INFLUENCE OF ORGANIC ACIDS ON PRESERVATION OF HIGH-MOISTURE MILO AND ANIMAL PERFORMANCE

by

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INTRODUCTION

Organic acids are naturally occurring products of digestion in the ruminant and supply 40 to 75 percent of the energy used by the animal. They have been used to preserve foods for human consumption for centuries. Presently, they are being used as preservatives for feed grains. Theoretically, organic acids impose a static condition on the grain by preventing seed germination and respiration and inhibiting mold growth. Research has shown an improvement in feed utilization for high-moisture grains as compared to dry grains when fed in beef cattle finishing rations. Previous methods for storing and processing high-moisture grains have been artificial drying and ensiling. Disadvantages to these methods, in regard to beef cattle performance, have been indicated in previous research. Artificially dried grain may have a lower nutritive value and digestibility than grain not artificially dried. The ensiling process, per se, requires microbial fermentation which results in heat production and energy loss.

This research was designed to observe the effects of organic acids on storage and preservation of high-moisture milo and to determine the feeding value of the preserved grain for beef cattle and lambs.

LITERATURE REVIEW

Dietary Uses of Organic Acids

Since organic acids are major energy sources in ruminant metabolism, their addition to ruminant diets was investigated utilizing both the free volatile fatty acids (VFA's) and their salts. Bentley et al. (1956), Matrone, Ramsey, and Wise (1957) and Essig, Hatfield, and Johnson (1959) indicated salts of VFA's could be utilized as energy sources by sheep. Different ratios of salts of VFA's were shown to have little effect on average daily gain in lambs. Essig, Garrigus, and Johnson (1962) reported a depression in feed consumption and reduction in average daily gain by lambs as the percent VFA's in the diet was increased. Levels of VFA's fed were 24, 30, 36 and 42%; VFA's were supplied as both salts and free acids. Rook et al. (1963) found that by infusing VFA's into the rumen, consumption of hay by beef cows was depressed. Similar results were noted by Montgomery, Schultz and Baumgardt (1963) with dairy cows and Ulyatt (1965) with sheep.

Pieterse and De Waal (1966) found that addition of VFA's at 3.7% of the diet increased dry matter intake in steers fed a high grain diet. The authors noted that levels of VFA mixtures above 5% of the total ration generally depressed feed intake.

Senel and Owen (1966) fed dairy heifers two levels of sodium acetate, 3.0 and 7.0%, which yielded 1.5 and 2.8% acetic acid, respectively. This corresponds to acetic acid levels commonly found in corn silage and high-moisture legume silage. Rations containing the high level of acetate resulted in 34% greater weight gain and 18% less dry matter required per pound of gain as compared to the control ration, but these responses were not statistically significant. In a subsequent study, Senel and Owen (1967) reported that voluntary dry matter intake of five dairy cows was not affected by 2% acetic acid, 1% butyric acid, or a combination of these acids added to a hay-concentrate diet. However, a mixture of 4% acetic and 2% butyric acids caused reduced dry matter intake and nasal irritation.

Dinus, Hill and Noller (1968) added five levels of acetic acid (0, 1.5, 3.0, 4.5 and 6.0%) to green corn forage and corn silage rations. Forage dry matter intake of dairy heifers was decreased by the addition of acetate to the control ration, but only the 6.0% level was significantly lower. Caloric intake was not influenced by the addition of acetic acid; as the energy supplied by acetate increased, there was a reduction in forage energy intake.

Marion et al. (1972) fed acetic and propionic acids in beef cattle rations to determine levels of tolerance to the acids. Steers receiving 0, 4, 6% acetic acid gained 1.31, 1.40 and 1.18 kg/hd daily, respectively, while those fed propionic acid at comparable levels gained 1.31, 1.35 and 1.14 kg/hd daily, respectively. Daily gains were significantly higher for animals fed 4% acetic acid and significantly lower for animals fed 6% level of both acetic and propionic acids. Feed intake was significantly depressed at the 6% level of both acids.

McCullough, Sisk, and Smart (1969), added sodium salts of acetic and propionic acids to a high silage ration for dairy cows to parallel the effects of producing a corn silage with increased percentages of lactic or acetic acids. Rations contained 65% corn silage and 35% concentrate mixture, plus 600 g of either sodium acetate or sodium propionate per cow daily. Sodium acetate significantly increased total and 4% fat corrected milk production and resulted in small but non-significant increase in milk fat total solids. Sodium propionate decreased milk fat and increased solids-non-fat, but did not affect total milk production.

