THE EFFECT OF MILO PROCESSING METHOD AND TYPE OF GRAIN ON VFA PRODUCTION AND FEEDLOT PERFORMANCE

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INTRODUCTION

The production of short chained fatty acids from the fermentation of feedstuff in rumen fluid was first reported in 1883. The true nutritional significance of this was not appreciated until English workers during the 1940's demonstrated that these VFA's (volatile fatty acids) were absorbed from the rumen and metabolized in the liver or other tissues.

Additional investigations indicated that acetic acid was metabolized less efficiently than propionic and butyric acids. This gave rise to much research dealing with the comparison of VFA production of various rations. Some workers reported that the VFA production was associated with the efficiency of production of a ration. Much of this early work was done with dairy cattle and most of the rations comparisons involved concentrate to roughage ratios. Some workers reported on comparisons of ration processing methods or comparisons of grains in conventional fattening rations.

Milo processing methods have drawn considerable attention and several possible reasons have been given for differences in feed efficiency observed between processing methods. The possibility of a cause and effect relationship has been discussed by several workers for VFA production and feed efficiency.

Two experiments were conducted to evaluate several processing methods of milo for fattening cattle. Evaluation was based on feedlot performance and VFA production. A third trial compared the feedlot performance and VFA production of wheat, milo and a milo-wheat combination. Another trial was conducted to evaluate the VFA production of oats, barley, milo and corn.

REVIEW OF LITERATURE

Effect of Ration Composition

Phillipson (1952) reported that diets containing high proportions of flaked maize (corn) fed to eight fistulated lambs produced high and sustained concentrations of lactic acid, a very low acetic:propionic acid (A/P) ratio, and a low pH. The low acetic:propionic acid ratio was caused by the high proportion of the total VFA's (volatile fatty acids) represented by propionic acid. Balch and Rowland (1957) reported similar findings when a diet high in flaked maize (corn) was fed to dairy cows.

Jorgenson et al. (1965) compared pelleted corn and pelleted oats in a 75% concentrate ration fed to dairy cows for 56 days. There were no significant differences in average molar percentages of any VFA's for the entire period, but pelleted oats did maintain a wider acetic:propionic acid ratio than pelleted corn (2.29:1 compared to 1.79:1) during the last 28 days. Corn produced a significantly ($P<.05$) higher concentration of VFA's than oats. Jorgenson and Schultz (1965) compared concentrate to roughage ratios of 3:1, 3½:1 and 4:1 for dairy cows. The concentrates fed were pelleted corn, ground corn, corn and cob meal and pelleted oats. They reported that the type of concentrate had a greater effect on rumen VFA changes than the concentrate:roughage ratio. Parrott et al. (1968) reported that the acetic:propionic acid ratio was considerably narrowed for steers when the concentrate level was 80% or higher in a steam process-flaked milo ration, but that above the 80% concentrate level the acetic:propionic ratio remained unchanged. In a similar trial they found no significant change in the acetic:propionic ratio when the concentrates made up over 75% of the ration.

Oltjen et al. (1966) compared ruminal data from steers fed ad libitum, all-concentrate rations containing 90% soft, red, winter wheat or 90% corn or 60:30 combinations of each grain and reported that the steers on the high wheat-containing rations had significantly higher total concentrations of VFA's and significantly lower ruminal pH values than steers on high corn containing rations. In another trial, using two sets of identical twins fed the 90% corn and 90% wheat rations, they obtained biweekly ruminal samples and found no significant VFA difference due to ration, but significance was observed for biweekly sampling differences (across rations) for total concentration of VFA; peak concentrations of VFA appeared after 6 weeks on trial.

Oltjen et al. (1967) reported a significantly greater production of ruminal total VFA's for steers fed all-concentrate rations of barley and wheat compared to rations containing milo and corn when the animals were fed 1% of body weight daily.

Theurer *et al*. (1966) compared the *in vitro* VFA production of milo and barley, both steam process-flaked. They reported that barley produced 9% more total VFA's per gram of dry matter than milo. There was little difference between grains for molar percentages of individual acids. Brown *et al*. (1958) reported that *in vitro* VFA production was similar to *in vivo* VFA production by sheep with hay:concentrate ratios of 4:1, 3:2, 1:3 and 1:4 for both total concentrations and molar percentages of VFA's.

Effect of Physical Form

Shaw *et al*. (1960) reported that grinding and pelleting the hay and flaking the corn produced a marked decrease in molar percentage of rumen acetic acid, an increase in propionic and over a 100% increase in total rumen VFA concentraion. The ration was 50% concentrate and the basal ration contained chopped hay and ground corn. The processing of the hay and corn resulted in a 12% increase in protein digestibility, a 22% increase in body weight gain and a 15.3% increase in efficiency of feed utilization by dairy steers. Thompson *et al*. (1965) reported that there was no difference between flaked corn and ground corn in molar percentages of VFA's produced by steers, but steers fed ground corn produced significantly ($P < .05$) more total VFA's than the steers fed flaked corn. Oltjen and Davis (1965) reported no significant difference between pelleted corn and cracked corn in any VFA concentrations when all concentrate rations were fed to steers. Clanton and Woods (1966) reported no significant difference in molar percent or total concentration of VFA's when rumen samples were taken once from all steers fed rations consisting of either different pelleted alfalfa-to-cracked corn ratios (100:0 to 25:75) or coarsely ground alfalfa hay fed with either cracked or pelleted corn and pelleted alfalfa hay fed with either cracked or pelleted corn at a concentrate:roughage ratio of 75:25. When two animals from each treatment were sampled repeatedly over an 8-hour period, a significant increase in percent ruminal propionic acid was observed when the concentrate:roughage ratio was changed from 0:100 to 75:25. Pelleting corn in the ration did not alter significantly the total concentration or molar percentage of VFA's.

Woods and Luther (1962) compared several methods of processing 67% concentrate corn-containing rations for lambs and found that pelleting the complete ration narrowed the acetic:propionic ratio and that heating the ration had little or no effect on rumen fermentation.

