control	57.3 ^B	21.4	61.4	53.7	66.4 ^B	56.0 ^B
Ground	61.8 ^A	22.2	64.4	55.2	71.9 ^A	60.6 ^A
Variety						
Sourless	59.1	20.7	59.6 ^b	56.8 ^A	68.0	58.0
FSIA	60.0	22.9	66.2 ^a	52.0 ^B	70.3	58.6

^{A, B} Values in a column with different suffixes are significantly different ($P < 0.01$); ^{a, b} ($P < 0.05$).

extract, and energy of ground silages were more digestible than those of the controls ($P < 0.01$). Apparent digestibility of Sourless crude fiber was superior ($P < 0.01$) and of ether extract inferior ($P < 0.05$) compared with those of FSIA. Grinding the seed heads increased the apparent digestibilities of dry matter and crude protein of FSIA but grinding of Sourless did not influence significantly the apparent digestibility of dry matter but decreased the apparent digestibility of crude protein (Table 12).

TABLE 12

Apparent digestion coefficients by silages

Silage	Dry matter	Crude protein	Ether extract	Crude fiber	Nitrogen free extract	Energy
Sourless control	57.6 ^{b,c}	26.8 ^a	59.2 ^b	56.6 ^a	65.7 ^c	56.4 ^{b,c}
Sourless ground	60.6 ^{b,a}	14.6 ^b	60.0 ^b	57.1 ^a	70.4 ^{b,a}	59.7 ^{a,b}
FSIA control	56.9 ^c	16.0 ^b	63.6 ^b	50.7 ^b	67.1 ^{b,c}	55.7 ^c
FSIA ground	63.1 ^a	30.0 ^a	68.9 ^a	53.3 ^b	73.5 ^a	61.5 ^a

a, b, c Values in a column with different suffixes are significantly different ($P < 0.05$).

Volumes, weights, and densities of whole dried seeds of the two kinds of silage are presented in Table 13. Whole dry seeds of the Sourless forage appear to weigh less, have less volume,

and have greater density than those from FSIA.

TABLE 13
Whole seed (dry) measurements

Variety	Volume of 1000 seeds	Weight of 1000 seeds	Density
	cm ³	g	g/cm ³
Sourless	12.5	16.1	1.29
FSIA	23.0	24.9	1.08

Percentages of whole seeds in silages and of those voided in feces are presented in Table 14.

TABLE 14
Percentages of whole seeds in silage and feces

Silage	Whole seed DM	Whole seed DM in feces
	Silage DM	Whole seed DM in silage consumed
(%)		
Process		
Control	20.6	24.7
Ground	7.1	31.3
Variety		
Sourless	15.9	37.6 ^A
FSIA	16.8	18.4 ^B

^{A,B} Values differ significantly ($P < 0.01$).

The whole seed contents of the varieties of silage were similar but whole grain passage in feces was significantly greater ($P < 0.01$) for the Sourless variety.

Means of daily consumption of silage dry matter and digestible energy (calculated by using apparent digestion coefficients of silage dry matter obtained in digestion trial) and daily FCM yields are presented in Table 15.

TABLE 15

Daily silage digestible energy consumption and FCM yield

Silage	Daily intake of			FCM/animal
	Silage dry matter intake/animal	Silage energy/animal	Digestible silage energy/animal	
	(lb)	——(Therms)——		(lb)
Process				
Control	24.8 ^A	109.1	61.1	39.1
Ground	22.6 ^B	99.4	60.1	39.1
Variety				
Sourless	23.6	103.8	60.2	39.6
FSIA	23.8	104.7	61.2	38.7

^{A,B} Values differ significantly ($P < 0.01$).

Dry matter intake was less for ground ($P < 0.01$) than the control silage but intake of digestible energy and FCM yields were almost identical.

DISCUSSION

The dry matter consumption of ground silages was significantly lower than controls. Despite this, the cows fed on ground silages received as much digestible energy and yielded similar FCM and energy as those fed control silages. Greater efficiency of ground silages was due to higher digestibilities of dry matter, nitrogen free extract and energy, and smaller fecal losses of whole grain.