Armstrong and Blaxter (1957a), Armstrong and Blaxter (1957b), Armstrong, Blaxter and Graham (1957), and Armstrong et al. (1958) studied the efficiency of VFA utilization in fasting, maintenance, and fattening sheep. When acids were administered individually, acetic acid had a much higher heat increment than either propionic or N-butyric acids. VFA's were utilized with equal efficiency when mixtures containing various proportions of VFA's were fed for maintenance. Also, in fattening sheep it appeared that acetic acid was utilized less efficiently than either propionic or butyric acids. However, Orskov and Allen (1966), and Orskov, Hovell and Allen (1966) reported no apparent differences in utilization of acetate, propionate, or butyrate in the promotion of body weight gain. They concluded that the energy of the VFA's was utilized with an efficiency equal to the calculated metabolizable energy of concentrates.

In summary, short chain volatile fatty acids are utilized as energy sources and are an integral part of the metabolic pathways in the ruminant animal. When fed at low levels in the diet, beneficial results have been obtained in terms of animal performance.

Utilization of High-Moisture Milo by Beef Cattle

Cattle feeders have fed high-moisture grain periodically over the past 70 years. Kennedy et al. (1904) observed that 35% moisture corn was equal to mature corn for finishing steers. During the 1930's storage of high-moisture milo was tried in Texas. Whole milo at 38 and 48% moisture was stored in trench silos. High spoilage losses together with slow rate of gain and poor feed utilization in beef cattle led to the conclusion that high-moisture milo could not be stored and fed satisfactorily from trench silos.

In the past several years milo has become a basic energy source for finishing cattle. New methods of handling, processing, storing, and feeding milo have been researched and the use of high-moisture milo has been reconsidered.

Two methods for obtaining high-moisture milo are early field harvesting or reconstituting. Reconstituted grain is prepared by adding water to air-dry grain to increase its moisture content. Laboratory evaluations by Hale et al. (1969) indicated optimum conditions for reconstituting milo to be 26 to 30% moisture, a temperature of 38°C and a storage time of at least 21 days. Cattle feeders and university research stations have demonstrated that field harvested, high-moisture milo and reconstituted milo can both be stored in oxygen-limiting, conventional upright, trench or bunker silos with only minimum spoilage.

It has been well established that whole milo must be processed in some manner for efficient utilization by beef cattle. Berry (1970) stated that although dry grinding is the simplest and least expensive processing method for milo, it does not produce optimum rate and efficiency of gain. White et al. (1969a) observed that finely rolled high-moisture milo was used more efficiently by beef cattle than either coarsely rolled and finely ground high-moisture milo or finely ground and very finely ground dry milo. The authors also noted that whole milo was not well utilized by cattle.

Riggs and McGinty (1970), in one of seven trials, compared ground and whole wet milo for finishing cattle. Animals fed whole kernel milo failed to make satisfactory gain and feed efficiency was poor. Grinding the milo increased daily gain by 11% and decreased grain dry matter required per unit of gain by 37% when compared to the whole milo ration. In subsequent trials, the authors compared ground or rolled and dry or wet (both field harvested and reconstituted) milo, in finishing cattle rations. Field harvested, wet milo ranged from 23% to 32% moisture. Reconstituted grain averaged 11.3, 10.3, and 9.7% moisture prior to reconstitution and 29.7, 25.6 and 30.2% after reconstitution. Dry grain was harvested at 14 to 16% moisture and dried to 13% moisture or less by aeration. Animals fed wet milo required less dry matter per unit of gain that those fed dry milo. This reduction, calculated as a percent of the requirement for cattle fed dry milo, ranged from 11 to 26%. Dry matter intake was slightly less for cattle fed the wet milo rations as compared to those fed the dry milo rations.

In two trials, Hale et al. (1969) found average daily gain 23% greater and feed requirements 14% lower for steers fed reconstituted milo as compared to steers fed dry milo.

In order to study the influence of storage time and moisture level on the feeding value of whole, reconstituted milo, Wagner, Christiansen and Holloway (1971) compared five methods of processing milo in high concentrate rations for finishing heifers. They concluded that storage time at 20 days or longer was necessary for obtaining maximum benefit from reconstitution of milo at 30% moisture, and increased moisture levels decrease the fermentation time required. However, White and Totusek (1969) indicated that no advantage was gained by raising the moisture level of reconstituted milo to 38%. The authors observed also that the storage time of one day for reconstituted milo is not sufficient to improve utilization by beef cattle.

To gain maximum benefits from reconstitution Penic et al. (1968), White et al. (1969b) and Martin et al. (1970) indicated that milo must be stored whole after reconstitution. Data reported by Schake et al. (1969) does not support this conclusion. These authors compared steam flaked milo, reconstituted whole milo (stored two weeks before being rolled prior to feeding) and reconstituted rolled milo (stored two weeks prior to feeding). Differences in gain between steers fed the two reconstituted rations were not significant.