Rhodes and Woods (1962) reported results from four experiments with lambs on 67% concentrate rations comparing the affect of various physical forms of the ration on ruminal VFA's. They observed that pelleting the ration lowered the proportion of acetic acid and raised the proportion of propionic acid as compared to the ground ration. One trial, dealing with the effect of time after feeding on VFA production, suggested that the acetic:propionic acid ratio widens with increased length of time after feeding.

Theurer *et al*. (1966) studied the influence of steam processing and various degrees of flaking of milo and barley on the *in vitro* production of VFA's. The steaming of milo without rolling decreased the total VFA production by 16% compared to untreated milo, but the ratios of the individual acids were not changed. Rolling the steam-processed milo or barley increased the total VFA production by 42% and 40% over the untreated milo and barley, respectively. This increase in VFA production was greater for propionic and butyric acids than for acetic, resulting in a narrow acetic: propionic ratio.

MATERIALS AND METHODS

General

Cattle in four separate feeding trials were sampled for ruminal VFA analysis. Two of the trials were conducted to determine the effect of milo processing method on the feeding value of milo, and a third trial compared wheat, milo and a milo-wheat combination for finishing beef cattle. These three trials were evaluated by feedlot performance and ruminal VFA production. The fourth trial was conducted to determine the effect of four different grains on the ruminal VFA production of beef cattle. Identification of the four trials will be as follows: Trial I - Ft. Reno, 1965-66; Trial II - Stillwater, 1965-66; Trial III - Ft. Reno, 1966-67; Trial IV - Stillwater VFA Trial, 1966.

Discussion of Trials I, II, and III will be limited to feedlot performance and ruminal VFA production. Carcass merit and net energy determinations for these trials were described by Newsom (1968).

Trial I

Trial I, initiated December 6, 1965, was conducted to compare five milo processing methods. After having been fed a standard ration, 54 Hereford steer calves with an average weight of 224 kg. were allotted on the basis of shrunk weight and condition score. The experimental design was a randomized complete block, and calves were randomly assigned to treatments within each block. The calves were blocked into three groups of 18 steers each on the basis of weight. Each grain processing treatment included a total of nine steers, three pens of three calves per pen. Nine calves were fed only the basal ration at a maintenance level. Table I and II show the experimental design. The rations consisted of a basal mix fed with or without milo. The milo was processed as follows: coarsely ground, finely ground, steam process-flaked, reconstituted-rolled and reconstituted-steam process-flaked.

The steers were allowed access to feed and water at all times, but feed was mixed and fed once daily. The basal ration was fed to meet the maintenance energy requirement of the steers. Milo was fed to appetite above maintenance. The maintenance TDN requirement was calculated using the equation derived by Garrett et al. (1959), that is, kg. of TDN for maintenance = 0.065 $W^{.75}$, where W is the weight in kg. of the steer. The kg. of basal required per day for maintenance was obtained by dividing the estimated TDN of the basal ration into the kg. of TDN required for maintenance of the animal. Table III contains the composition of the basal ration, and the proximate analysis of the basal and five types of processed milo is shown in Table IV. The estimated TDN of the basal ration was 56.5%, consequently 0.1152 kg. of basal per kg. $W^{.75}$ per steer per day was

TABLE I

TRIAL I: EXPERIMENTAL DESIGN FOR FEEDLOT PERFORMANCE

		Processed Milo				
Blocks	Basal	Coarsely Ground	Finely Ground	Steam-Pro-cess Flaked	Recon.-Rolled	Recon.-Steam Process-Flaked
1	3	3	3	3	3	3
2	3	3	3	3	3	3
3	3	3	3	3	3	3
	9	9	9	9	9	9
					Total = 54 hd.	

TABLE II

TRIAL I: EXPERIMENTAL DESIGN FOR VFA DATA

	Processed Milo									
	Coarsely Ground		Finely Ground		Steam Process-Flaked		Recon.-Rolled		Recon.-Steam Process-Flaked	
Block	1[a]	2[a]	1[a]	2[a]	1[a]	2[a]	1[a]	2[a]	1[a]	2[a]
1	3[b]	3	3	2	3	3	3	2	3	3
2	2	2	3	2	3	3	3	3	3	3
3	3	3	3	3	3	3	3	3	3	3
	16		16		18		17		17	
					Total samples - 84					

[a]Indicates first (1) or second (2) rumen sample taken from steers.

[b]Indicates number of steers from which rumen samples were obtained and analyzed.

TABLE III

TRIAL I: COMPOSITION OF BASAL RATION

Ingredient	Percent
Chopped alfalfa hay	35.0
Cottonseed hulls	23.0
Cottonseed meal (41% C.P., solvent)	40.0
Salt	1.0
Dicalcium phosphate	1.0
	100.0
Added per ton:	
Vitamin A supplement	4,000,000 I.U.
Aurofac 10	907 gm.
Chlortetracycline	75 mg./hd./day

TABLE IV

TRIAL I: PROXIMATE ANALYSES[a]

Feedstuff	% Dry Matter[b]	% Ash	% Crude Protein	% Ether Extract	% Crude Fiber	% N.F.E.
Basal ration	89.8	7.4	18.5	2.3	21.6	50.2
Coarsely ground milo	87.4	1.5	8.3	2.1	2.5	85.6
Finely ground milo	87.9	1.5	8.3	2.9	1.1	86.2
Steam-process-flaked milo	82.0	1.0	6.3	2.3	3.9	86.5
Reconstituted-rolled milo	73.6	1.4[c]	6.6	2.2	2.1	87.7
Reconstituted-steam-process-flaked milo	70.0	1.3[c]	5.9	1.5[c]	4.1	87.2

[a]All values are on a dry matter basis.

[b]Dry matters are average of four determinations.

[c]All values except the ones so marked are the average of two proximate analyses.

required. Enough milo was fed with the basal to assure availability of feed until the next feeding. Unconsumed feed was weighed back as necessary.

The milo grain variety Northrup King 222, was grown and processed on the Fort Reno Station. Coarsely ground milo was produced by a hammer mill with a 4.76 mm. screen, while finely ground milo was processed by the same mill with a 3.18 mm. screen. Steam process-flaked milo was produced in a manner similar to that reported by Hale et al. (1966). Milo grain was subjected to live steam at atmospheric pressure for approximately 20 minutes at a temperature of 96^{o} C. in the steam chamber, and was then rolled with no tolerance between the rollers. The steam chamber was 0.51x 0.76 m. and the Davis rollers were smooth with dimensions of 0.15 x 0.46 m.