Ground silages possibly provide more starch as a substrate for ruminal fermentation. Van Soest and Allen (1959) observed that readily fermentable carbohydrates are fermented in rumen to yield larger proportions of propionic acid than acetic acid. Lipogenesis is slowed down due to decreased availability of acetic acid from rumen (Rook and Balch, 1961). Hence, feeding ground silages to cows probably altered the course of fat metabolism as indicated by significant milk fat depression and decreased weight gain. Greater weight gain associated with feeding the control silages may be due to greater ketogenicity of the ration. Boren et al. (1962) reported that animals fed on ground and control silages made similar weight gains.

Grinding the seed heads of FSIA silage decreased the total solids percentage of milk significantly and was associated with nonsignificant lowering of milk fat. However, the total solids percentage was not affected by grinding the seed heads of the Sourless forage. Differences in dry matter intake between varieties by cows in lactation trial were nonsignificant. The

Sourless variety was significantly more efficient for milk production. The slightly greater milk production which resulted from feeding the Sourless silage probably is balanced out by the difference, though nonsignificant, in weight gain.

There were significantly greater losses of whole seeds of the Sourless silage in feces as also was reported by Brethour and Duitsman (1963). Whole seeds of Sourless silage had greater possibility of escaping mastication because of the smaller volume. The seeds probably had a shorter stay in the digestive tract since they were more dense and more nearly typified the optimal conditions for rapid passage described by King and Moore (1959).

The crude protein content and its apparent digestibility were low compared to those of other nutrients of the silages. Reid et al. (1959) and Thurman et al. (1960) concluded that feeding forage of low crude protein and high crude fiber, such as sorghum silage, accentuates excretion of metabolic fecal nitrogen; consequently low apparent digestibility for the crude protein was obtained, but the true digestibility may be actually higher. Blaxter and Mitchell (1948) reported that the amount of metabolic fecal nitrogen was directly dependent on dry matter intake. Dry matter consumption of control FSIA silage was significantly greater, consequently a larger excretion of metabolic fecal nitrogen, hence the low apparent digestibility of crude protein; and vice versa for ground FSIA.

Grinding seed heads increased the digestible energy of the silages over 10% in one case and averaged 8% for the two varieties. Even though this treatment resulted in decreased silage

dry matter intake, the resulting economy in milk production indicates that further investigation is justified concerning the economics of this process.

SUMMARY

A nonsweet hybrid sorghum (Dekalb FSIA) and a sweet open-pollinated sorghum (White Sourless) were each ensiled with and without hammermilling the seed heads. The silages were evaluated by digestion and lactation trials.

The lactation trial was conducted with 12 Holstein cows, using a 2-week standardization period and 21-day experimental periods in three replicates of a 4 x 4 Latin square design. The standardization period was used to accustom the cows to silages and to collect FCM data for calculating quantities of grain mixture to be allotted to each cow during the trial. Grain feeding was adjusted during the trial to allow for an assumed 2% decline in FCM production weekly.

The digestion trial was conducted with four Holstein steers, using a 2-week preliminary period. There were four experimental periods. Each period of 21 days duration was distributed as a 14-day preliminary period, when the steers were in stanchions, and a 2-day adjustment period allowed for the transferring of the animals to metabolism cages, followed by 5-day feces collection periods in a 4 x 4 Latin square design. Soybean oil meal was fed as a protein supplement.

Dry matter of silages made with ground seed heads was consumed in significantly ($P < 0.01$) less amounts but had higher

apparent digestibilities for dry matter, nitrogen free extract, and energy. These silages were also more efficiently utilized for milk production. Milk fat percentages and gains in body weight were significantly lower ($P < 0.05$, < 0.01 , respectively) for the ground than for the control silages. Whole seed passage in feces was reduced by grinding. The possibility that ground silages provided more starch as a substrate for rumen fermentation and increased relative concentration of antiketogenic propionic acid, thus altering the course of fat metabolism was discussed.

Grinding Dekalb FSIA heads significantly increased ($P < 0.05$) the digestibilities of nutrients, but resulted in reduced dry matter consumption and total solids percentage of milk. An increase in the rate of whole seed elimination and reduction in apparent digestibility of crude protein were noted on feeding ground Sourless silage.