Brethour and Duitsman (1970) compared field harvested, high-moisture milo, which was rolled and packed into a small concrete trench and reconstituted milo, which was rolled and packed into an identical trench. Both milos were 30% moisture at storage time. Rates of gain (lb) and feed conversions (lb) were 3.09, 8.31 and 3.18, 7.90, respectively for field harvested high-moisture milo and rolled, reconstituted milo.

Sullins, Rooney, and Riggs (1971) investigating the physical changes occurring in the milo kernel during reconstitution, concluded that an actual breakdown occurs within the kernel during the reconstitution process. Microscopic analysis indicated that the structure of the endosperm of reconstituted grain was modified, which aided in the rupture of the protein matrix and the release of free starch granules. The authors indicated that the probable cause for the modifications is enzymatic hydrolysis of protein, starch, and other carbohydrates that occurs during the high-moisture storage of milo in the whole form. Also the rolling or grinding of reconstituted milo prior to feeding causes a more complete breakdown of the endosperm which would account for part of the increased feed efficiency of reconstituted milo.

Research has demonstrated that high-moisture milo, either reconstituted or high-moisture harvested, is utilized more efficiently by beef cattle than dry milo. Generally a 10 percent or greater increase in feed efficiency due to high-moisture processing is not uncommon.

EXPERIMENTAL PROCEDURES AND RESULTS

Statistical analyses of the data were by the least squares method of analyses described by Harvey (1960). Where statistical significance was revealed Duncan's New Multiple Range Test was used to determine significant differences (Steele and Torrie, 1960).

Influence of Organic Acids Upon Preservation of High-Moisture Milo and Animal Performance.

Animal Performance Trial I.

One hundred yearling steers of Angus, Hereford and Hereford-Angus breeding, weighing an average of 370 kg, were used in this trial. Seventy-five steers were randomly allotted by breed and weight to 15 pens of five steers each. Twenty-five steers were randomly allotted by breed and weight to individual pens. Three group-fed pens and five individually-fed pens were randomly assigned to each of the five treatments. Initial and final weights were determined by weighing the animals full on two consecutive days. Twenty-eight day weighings monitored the steers progress during the 112 day trial (June 30, 1971 to October 20, 1971). Final live weights were adjusted to a 60.9% dress and performance was calculated on that basis. Prior to the trial each steer was implanted with 30 mg of diethylstilbestrol. Group-fed steers were confined to unsheltered concrete pens and individually-fed steers were housed in partially sheltered concrete pens.

The five experimental rations contained the following milo treatments: (1) steam flaked; (2) reconstituted and stored whole in an oxygen-limiting silo; (3) reconstituted, acid-treated and stored whole in a concrete stave silo; (4) reconstituted, acid-treated and stored whole in a metal grain bin; (5) reconstituted, rolled and stored in a concrete stave silo. Full feed rations contained 81% of the appropriate milo, 15% corn silage, and 4% supplement on a dry matter basis. Composition of the supplement is shown in Table 1. The supplement provided each ration with equal amounts of crude protein, vitamins, minerals and additives. Urea supplied 56.6% of the crude protein equivalent in the supplement. All rations were mixed and fed twice daily. A 14 day feed adjustment period accustomed the steers to the full feed rations. The starting ration contained 68% milo, 27% corn silage and 5% supplement. The milo fraction was increased and the corn silage fraction decreased until the full feed ration was attained.

All grain treatments were prepared from the same source of elevator-run red milo averaging 15.2% moisture. Approximately 108 metric tons were divided into five equal lots. Lot 1 was steam flaked by exposing dry milo to live steam for approximately 40 minutes at 98.8°C under atmospheric pressure. The grain was rolled between two steel corrugated rollers set at zero tolerance. Lots 2-5 were reconstituted to 29.5% moisture. Lots 3 and 4 were treated with an organic acid mixture (60% acetic and 40% propionic acids) applied at 14.2 kg/metric ton of reconstituted grain. Lot 3 was stored whole in a concrete stave silo; lot 4 was stored in upright, hopper-bottomed metal bins. Organic acids were applied as a spray to the grain as it passed through an auger. Lot 5 was coarsely rolled and packed into a concrete stave silo. Lot 2 was stored whole in an oxygen-limiting silo. Milo stored whole was coarsely rolled prior to feeding.

Performance data of the group-fed steers and individually-fed steers were pooled and are presented in Table 2. There were no signifi-

Table 1. Composition of the Supplement Fed in Animal Performance Trial 1.

Ingredient	% (Dry matter basis)
Rolled milo	10.9
Soybean meal	45.5
Urea	10.7
Salt	12.5
Limestone	18.4
Trace minerals	0.5
Vitamin A[a]	0.7
Chlortetracycline[b]	0.8

[a]Formulated to supply 30,000 IU per steer per day.