Whole reconstituted milo was produced by soaking the air-dry whole grain in water in 0.86 x 1.58 x 4.09 m. tanks for 1 to 2 hours, after which the excess water was drained. The reconstituted grain in the tank was covered with polyethylene sheeting, weighted with sand and allowed to set for at least 20 days before feeding. The moisture level of the grain was raised to 25-30% by this method. The reconstituted milo was rolled prior to feeding with the Davis rollers set at approximately 0.076 mm. tolerance between rollers.

Reconstituted-steam process-flaked milo was produced by steaming whole reconstituted milo for about five minutes, then rolling with no tolerance between the rollers. The maximum temperature in the steam chamber was 88°C. When a longer steaming period was attempted, the moisture level was raised and rolling was difficult due to accumulation of material on the rollers.

Rumen samples were collected from each steer (except basal steers) on day 136 and again on day 165 of the feeding trial. The sampling was done by a modification of the procedure described by Raun and Burroughs (1962). The rumen samples were taken by stomach tube with a stainless steel suction strainer coupled to a suction line with a 50-ml. hypodermic syringe connected. Microbial action in the rumen fluid was stopped by adding 1 ml. of saturated mercuric chloride to 50 ml. of rumen fluid. Samples were then stored at -10° C. for later analysis. VFA analysis was conducted according to the procedure of Erwin et al. (1961). An Aerograph Hy-Fi Model A-600 B gas chromatograph connected to a Sargent recorder was used in the determinations. Response criteria included total VFA concentration in rumen fluid, the molar percentage of acetic, propionic and butyric acids and the acetic:propionic ratio. Performance data related to VFA production included average daily gain, average daily feed intake and feed per kg. of gain.

Table V illustrates the influence of processing methods on particle size and density of the milo grain.

Appropriate statistical analyses were run using a high speed computer. Sources of variation and degrees of freedom

TABLE V

TRIAL I: PARTICLE SIZE[a] AND DENSITY[b] OF PROCESSED MILO

Process	Screen Size (mm.)									gm. per l.
	7.15	6.35	4.76	3.18	2.12	1.41	1.02	0.36	thru 0.36	
	% retained on screen									
Recon.-Rolled	0	0.15	10.86	38.00	18.19	15.92	4.52	6.50	8.55	342
Recon.-steam-Process-Flaked	0.27	2.45	17.37	17.30	9.99	9.21	7.50	14.70	18.80	331
Steam-Process-Flaked	5.67	16.44	42.49	23.93	5.21	2.18	0.86	0.90	0.09	293
Coarsely Ground	--	--	--	--	--	--	--	--	--	620
Finely Ground	--	--	---	--	--	--	--	--	--	575

[a]Particle size values: 100 gm. samples of each grain were sieved.

[b]Test weights reported are averages of 14 - 22 determinations, and are on 90% dry matter basis.

are shown in Tables VI, VII, and VIII.

Trial II

Trial II was initiated on December 8, 1965 to compare conventional steam-rolled milo and wheat. Thirty-six Hereford steer calves, with an average weight of 231 kg., were allotted to four treatments for a 180-day feeding period. The treatments were: (1) basal, (2) milo, (3) wheat and (4) ½ milo and ½ wheat. The basal ration was fed at a maintenance level to nine steers. Steers were grouped according to shrunk weight, using a stratified randomization procedure. The 45 steers available initially were divided into three groups of 15 each, with nine steers slaughtered before the trial began and 36 assigned to treatments. Table IX shows the experimental design of the experiment. The rations consisted of a basal maintenance ration with or without grain. The basal ration was fed to meet the maintenance energy requirement of the steers; grain was fed to appetite above maintenance. Calculations used to estimate the daily maintenance requirement of each steer were identical to those used in Trial I, except that the TDN content of the basal ration was estimated to be 58.2%; the requirement was 0.1120 kg. of basal ration per kg $W^{.75}$ per steer per day. Table XI contains the composition of the basal ration. The proximate analyses of the basal, milo and wheat are shown in Table XII.

The calves were fed twice daily in individual stalls

TABLE VI

TRIAL I: ANALYSIS OF VARIANCE FOR VFA DATA

Source	df
Total	83
Block	2
Treatment	4
Block x Treatment	8
Within Pen[a]	69

[a]Error term used to test treatment

TABLE VII

TRIAl I: ANALYSIS OF VARIANCE FOR FEED INTAKE AND FEED/KG. GAIN

Source	df
Total	14
Block	2
Treatment	4
Block x Treatment[a]	8

[a]Error term used to test treatment

TABLE VIII

TRIAL I: ANALYSIS OF VARIANCE FOR AVERAGE DAILY GAIN

Source	df
Total	44
Block	2
Treatment	4
Block x Treatment[a]	8
Within pen	30

[a]Error term used to test treatment

TABLE IX

TRIAL II: EXPERIMENTAL DESIGN

Basal	Milo	Wheat	½ Milo ½ Wheat
9	9	9	9
		Total - 36 hd.	

TABLE X

TRIAL II: EXPERIMENTAL DESIGN FOR VFA DATA

Basal	Milo	Wheat	½ Milo ½ Wheat
9[a]	7[b]	6[b]	8[b]
		Total = 21	

[a]No samples taken.

[b]Samples not available on all 9 animals.

TABLE XI

TRIAL II: COMPOSITION OF BASAL RATION

Ingredient	Percent
Alfalfa meal pellets (17% C.P.)	35.0
Cottonseed hulls	18.0
Cottonseed meal (41% C.P., expeller)	40.0
Molasses	5.0
Salt	1.0
Dicalcium phosphate	1.0
	100.0

TABLE XII

TRIAL II: PROXIMATE ANALYSES[a]

Feed-stuffs	% Dry Matter	% Ash	% Crude Protein	% Ether Extract	% Crude Fiber	% N.F.E.
Basal	90.9	7.0	18.9	1.5	22.6	50.0
Milo	86.5	1.5	7.9	1.7	1.6	87.3
Wheat	87.7	1.6	10.5	1.2	2.1	84.6

[a]All values are on a dry matter basis.

that measured 3.0 x 0.75 m.; no water was available during each 1 hour feeding period. The daily basal maintenance ration was divided into two equal parts and fed with the grain at each feeding. Grain (milo, wheat or ½ milo and ½ wheat) was fed to appetite and any unconsumed feed was removed and weighed at each feeding. The cattle had access to water in four paved lots between feedings.