Dry matter consumptions of White Sourless and Dekalb FSIA silages were similar in the lactation trial. The Sourless variety had a higher ($P < 0.01$) digestibility coefficient for crude fiber but lower ($P < 0.05$) for ether extract. The Sourless silage was significantly superior ($P < 0.05$) to FSIA in efficiencies of milk production. The whole seeds of the Sourless variety silage were masticated less thoroughly due to smaller volume, and were eliminated in larger proportions in the feces.

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THE EFFECT OF GRINDING SEED HEADS
ON THE NUTRITIVE VALUE OF SORGHUM SILAGE

by

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Sorghum crops can survive droughts and are adaptable to a wide variety of soils. The yield from sorghum crops is large compared to that of other fodder crops. These attributes lend popularity to sorghums as feeds for ruminant animals. Sorghums are grown chiefly on the Southern Plains of the United States of America and the Deccan Plateau of India. The poor feeding value of sorghum silage has been attributed to poor nutrient content, particularly protein, and extensive elimination of whole seeds in feces.

This research was conducted to evaluate, by lactation and digestion trials, silages made from sweet White Sourless and nonsweet Dekalb FSIA sorghums with and without heads ground. The control silages were prepared by conventional methods; whereas, the ground silages were prepared by separating the heads from the plants, hammermilling them, and reincorporating them with the chopped headless forage during ensiling.

The lactation trial was conducted with 12 Holstein cows in three replicates of 4 x 4 Latin square design. The cows were subjected to a 2-week standardization period to accustom them to the silages and to obtain data from calculating allotment of grain mixture--7 parts ground yellow corn, 5 parts soybean oil meal, 1% salt, and 1% dicalcium phosphate--assuming 0.17 therm net energy per pound of silage, 0.79 therm net energy per pound grain mixture, and 0.34 therm net energy per pound 4% fat corrected milk. The grain mixture allotment was reduced, assuming 2% decline in FCM weekly. Each of four periods in the lactation trial consisted

of 21 days, the initial 14 days allowed for transitional adjustments and the final 7 days for data collection. The animals were weighed on two successive days at the end of each period and the average was used for calculation. Silage and grain mixture consumptions and milk yields were recorded daily. Composite milk samples were collected each week for analysis.

The digestion trial was conducted with four yearling Holstein steers using a 4 x 4 Latin square design. The steers were accustomed to the silages during a 2-week preliminary period, and the trial was conducted in four periods, each period of 21 days duration. Soybean oil meal (45% protein) was fed to the steers as a protein supplement along with the silages. Feces were collected from the steers in metabolism cages during the last five days of each period. The dry matter percentage, seed content, and proximate composition of feces samples were determined.

Samples of silages, grain mixture fed to cows, and soybean oil meal fed to steers were used for dry matter estimation and proximate analysis. Whole grain (dry) weight and proportion in the silages were also estimated.

Grinding the heads resulted in highly significant reduction in dry matter consumption and improvement in apparent digestibilities of dry matter, nitrogen free extract, and energy. Ground silages were more efficient in milk production and suffered fewer whole seed losses in feces than the control silages. Ground silages probably provided more starch as a substrate for rumen fermentation and increased relative concentration of propionic acid whose anti-ketogenicity altered fat metabolism as indicated

by significantly less milk fat percentage and highly significant less weight gain.

Dry matter consumptions of White Sourless and Dekalb FSIA silages were similar in the lactation trial. The Sourless silage had significantly greater crude fiber digestibility but had a lower digestibility coefficient for ether extract. Milk was produced more efficiently when the Sourless silage was fed. A larger proportion of whole seeds of the Sourless silage escaped mastication, probably due to smaller seed volume, and were eliminated in the feces.

Grinding Dekalb FSIA seed heads increased the digestibility of nutrients, but reduced the dry matter consumption and the total solids percentage in the milk.

The following conclusions were drawn from the experiments. Grinding seed heads before ensiling improves the digestibility of sorghum silage nutrients, increases the feed efficiency of milk production, and decreases the fecal losses of whole grain, but is unfavorable to fat synthesis. Dry matter consumption of White Sourless and Dekalb FSIA sorghums is similar, but the Sourless silage has greater crude fiber digestibility, supports more efficient milk production, and has greater whole seed losses in feces. Grinding Dekalb FSIA seed heads resulted in more improvement than grinding those of the Sourless forage as indicated by differences in digestibility.