[b]Formulated to supply 70 mg per steer per day.

Table 2. Steer Feedlot Performance for Animal Performance Trial 1.

	Ration No. and Treatment				
	1	2	3	4	5
		Reconstituted Milo			
Item	Steam flaked milo	Ensiled-whole	Or. acid stave silo	Or. acid metal bins	Ensiled-rolled
No. steers	20	20	20	20	20
Initial wt., kg	365.2	381.6	373.2	366.1	368.9
Final wt., kg[a]	512.4	532.8	525.3	532.2	507.9
Avg. daily gain, kg	1.32	1.49	1.39	1.42	1.27
Avg. daily feed, kg[b]	8.21	9.56	9.40	9.72	9.00
Feed/kg gain, kg	6.13	6.36	6.89	7.05	7.05
Dressing %	60.2	60.4	61.1	61.7	60.5
Yield Grade[c]	3.16	3.54	3.41	3.74	3.52

[a] Adjusted to 60.9% dress.

[b] Dry matter basis.

[c] 2.50 + (2.5 x adj. fat thick) + (0.2 x % K.K.) + (0.0038 x hot car. wt) - (0.32 x L.E.A.).

cant differences in average daily gain among steers fed rations 1 through 4; however, steers fed ration 2 (ensiled-whole) gained faster ($P<.05$) than steers fed ration 5 (ensiled-rolled). Feed consumption was lowest for steers receiving the steam flaked milo ration compared to those receiving the other four rations, but this was not a significant decrease. Animals fed the acid-treated milo rations tended to consume more feed, require more feed per kg of gain and dress higher than steers fed the other three rations. Steers fed ration 4 (acid-bin) dressed higher ($P<.05$) than steers fed ration 1 (steam flaked). Yield grade was not affected by milo treatment.

Animal Performance Trial II.

Sixty steers of Hereford and Angus breeding weighing an average of 317 kg were randomly allotted by breed and weight to 12 pens of five steers each. Three pens were randomly allotted to each of four treatments. Weighing procedures, pen facilities, ration adjustment, and implantations of the steers were similar to animal performance trial I. Steers were fed 104 days (April 6, 1972 to July 19, 1972). Final live weights were adjusted to a 59.95% dress and animal performance was calculated on that basis.

The four experimental rations contained the following milo treatments: (1) 14% moisture, untreated; (2) 14% moisture, acid-treated; (3) 24% moisture, ensiled; (4) 24% moisture, acid-treated. Full feed rations contained 82% of the appropriate milo, 13% sorghum silage, and 5% supplement on a dry matter basis. Composition of the supplement is shown in Table 3. The supplement was formulated to supply each ration with equal amounts of crude protein, vitamins, minerals, and feed additives. Urea supplied 60.90% of the crude protein equivalent in the supplement. All rations were mixed and fed twice daily.

All grain was harvested from one source at approximately 24% moisture and divided into four, 27 metric ton, lots. Lots 1 and 2 were dried to a 14% moisture with an artificial grain dryer. Lot 1 was stored in a metal bin; lot 2 was treated with an organic acid mixture (60% acetic and 40% propionic acids) at 1.4% by weight and stored in an unlined concrete bin; lot 3 was stored whole in an oxygen-limiting silo; and lot 4 was treated and stored similarly to lot 2. All grain was rolled prior to being mixed into the rations.

Performance of the steers is shown in Table 4. Steers receiving

Table 3. Composition of the Supplement Fed in Animal Performance Trial II.

Ingredient	% (Dry matter basis)
Soybean meal	56.75
Urea	15.15
Dicalcium phosphate	3.85
Limestone	14.20
Salt	7.50
Fat	1.00
Trace minerals	0.40
Chlortetracycline[a]	0.88
Vitamin A[b]	0.28

[a] Formulated to supply 70 mg per steer per day.

[b] Formulated to supply 30,000 IU per steer per day.

Table 4. Steer Feedlot Performance for Animal Performance Trial II.

Item	Ration No. and Treatment			
	1	2	3	4
	14% milo	14% milo +organic acid	24% milo, ensiled	24% milo +organic acid
No. steers	15	15	15	15
Initial wt., kg.	319.6	314.7	319.6	316.5
Final wt., kg[a]	453.0	447.4	459.7	455.7
Avg. daily gain, kg	1.28	1.28	1.36	1.34
Avg. daily feed, kg[b]	9.85	10.45	9.44	9.87
Feed/kg gain, kg	7.75	8.16	6.94	7.38
Dressing	59.1	59.3	60.0	61.0
Yield grade[c]	2.33	2.34	2.40	2.80

[a] Adjusted to 59.95% dress.