Both basal mix and grain were obtained from the Stillwater Milling Company as needed. The conventional steam-rolled milo and wheat were prepared by steaming the whole grains for 3 - 5 minutes before coarse rolling with standard corrugated rolls.

Samples of rumen fluid for VFA determinations were taken from all animals after 131 days on feed. The procedures used for obtaining rumen fluid samples and analyses for VFA's were conducted as stated for Trial I.

The steers were removed from the feeding trial and slaughtered on three different days, with an average feeding period of 181 days. Appropriate statistical analyses were conducted using a high speed computer. Analyses of variance are shown in Tables XIII and XIV.

Trial III

This trial was initiated on December 28, 1966 to compare six types of processed milo fed in a high concentrate ration. Seventy-two Hereford steer calves, averaging 243 kg. were blocked on weight and condition score and randomly assigned

TABLE XIII

TRIAL II: ANALYSIS OF VARIANCE FOR VFA DATA

Source	df
Total	20
Treatment	2
Error	18

TABLE XIV

TRIAL II: ANALYSIS OF VARIANCE FOR FEEDLOT PERFORMANCE

Source	df
Total	26
Treatment	2
Error	24

to treatments within each block. The randomized complete block design is shown in Table XV.

The 72 calves for this trial were selected from a group of 154. The 154 head were plotted on graph paper, using shrunk weight and visual condition score as the X and Y axis. Diagonal lines were then used to divide them into five groups; the block that contained the 30 thinnest and lightest calves was eliminated and the calves were sold. Of the remaining 122 head, 72 were used in this trial, 40 were assigned to another trial, and 12 were slaughtered to allow estimation of initial body composition for net energy determination of the rations in Trial III.

Each treatment consisted of 12 steers in four pens of three steers each.

In this trial a high concentrate (90% concentrate, 10% roughage) ration was fed ad libitum. The six types of processed milo fed were: finely ground, coarsely ground, dry rolled, steam process-flaked, reconstituted-rolled and reconstituted-ground. A premix containing supplement and roughage was fed with the grain; the composition of the ration and premix is shown in Table XVI. Proximate analyses are shown in Table XVII.

All steers were fed a 60% concentrate starter ration for four weeks before the trial began, then were gradually shifted to the appropriate test rations.

The cattle were fed once daily in sufficient quantity to assure availability of feed until the next feeding.

TABLE XV

TRIAL III: EXPERIMENTAL DESIGN FOR VFA DATA AND FEEDLOT PERFORMANCE

	Processed Milo					
Blocks	Coarsely Ground	Finely Ground	Dry Rolled	Steam Process-Flaked	Recon.-Ground	Recon.-Ground
1	3	3	2[a]	3	3	3
2	3	3	3	2[a]	2[a]	2[a]
3	3	3	3	3	3	3
4	3	3	3	3	2[a]	3
	12	12	11	11	10	11
				Total = 67 hd.		

[a]Samples not available on all three animals.

TABLE XVI

TRIAL III: COMPOSITION OF RATION AND PREMIX

Ingredient	% in Premix	% in Total Ration
Milo	----	83.4[a]
Alfalfa hay, chopped	36.2	6.0
Cottonseed hulls	24.1	4.0
Cottonseed meal (41% C.P., solvent)	24.1	4.0
Urea ("262")	6.0	1.0
Salt	6.0	1.0
Bonemeal	3.6	0.6
	100.0	100.0
Added per ton:		
Vitamin A. supplement (30,000 I.U./gm.	600 gm.	100 gm.
Aurofac 10 (1st 40 days)	5400 g.	908 gm.
(rest of trial)	2725 gm.	454 gm.

[a]Dry matter basis.

TABLE XVII

TRIAL III: PROXIMATE ANALYSES[a]

Feedstuff	% Dry Matter[b]	% Ash	% Crude Protein[d]	% Ether Extract[d]	% Crude Fiber[c]	% N.F.E.[e]
Coarsely ground milo	87.0	1.71	10.03	2.54	1.70	84.02
Finely ground milo	87.3	1.57	10.00	3.42	1.58	83.43
Dry rolled milo	87.3	2.32	10.11	2.79	1.76	83.02
Recon.-rolled milo	79.9	1.34	10.54	2.03	1.71	84.38
Recon.-ground milo	80.9	1.70	10.70	1.55	1.67	84.38
Steam-Proc.-Flaked milo	83.2	1.55	10.77	2.18	1.38	84.12
Premix	90.4	14.16	36.99	4.08	16.33	28.44

[a]All values are on a dry matter basis.

[b]Average of seven determinations.

[c]One determination.

[d]Average of three determinations.

[e]100 - (sum of values reported for ash, crude protein, ether extract and crude fiber).

Excess feed was weighed back when it was deemed necessary, and the feeding level was lowered for the pen if feed refusal continued. The feeding level was raised as a pen's intake increased. Samples of grain and premix were taken every 21 days for dry matter determinations to adjust all rations to the same ratio between grain and premix on a dry matter basis.

Coarsely ground and finely ground milo were processed and combined with the required amount of premix in one-ton quantities. Dry rolled milo was also processed in one-ton quantities but was combined with the premix in the feed bunk at the time of feeding to prevent breaking of particles during mixing in a mechanical mixer. The "wet" grains, steam process-flaked, reconstituted-rolled and reconstituted-ground were processed daily, with the exception that enough was processed on Friday to feed over the weekend. The wet grains were combined with the premix in the feed bunk in the same manner as dry rolled milo.

Dry whole milo was stored in a 4.3 x 8.2 m. glass-lined, air-tight Harvestore silo. Coarsely and finely ground milo were processed as previously described in Trial I. Dry rolled milo was produced by rolling the whole milo with a roller tolerance in excess of 0.076 mm. using a Ross roller mill with rollers 0.46 m. in diameter and 0.61 m. long.