[b] Dry matter basis

[c] 2.50 + (2.5 x adj. fat thick.) + (0.2 x % K.K.) + (.0038 x hot car. wt) - (0.32 x L.E.A.).

high-moisture milo, rations 3 and 4, gained faster ($P<.10$), consumed less feed ($P<.01$), required less feed per kg of gain ($P<.01$), and dressed higher ($P<.01$) than steers fed dry milo, rations 1 and 2. Moisture content of the milo did not affect carcass yield grade. Steers fed the acid-treated milo, rations 2 and 4, consumed more feed ($P<.01$) and required more feed per kg of gain ($P<.10$) than steers fed untreated milo, rations 1 and 3. Average daily gain, dressing percent and yield grade were not influenced by acid treatment.

Animal Performance Trial III.

Thirty-two wether lambs weighing 37 kg were randomly allotted by weight to eight pens of four lambs each. Two pens were randomly assigned to each of the four treatments. Feed and water were withdrawn approximately 15 hours prior to the initial and final weighings. Fourteen-day full weighings monitored the progress of the lambs during the 59 day trial (March 11, 1972 to May 8, 1972). Final live weights were adjusted to a 51.05% dress and animal performance was calculated on that basis. Lambs were fed in partially sheltered lots. Each lamb received a 2 mg implant of diethylstilbestrol prior to the start of trial.

Milo treatments used were previously described in animal performance trial 2. Lambs received a ration of 50% of the appropriate milo, 45% sorghum silage, and 5% supplement at the start of the trial. Milo was substituted for silage until the lambs were on full feed after 14 days. Final rations were 82% milo, 13% sorghum silage, and 5% supplement on a dry matter basis. Composition of the supplement is shown in Table 5. The supplement provided each ration with equal amounts of crude protein, vitamins, minerals, and additives. Urea supplied 85.1% of the crude protein equivalent in the supplement. All rations were mixed and fed twice daily.

Performance of the lambs is shown in Table 6. Lambs fed high-moisture milo, rations 3 and 4, gained faster ($P<.05$), consumed more feed ($P<.10$) and required less feed per kg of gain ($P<.10$) than lambs fed dry milo, rations 1 and 2. Lambs receiving acid-treated milo, rations 2 and 4, gained faster ($P<.10$) than lambs receiving untreated milo, rations 1 and 3. A milo x acid interaction ($P<.05$) was observed for daily feed consumption. Acid-treated dry milo was consumed in greater amounts than untreated dry milo;

Table 5. Composition of Supplement Fed in Animal Performance Trial III.

Ingredient	% (Dry matter basis)
Ground milo	47.3
Urea	14.2
Dicalcium phosphate	18.0
Dehydrated alfalfa	10.0
Fat	2.0
Salt	6.0
Trace minerals	1.0
Chlortetracycline[a]	1.2
Vitamin A[b]	0.4
Vitamin D[c]	0.025

[a] Formulated to supply 12 mg. per lamb per day.

[b] Formulated to supply 3,000 IU per lamb per day.

[c] Formulated to supply 300 IU per lamb per day.

Table 6. Lamb Feedlot Performance for Animal Performance Trial III.

	Ration No. and Treatment			
	1	2	3	4
Item	14% milo	14% milo +organic acid	24% milo, ensiled	24% milo +organic acid
No. lambs	7[d]	8	8	6[e]
Initial wt., kg	38.1	36.3	36.8	37.2
Final wt., kg[a]	48.6	47.2	48.4	50.7
Avg. daily gain, kg	0.174	0.186	0.197	0.229
Avg. daily feed, kg[b]	1.20	1.28	1.28	1.26
Feed/kg gain, kg	6.32	6.83	6.29	5.29
Dressing %	50.55	52.69	51.77	51.37
Yield grade[c]	2.50	2.50	2.52	2.60

[a] Adjusted to 51.05% dress.

[b] Dry matter basis.

[c] 1.6623+ 6.6640 (adj. rib probe) - 0.0517 (leg conform. score)+ .25 (% Kid Knob).

[d] One lamb removed from the trial for failure to come to the ration.

[e] One lamb died from urinary calculi; one lamb died from an undetermined cause.

however, addition of acid to high-moisture milo depressed feed intake slightly compared to untreated high-moisture milo. There were no significant differences among treatments in dressing percent of yield grade.

DISCUSSION

Spoilage occurred in both the reconstituted, acid-treated milo and the field harvested, high-moisture, acid-treated milo. Deterioration was characterized by heating, molding and clumping of the grain. Large mite populations were also observed. Spoilage first appeared along the walls of the storage structures after the grain had been stored for approximately two and a half months. In the concrete stave silo, deterioration was generally limited to a 10 to 15 cm layer adjacent to the wall (photograph A). Spoilage in the metal bins was more extensive and considerable scaling and rusting was noted after the acid-treated milo was removed.