Reconstituted milo was produced in another 4.3 x 8.2 m. Harvestore silo. Water was added to the whole dry grain as it was augured into the silo, which raised the moisture level from 14% to 22%. The grain was reconstituted immediately after harvesting in October and stored until fed during the feeding trial.

Reconstituted-rolled milo was produced by rolling the reconstituted whole grain with the Ross roller mill with approximately 0.076 mm. tolerance between the rollers. The reconstituted-ground milo was obtained by grinding through a 3.18 mm. screen in a Doffin hammer mill.

Steam process-flaked milo was produced by steaming dry whole milo at atmospheric pressure in a 0.31 x 0.61 x 1.52 m steam chamber with a capacity of 226 kg., for approximately 20 minutes and rolled through the Ross mill with no tolerance between the rollers. The rollers were corrugated for the first 32 days of the trial, but at that time they were ground smooth to assure a flatter flake with less breakage. The variety of milo used in Trial III was Northrup King 222, grown on the Fort Reno Station.

Rumen samples were taken on the 72, 93 and 114 days of the trial. Each animal in the trial was sampled once; one steer from each pen was sampled each time. The steers were randomly selected from the pen with the stipulation that no steer could be sampled twice during the trial. The last rumen samples were obtained after the final weights were taken. The procedures for sampling and analyses for rumen VFA's were as described for Trial I.

The performance data was summarized at 149 days, because the cattle were subjected to rumen sampling and ultrasonic determinations following this time, but ration treatments were continued until time of slaughter, which was on three successive days after an average of 160 days on feed.

Table XVIII illustrates the influence of processing method on particle size and density of the milo grain.

Appropriate statistical analyses were conducted with a high speed computer. Variance components for this trial are shown in Table XIX.

Trial IV

This trial was conducted during the fall and winter of 1966-67; it was initiated on September 24, 1966. Trial IV was conducted to obtain information concerning the effect of type of grain on rumen VFA concentrations.

Sixteen mixed two year old cattle averaging 353 kg. were randomly allotted to four groups of four animals each. The cattle were composed of four Herefords, four Hereford crossbreds, four Angus, two Shorthorn and two Red Angus. The sex distribution was ten heifers and six steers. Each group of four animals was assigned to latin square design. The four latin squares were pooled for the analysis of variance. The grains compared were oats, barley, corn and milo.

Response criteria included total VFA concentration in rumen fluid; the molar percentages of acetic, propionic and butyric acids; and acetic:propionic ratio.

Rumen samples were taken the morning before the trial

TABLE XVIII

TRIAL III: PARTICLE SIZE[a] AND DENSITY[b] OF PROCESSED MILO

		Screen Size (mm.)								gm. per l.
		6.35	4.76	3.18	2.12	1.41	1.02	0.36	thru 0.36	
Recon.-ground	0	0	0	0.24	1.94	16.30	20.04	26.79	34.69	524
Finely ground	0	0	0	0.25	1.94	13.78	20.13	34.14	29.76	610
Coarsely ground	0	0	0	2.93	9.34	23.69	18.19	23.71	22.14	640
Dry rolled	0.02	0.30	0.34	3.11	18.14	27.89	16.38	21.12	12.69	499
Recon.-rolled	0.44	1.09	5.49	24.69	26.89	14.39	6.24	11.60	9.17	366
Steam-process-flaked	13.65	19.08	40.25	4.35	4.35	2.15	0.90	1.28	0.79	300
Steam-process-flaked (ran through mixer)					--	--	--	--	--	460
Whole dry	--	--	--	--	--	--	--	--	--	754
Whole reconstituted		--	--	---	--	--	--	--	--	641

[a]Particle size: Five 100 gm. samples were sieved for each grain and averages reported.

[b]Test weights reported are on 90% dry matter basis and are averages of several determinations throughout the trial. Considerably lower values were obtained at times for S.P.F. and recon.-rolled (lowest values: S.P.F. -16.6 recon.-rolled -26.6 lb./bu.)

TABLE XIX

TRIAL III: ANALYSIS OF VARIANCE

Source[a]	df
Total	23
Block	3
Treatment	5
Block x Treatment[b]	15

Source[c]	df
Total	66
Block	3
Treatment (adjusted)[d]	5
Block x Treatment	15
Within pen[b]	43

[a]For feed intake and feed/kg. gain using unweighted pen averages.

[b]Error term used to test treatment.

[c]For average daily gain and VFA data.

[d]Treatment adjusted for disproportionate data.

began and continuously at seven day intervals for 17 weeks. The procedure used for sampling and analyses were the same as previously described for Trial I. All rumen samples were analyzed for VFA's but only the last samples of each treatment period were analyzed statistically and reported. Period 1 was five weeks in length, but periods 2, 3 and 4 were only four weeks in length.

The rations fed consisted of 80% grain and 20% premix. This combination was calculated to meet the nutrient requirements (Morrison, 1957) of the cattle on the basis of a corn ration fed at a level of 2% of body weight. The composition of the premix is shown in Table XX. Proximate analyses of the grains and the premix are shown in Table XXI. The rations were fed in the following manner: In period 1 the cattle were fed the basal allotment plus a small amount of grain for the first two days, then the grain was increased one lb. per head daily until the desired intake of 2% body weight was reached (1.5 weeks). In period 2, 3 and 4 the complete change of grain was accomplished in only one week. In periods 3 and 4 the rations were fed at the level of 2.5% of body weight per day.

The conventional steam-rolled grain and premix were obtained from Stillwater Milling Company. The whole grains were exposed to steam for 3 to 4 minutes and then coarsely rolled. The grains were purchased in large quantities as the trial began to assure the same grain sources throughout the trial, but additional grain had to be purchased to

TABLE XX

TRIAL IV: COMPOSITION OF PREMIX

Ingredient	Percent
Alfalfa meal pellets (17% C.P.).	35.0
Cottonseed hulls	18.0
Cottonseed meal (41% C.P., expeller)	40.0
Molasses	5.0
Salt	1.0
Dicalcium phosphate	1.0
	100.0

TABLE XXI

TRIAL IV: PROXIMATE ANALYSES[a]

Feed-stuff	% Dry Matter[b]	% Ash[c]	% Crude Protein[d]	% Ether Extract[d]	% Crude Fiber	% N.F.E.[e]
Oats	88.5	3.09	13.11	4.50	10.80	68.51
Barley	87.5	2.29	11.94	1.94	4.63	79.20
Milo	87.3	1.49	9.77	3.04	1.55	84.15
Corn	87.4	1.39	9.54	2.92	1.82	84.32
Basal	90.3	10.60	22.36	3.00	18.67	45.37

[a]All values are on a dry matter basis.

[b]Average of eight determinations.

[c]One determination

[d]Average of three determinations

[e]100 - (sum of values reported for ash, crude protein, ether extract and crude fiber).

complete the last period of the trial.

Rumen samples were taken once from each animal every week of the trial at approximately 2 to 3 hours after the morning feeding. Animals were sampled in a random order to reduce any variation that might be due to time.

The rumen samples were taken, processed, and analyzed as described for Trial I.

Animal weights were taken at the beginning of every period to determine the feeding level. Weights were taken after the final rumen sampling of a period and animals were not removed from water before weighing.

One cup samples of the grains and basal were obtained each day to provide a large composite sample for each period from which samples could be taken for determination of density, moisture and proximate components. Table XXII shows the density (g./l.) of the grains for each period in Trial IV.

Statistical analyses were conducted by using a high speed computer. A factorial analysis of variance was run on all variables and Duncan's New Multiple Range Test (Steele and Torrie, 1960) was used to compare treatment means that produced significant F values. Analysis of variance is shown in Table XXIII.

TABLE XXII

TRIAL IV: GRAIN DENSITY[a]

Grains	Periods 1	2	3	4	Average
Oats	293	331	308	240	295
Barley	451	491	461	398	450
Milo	440	470	413	436	440
Corn	493	475	475	535	494
Basal	460	436	445	442	446

[a]Expressed in gm./l.

TABLE XXIII

TRIAL IV: ANALYSIS OF VARIANCE

Source	df	
Total	63	
Group	3	
Period in Group	12	
Period		3
Period x Group		9
Treatment in Group	12	
Treatment		3
Treatment x Group		9
Animal in Group	12	
Error[a]	24	

[a]Error term used to test treatment and period.

RESULTS

Trial I

VFA Data

Production of ruminal VFA's by steers fed five types of processed milo is shown in Table XXIV. There were no significant ($P>.05$) differences in production of acetic, propionic or butyric acid; acetic:propionic ratio or total VFA concentration.

Even though treatment means were not significantly ($P>.05$) different, acetic acid was highest in rumen fluid samples collected from steers receiving steam process-flaked milo. Propionic acid was highest for rumen fluid samples collected from steers fed steam process-flaked milo and lowest for steers fed coarsely ground milo. Total concentration of VFA's was highest for steam process-flaked milo and lowest for finely ground milo.

Feedlot Performance

Feedlot performance of the steers fed the five types of processed milo is shown in Table XXIV. Significant F values were obtained for average daily intake of the total ration ($P<.05$), average daily intake of milo ($P<.01$) and milo required/kg. gain ($P<.05$). Comparisons of treatment means indicated that steers fed reconstituted-steam process-

TABLE XXIV
TRIAL I: RESULTS

Item	Coarsely Ground	Finely Ground	Recon-Rolled	Recon.-Steam Process-Flaked	Steam Process-Flaked	$s_{\bar{x}}$[c]	F[d]
	Milo Processing Method						
VFA DATA							
No. Observations	16	16	17	17	18		
Acetic, molar %	60.94	59.04	58.59	56.66	56.10	1.834	1.23
Propionic, molar %	27.01	29.92	29.00	30.38	30.92	1.719	0.80
Butyric, molar %	12.08	11.00	12.44	12.96	12.86	0.695	1.39
Acetic:Propionic	2.51	2.18	2.16	2.04	1.96	0.216	0.96
Total VFA Conc., mM/l.	122.94	110.19	128.16	125.57	132.86	8.070	1.18
Feedlot Data							
No. steers	9	9	9	9	9		
Av. daily gain, kg.	1.10	1.14	1.11	1.10	1.19	0.042	0.90
Av. daily intake (total ration), kg.[a]	8.74[1,2]	8.33[2,3]	8.31[2,3]	8.07[3]	9.11[1]	0.160	6.80[e]
Av. daily intake (grain), kg.[b]	4.80[1,2]	4.45[2,3]	4.45[2,3]	4.21[3]	5.12[1]	0.106	11.51[f]
Feed/kg. gain (total ration), kg.	7.92	7.32	7.49	7.35	7.64	0.088	1.63
Feed/kg. gain (grain), kg.[a]	4.35[1]	3.91[2]	4.01[1,2]	3.84[2]	4.29[1]	0.048	4.73[e]

[a]Any two means without a common number differ significantly (P<.05).

[b]Any two means without a common number differ significantly (P<.01)

[c]Standard error of treatment means.

[d]Calculated F value from analysis of variance.

[e]Significant (P<.05).

[f]Significant (P<.01).

flaked milo consumed significantly less milo and total ration than those fed coarsely ground and steam process-flaked milo. Consumption of milo and total ration was significantly higher for steers fed steam process-flaked milo than finely ground and reconstituted-rolled milo. Milo required/kg. gain was significantly lower for steers fed finely ground milo and reconstituted-steam process-flaked milo than those fed coarsely ground and steam process-flaked milo. No significant ($P>.05$) differences were observed for daily gain or total ration/kg. gain.

Even though treatment means were not significantly ($P>.05$) different, rate of gain was 8.23% higher for steers fed steam process-flaked milo than coarsely ground and reconstituted-steam process-flaked, the lowest gaining processing methods. The most efficiently utilized ration contained finely ground milo and the least efficient ration contained coarsely ground milo.

Correlations

Correlation coefficients between VFA data and average daily gain are shown in Table XXV. Coefficients were not significantly ($P>.05$) different from zero for propionic acid and average daily gain, acetic:propionic ratio and average daily gain or total VFA concentration and average daily gain.

Trial II

VFA Production

Ruminal VFA production by steers fed conventional

TABLE XXV

TRIAL I: CORRELATIONS[a]

Variables	r_{xy}[b]
Propionic, molar % and av. daily gain (lb.)	0.20
A/P ratio and av. daily gain (lb.)	-0.20
Total VFA concentration and av. daily gain (lb.)	0.01

[a]All correlations were adjusted for treatment effects.