In the field harvested, high-moisture, acid-treated milo, spoilage loss was estimated to be 15-20% (photograph B). The undamaged milo was removed from the bin, cooled, retreated with a 0.5% organic acid mixture and transferred to a concrete bin which had been lined with polyethylene sheeting. This retreated grain was stored free of spoilage until the completion of trials 2 and 3.

Results from other studies indicate that storage bins must be either coated with an anti-corrosive paint or lined with plastic, if acid-treated grains are to be preserved without spoilage (Miller et al., 1972; Nelson et al., 1972 and Tolman and Guyer, 1973).

In animal performance trial I, steam flaking tended to depress ration dry matter intake without adversely affecting feed efficiency. Yauk, Drake and Schalles (1971) observed no significant differences in dry matter intake and feed efficiency between steers fed reconstituted milo, stored whole and rolled prior to feeding and steers fed from flaked milo that was processed

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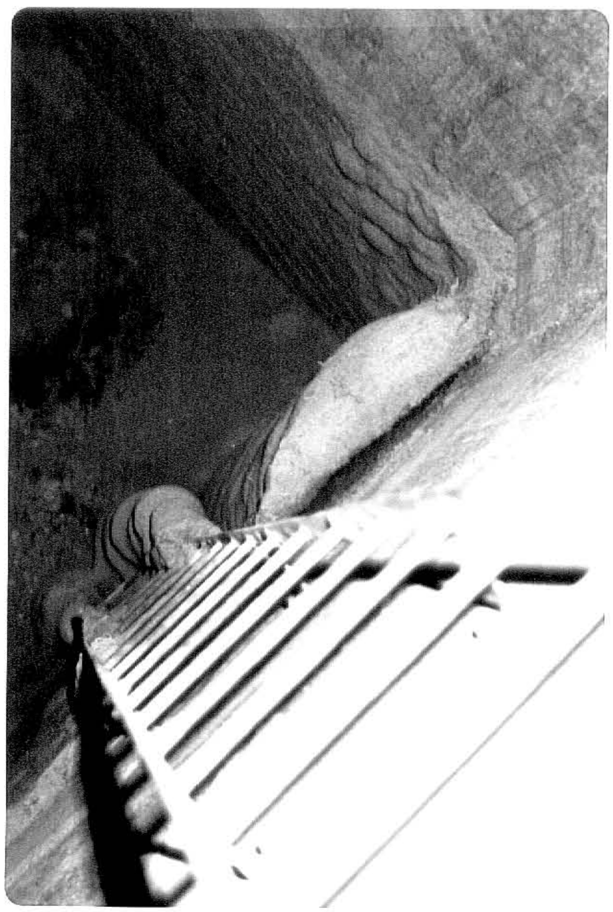
Photograph A: Spoilage in the Concrete Stave Silo Containing Reconstituted, Acid-Treated Milo.

Photograph B: Spoilage in the Concrete Bin Containing Field Harvested, High-Moisture, Acid-Treated Milo.



daily. In trial I reported here, milo was flaked weekly and stored for one to six days prior to feeding. Storing the flakes for this length of time apparently reduced acceptability of the milo.

In trial I, relatively poor performance was observed in animals fed reconstituted milo rolled prior to storage compared to those fed reconstituted milo stored whole. These results agree with data reported by the Oklahoma station. White et al. (1969b) reported that steers receiving reconstituted milo stored whole gained faster and required 12% less feed per pound of gain than steers receiving reconstituted milo ground prior to storage. Martin et al. (1970) found that milo reconstituted whole was utilized 18% more efficiently by beef cattle than milo which had been ground before reconstitution.

In trials I and II, steers fed high-moisture, acid-treated milo required more feed per kg of gain than those fed high-moisture milo stored in an oxygen-limiting silo. This agrees with results obtained by Tolman and Guyer (1973) (Table 7). These authors also observed that animals fed high-moisture corn stored in an oxygen-limiting silo gained faster than animals fed high-moisture, acid-treated corn. However, in trials I and II reported here, steers receiving high-moisture, acid-treated milo consumed more ration dry matter and, thus, their rate of gain was equal to that of steers receiving high-moisture milo stored in an oxygen-limiting silo. Results of Wilson et al. (1972) showed that steers fed a 1.2% organic acid-treated, high-moisture corn performed similarly to steers fed high-moisture corn stored in an oxygen-limiting silo. Average daily gain (lb) and feed requirement per lb. at gain (lb) were 2.93, 5.12 for cattle fed the acid-treated corn and 2.91, 5.09 for cattle fed the ensiled corn.

In trials II and III, animals fed acid-treated dry milo consumed more ration dry matter and were less efficient than animals fed untreated dry

Table 7. Performance of Beef Cattle Fed Acid-Treated, High-Moisture Corn.[a]

	Corn treatment			
	Acid-treated		Oxygen-limiting silo	
	Fed whole	Fed rolled	Fed whole	Fed rolled
	Trial I (heifers)			
Av. daily gain, lb.	1.94	1.86	2.15	2.04
Feed/lb: gain, lb.	10.2	10.0	8.7	9.1
	Trial II (steers)			
Av. daily gain, lb.	3.24	2.85	3.26	3.05
Feed/lb. gain, lb.	6.2	6.8	6.2	6.2

[a] Tolman and Guyer (1973)

milo. In contrast, Tolman and Guyer (1973) and Wilson et al. (1972) reported that animal performance was not influenced by the addition of 1.2% organic acids to dry corn.

In trial II, performance of steers fed high-moisture milo was greater than that of steers fed dry milo. These results agree with Parrett and Riggs (1967), White et al. (1969a) and Riggs and McGinty (1970).

In general, results of trial III agreed with those obtained in trial II with two major exceptions. First, lambs fed acid-treated milo gained faster than lambs fed untreated milo. Second, lambs receiving high-moisture, acid-treated milo were more efficient than lambs receiving high-moisture milo stored in an oxygen-limiting silo. These inconsistencies were probably due to the small number of animal observations obtained in the lamb trial.

In trials I and II, steers fed high-moisture acid-treated milo rations had a higher dressing percentage than steers fed the other rations. It is not known whether this observation is consistent with previous reports in the literature.

Results reported in this thesis support two general conclusions. First, high-moisture ensiled milo is utilized more efficiently by ruminants than dry rolled milo. Second, the feeding value of organic acid preserved high-moisture milo is equal to that of high-moisture, ensiled milo and superior to that of dry rolled milo.

SUMMARY

Three finishing trials, two with steers and one with lambs, were conducted to determine the feeding value of reconstituted and/or field harvested high-moisture milo preserved with an organic acid mixture (60% acetic and 40% propionic acids).

In trial I, three pens of five steers and five individually-fed steers were randomly assigned to each of five milo treatments: (1) steam-flaked; (2) reconstituted and stored whole in an oxygen-limiting silo; (3) reconstituted, acid-treated and stored whole in a concrete silo; (4) same as treatment 3, but stored in a metal bin and; (5) reconstituted, rolled and stored in a concrete silo. The organic acid mixture was applied at 14.2 kg per metric ton weight of milo. Ration composition was 81% milo, 15% corn silage, and 4% supplement on a dry matter basis. Average weight of the steers was 368 kg at the start of the 112 day trial. Average daily gain (kg), dry matter intake (kg) and kg feed/kg gain for the five milo treatments were: (1) 1.32, 8.21, 6.13; (2) 1.49, 9.56, 6.36; (3) 1.39, 9.40, 6.89; (4) 1.42, 9.72, 7.05: (5) 1.27, 9.00, 7.05. There were no significant differences in average daily gain among steers fed rations 1 through 4; however, steers fed ration 2 gained faster ($P < .05$) than steers fed ration 5. Animals fed acid-treated milo rations tended to consume more feed, require more feed per kg of gain and dress higher than those fed the other three rations.

In trial II, sixty yearling steers averaging 317 kg were randomly assigned to four milo treatments: (1) artificially dried; (2) artificially dried, acid-treated; (3) high-moisture, ensiled and (4) high-moisture, acid-treated. Dry and high-moisture milo contained 14 and 24% moisture, respec-

tively. Milo in treatments 1, 2 and 4 was stored in concrete bins; milo in treatment 3 was ensiled whole in an oxygen-limiting silo. Application rates of the organic acids were the same as trial I. Full feed ration composition for the 104 day trial was 82% milo, 13% sorghum silage and 5% supplement on a dry matter basis. Average daily gain (kg), dry matter intake (kg) and kg feed/kg gain for the four milo treatments were: (1) 1.28, 9.85, 7.75; (2) 1.28, 10.45, 8.16; (3) 1.36, 9.44, 6.94; (4) 1.34, 9.87, 7.38. Steers fed high-moisture milo, rations 3 and 4, gained faster ($P<.10$), consumed less feed ($P<.01$), were more efficient ($P<.01$) and dressed higher ($P<.01$) than steers fed dry milo, rations 1 and 2. Steers fed acid-treated milo rations 2 and 4, consumed more feed ($P<.01$) and were less efficient ($P<.10$) than steers fed untreated milo, rations 1 and 3. Percent dress, carcass quality and yield grades were not influenced by milo treatment.