[b]Correlation coefficients all were non-significant ($P > .05$)

steam-rolled milo, wheat and a mixture of equal parts milo and wheat is shown in Table XXVI. There were no significant ($P > .05$) differences in molar % individual acids, acetic:propionic ratio or total concentration of VFA's.

Although treatment differences were non-significant, acetic acid was highest for the milo-wheat combination, with milo intermediate and wheat lowest. Propionic acid was highest for wheat, lowest for milo and intermediate for the combination of the two grains but differences were small. Acetic:propionic ratio was highest for the milo-wheat combination, with milo and wheat being very similar. Total concentration of VFA's was highest for the milo-wheat combination and lowest for wheat, with milo intermediate between the two.

Feedlot Performance

A summary of the feedlot performance is shown in Table XXVI. There were no significant ($P > .05$) differences between treatments for gain, feed intake or feed efficiency. Although treatment differences were not significant, rate of gain was highest for milo and comparable for wheat and the milo-wheat combination. Milo had the highest intake, the combination of milo and wheat was lowest and wheat was intermediate. Feed required/kg. of gain was lowest for milo and similar for wheat and the milo-wheat combination.

Correlations

Correlation coefficients between VFA production and feedlot performance are shown in Table XVII. Correlations

TABLE XXVI

TRIAL II: RESULTS

Item	Milo	Wheat	½ Milo ½ Wheat	$s_{\bar{x}}$[a]	F[b]
	(conventional steam-rolled)				
VFA Data					
No./Steers	7	6	8		
Acetic, molar %	52.94	51.90	54.34	1.962	0.30
Propionic, molar %	33.90	34.68	34.24	2.141	0.02
Butyric, molar %	13.16	13.44	11.37	1.141	0.80
Acetic/Propionic	1.57	1.53	1.80	0.208	0.41
Total Con. mM/l.	84.97	79.65	90.73	9.048	0.29
Feedlot Data					
No./Steers	9	9	9		
Av. daily gain, kg.	1.02	0.94	0.93	0.068	0.52
Av. daily intake (total ration), kg.	6.76	6.52	6.33	0.338	0.41
Av. daily intake (grain), kg.	3.08	2.93	2.79	0.257	0.57
Feed/kg. gain (total ration), kg.	6.65	6.96	7.08	0.295	0.58
Feed/kg. gain (grain), kg.	3.02	3.05	3.00	0.133	0.05

[a]Standard error of treatment means.

[b]Calculated F value from analysis of variance, all non-significant ($P > .05$).

TABLE XXVII

TRIAL II: CORRELATIONS[a]

Variables	Propionic molar %	A/P ratio	Total VFA conc., mM/l.
Av. daily gain, kg.	0.48[b]	-0.59[c]	0.36
Av. daily intake (total ration), kg.	0.54[b]	-0.62[c]	0.10
Av. daily intake, (grain), kg.	0.44[b]	-0.58[c]	0.40
Feed/kg. gain (total ration), kg.	-0.34	0.41	-0.56[c]
Feed/kg. gain (grain), kg.	0.41	-0.40	-0.15

[a]All correlations were adjusted for treatment effects.

[b]Significantly different from zero (P .05).

[c]Significantly different from zero (P .01).

were significantly ($P<.01$) different from zero for propionic acid and average daily intake of total ration, acetic:propionic ratio and average daily gain, acetic:propionic ratio and average daily intake of total ration, acetic:propionic ratio and intake of grain, and total VFA concentration with feed/kg. of gain. Correlations significantly ($P<.05$) different from zero were obtained for propionic acid and average daily gain, and propionic acid and average daily grain intake.

Propionic acid was positively ($P<.05$) correlated with average daily gain, average daily intake of total ration and average daily intake of grain, Acetic:propionic ratio was negatively ($P<.01$) correlated with average daily gain, average daily intake of total ration and average daily intake of grain. A significant ($P<.01$) negative correlation between total VFA concentration and kg. of total ration/kg. of gain was also obtained. Since the sample size was small (21 steers), no mention was made of the direction of correlation coefficients which were not significantly ($P>.05$) different from zero.

Trial III

VFA Data

Ruminal VFA data of steers fed the six types of processed milo is shown in Table XXVII. There were no significant ($P>.05$) differences in individual molar % VFA's, acetic:propionic ratio or total VFA's.

TABLE XXVIII

TRIAL III: RESULTS

Item	Coarsely Ground	Finely Ground	Dry Rolled	Recon.-Rolled	Recon.-Ground	Steam Process-Flaked	$s_{\bar{x}}$[b]	F[c]
VFA Data								
No. steers	12	12	11	11	10	11		
Acetic, molar %	46.72	45.69	43.19	45.35	44.05	37.73	2.939	1.34
Propionic, molar %	36.07	41.57	43.56	42.24	38.26	45.53	2.683	1.89
Butyric, molar %	17.20	12.74	13.26	12.42	17.69	16.75	1.662	2.40
Acetic/Propionic	1.44	1.13	1.02	1.28	1.32	0.87	0.199	1.24
Total Con., mM/l.	110.21	89.53	109.23	103.46	119.83	105.93	10.454	1.02
Feedlot Data								
No. steers	12	12	11	11	10	11		
Av. daily gain, kg.	1.14[1]	1.18[1]	1.14[1]	1.14[2]	1.14[1]	1.28[1]	0.058	1.05
Av. daily intake, kg.[a]	7.70[1]	7.63[1]	7.38[1]	6.62[2]	7.33[1]	7.45[1]	0.201	3.70[d]
Feed/kg. gain, kg.[a]	6.77[1]	6.47[1,2]	6.43[1,2]	5.82[2]	6.44[1,2]	5.90[2]	0.091	3.49[d]

[a]Any two means without a common number differ significantly ($P < .05$).

[b]Standard error of treatment means.

[c]Calculated F vlue from analysis of variance.

[d]Significant ($P < .05$).