In trial III, 32 wether lambs weighing 37 kg were randomly allotted to eight pens of four lambs each. Two pens were assigned to each of the four treatments and rations as previously described in trial II. Average daily gain (kg), dry matter intake (kg), and kg feed/kg of gain for the four milo treatments were: (1) 0.174, 1.20, 6.32; (2) 0.186, 1.28, 6.83; (3) 0.197, 1.28, 6.29; (4) 0.229, 1.26, 5.29. Lambs fed high-moisture milo, rations 3 and 4, gained faster ($P<.05$), consumed more feed ($P<.10$), and required less feed per kg of gain ($P<.10$) than lambs fed dry milo, rations 1 and 2. Lambs receiving acid-treated milo, rations 2 and 4, gained faster ($P<.10$) than lambs receiving untreated milo, rations 1 and 3. A milo x acid interaction ($P<.05$) was observed for daily feed consumption. Acid treated dry milo was consumed in greater amounts than untreated dry milo; however, addition of acid to high-moisture milo depressed feed intake slightly compared to untreated high-moisture milo. There were no significant differences among treatments in dressing percent or yield grade.

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APPENDIX

Table 1. Analysis of Variance for Animal Performance Trial I

Source of variation	D.F.	Mean square: Avg. daily gain	Mean square: Avg. daily feed	Mean square: Feed per unit gain	Mean square: Dress %	Mean square: Yield grade
Ration	4	2.691[a]	2.661	2.188	5.198[a]	0.681
Way fed	1	0.314	39.031	0.237	0.001	0.316
Ration & way fed	4	0.205	6.107	0.119	1.002	0.241
	1					
Start wt.	1	3.282	9.709	1.778	14.794	3.219
Residual	29	1.072	4.305	1.752	2.340	1.143
Total	39					

[a](P .05)

Table 2. Analysis of Variance for Animal Performance Trial II

			Mean square		
Source of variation	D.F.	Avg. daily gain	Avg. daily feed	Feed per unit gain	Dress %
Milo	1	0.076[a]	3.523[b]	1.927[b]	7.523[b]
Acid	1	0.004	6.648[b]	0.477[a]	0.148
Milo x acid	1	0.012	0.556	0.0003	0.615
Start wt.	1	0.182	5.340	0.099	0.078
Residual	4	0.023	0.242	0.111	0.520
Total	11				

[a] (P .10)

[b] (P .01)

Table 3. Analysis of Variance for Animal Performance Trial III

			Mean square		
Source of variation	D.F.	Avg. daily gain	Avg. daily feed	Feed per unit gain	Dress %
Milo	1	0.011[b]	0.025[a]	1.175[a]	0.937
Acid	1	0.005[a]	0.061	0.086	1.589
Milo x acid	1	0.0001	0.095[b]	0.602	1.245
Start wt.	1	0.0006	0.084	0.080	3.238
Residual	3	0.0006	0.005	0.204	1.013
Total	7				

[a](P .10)

[b](P .05)

INFLUENCE OF ORGANIC ACIDS ON PRESERVATION OF HIGH-MOISTURE MILO AND ANIMAL PERFORMANCE

by

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ABSTRACT

Three finishing trials, two with steers and one with lambs, were conducted to determine the feeding value of reconstituted and/or field harvested high-moisture milo preserved with an organic acid mixture (60% acetic and 40% propionic acids).

In trial I, three pens of five steers and five individually-fed steers were randomly assigned to each of five milo treatments: (1) steam flaked; (2) reconstituted and stored whole in an oxygen-limiting silo; (3) reconstituted, acid-treated and stored whole in a concrete silo; (4) same as treatment 3, but stored in a metal bin and; (5) reconstituted, rolled and stored in a concrete silo. The organic acid mixture was applied at 14.2 kg per metric ton weight of milo. Ration composition was 81% milo, 15% corn silage, and 4% supplement on a dry matter basis. Average weight of the steers was 368 kg at the start of the 112 day trial. Average daily gain (kg), dry matter intake (kg) and kg feed/kg gain for the five milo treatments were: (1) 1.32, 8.21, 6.13; (2) 1.49, 9.56, 6.36; (3) 1.39, 9.40, 6.89; (4) 1.42, 9.72, 7.05; (5) 1.27, 9.00, 7.05. There were no significant differences in average daily gain among steers fed rations 1 through 4; however, steers fed ration 2 gained faster ($P<.05$) than steers fed ration 5. Animals fed acid-treated milo rations tended to consume more feed, require more feed per kg of gain and dress higher than those fed the other three rations.

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