Although treatment differences were non-significant ($P>.05$), acetic acid was highest for coarsely ground milo and lowest for steam process-flaked milo. Propionic acid was highest for steam process-flaked milo and lowest for coarsely ground milo. Acetic:propionic ratio was highest for coarsely ground and lowest for steam process-flaked ratio. Butyric acid was highest for reconstituted-ground and lowest for reconstituted-rolled milo. Steers on reconstituted-ground had the highest concentration of total VFA's and those fed finely ground milo had the lowest.

Feedlot Performance

Feedlot performance is shown in Table XXVIII. Significant ($P<.05$) F values were obtained for average daily intake and feed/kg. gain. When treatment means were compared, the average daily intake of reconstituted-rolled milo was significantly less than for the other five processing methods. Feed required/kg. of gain was significantly lower for reconstituted-rolled milo than for coarsely ground. Steam process-flaked milo was also significantly more efficiently utilized than coarsely ground milo.

Although treatment differences in average daily gain were non-significant, steam process-flaked and finely ground milo produced gains 11.0 and 3.2% higher than the other processing methods. Average daily intake was reduced by all processing methods when compared to coarsely ground milo, but reconstituted rolled milo reduced consumption the greatest amount, with a decrease of 14.1% as compared to coarse grinding. Feed required/kg. of gain was highest for coarsely ground milo, similar and intermediate for finely ground, dry rolled and reconstituted-ground and lowest for reconstituted-rolled and steam process-flaked.

Correlations

Correlation coefficients between VFA production and average daily gain are shown in Table XXIX. A significant ($P<.01$) positive correlation was obtained for average daily gain and molar percent propionic acid, and a significant ($P<.01$) negative correlation between average daily gain and acetic:propionic ratio was also obtained. Total VFA concentration was not significantly ($P>.05$) correlated with average daily gain.

Trial IV

VFA Data

Ruminal VFA's produced by cattle fed conventional steam-rolled oats, barley, milo and corn are shown in Table XXX. A significant ($P<.01$) F value was obtained for butyric acid production. Comparison of the means of the four grains indicated that when the animals were fed barley, they produced significantly more ruminal butyric acid than those fed the other three grains. A significant ($P<.05$) F value was obtained for propionic acid production. Comparison of treatment means of the four grains indicated that when the cattle were fed barley they produced significantly less ruminal propionic acid than animals fed the other grains.

TABLE XXIX

TRIAL III: CORRELATIONS[a]

Variables	r_{xy}
Propionic, molar % and av. daily gain[b]	0.4698[b]
A/P ratio and av. daily gain	-0.4622[b]
Total VFA con. mM/1 and av. daily gain	0.1030

[a]Correlations adjusted for treatment effects.

[b]Significantly different from zero ($P<.01$)

TABLE XXX

TRIAL IV: VFA PRODUCTION

VFA Data	Oats	Barley	Milo	Corn	$s_{\bar{x}}$[b]	F[c]
No. Observations	16	16	16	16		
Acetic, molar %	49.00	48.85	49.21	45.30	1.411	1.653
Propionic, molar %[a]	40.08[1]	33.29[2]	38.50[1]	40.77[1]	1.611	4.415[d]
Butyric, molar %[a]	10.94[1]	17.92[2]	12.36[1]	13.95[1]	1.264	5.681[e]
A/P ratio	1.29	1.59	1.57	1.25	0.123	2.047
Total Con. mM/l.	120.21	132.23	119.21	121.30	4.546	1.775

[a]Any two means without a common number differ significantly ($P<.05$).

[b]Standard error of treatment means.

[c]Calculated F value from analysis of variance.

[d]Significant ($P<.025$).

[e]Significant ($P<.005$).

Although treatment differences were non-significant ($P > .05$), acetic acid was highest for milo and lowest for corn. Acetic:propionic ratio was highest for barley and milo, with oats and corn similar and lowest. Barley produced the highest concentration of total VFA's and milo produced the lowest concentration.

Significant ($P < .005$) F values were obtained for period differences for acetic acid, propionic acid and acetic:propionic ratio. Comparison of period means indicated that rumen samples taken in period 1 had significantly less acetic acid than the other three periods, while period had significantly more acetic acid than the other periods. 2 (Table XXXI).

Another comparison indicated that samples from period 2 had significantly less propionic acid than rumen samples in other periods. Acetic:propionic ratio was significantly wider for period 2 than for the other periods.

TABLE XXXI

TRIAL IV: VFA PRODUCTION BY PERIODS

VFA's	Periods 1	2	3	4	$s_{\bar{x}}$ [b]	F [c]
No. Observations	16	16	16	16		
Acetic, molar % [a]	40.66[1]	57.59[2]	45.70[3]	48.40[3]	1.411	23.92[d]
Propionic molar % [a]	43.24[1]	27.50[2]	41.53[1]	40.38[1]	1.611	20.00[d]
Butyric molar %	16.08	15.03	12.79	11.28	1.264	2.94
A/P ratio [a]	0.95[1]	2.25[2]	1.18[1]	1.27[1]	0.123	20.82[d]
Total Con. mM/l.	118.78	128.93	118.02	127.22	4.546	1.54

[a] Any two means without a common number differ significantly ($P < .05$).

[b] Standard error of treatment mean.

[c] Calculated F value from analysis of variance.

[d] Significant ($P < .005$).

DISCUSSION

Results of Trials I and III were similar for VFA data and feedlot performance. Both trials compared processing methods of milo in group feeding experiments, with rations fed *ad libitum*. The processing methods common to both trials were coarse grinding, fine grinding, reconstituting-rolling and steam process-flaking. Processing methods not common to both trials were reconstituting-steam process-flaking for Trial I and dry rolling and reconstituting-grinding for Trial III. Trial I rations averaged approximately 54% milo while Trial III rations contained 83.4% milo.

VFA production similar for Trials I and III were molar percent acetic and propionic acids, and acetic:propionic acid ratio. Coarsely ground milo produced the highest molar percent acetic acid, the lowest molar percent propionic acid and the widest acetic:propionic ratio in both trials. Steam process-flaked milo produced the lowest molar percent acetic acid, with 4.84 and 8.99 molar percent less than coarsely ground milo for Trials I and III, respectively. Reconstituted-rolled milo decreased the molar percent acetic acid content compared to coarsely ground by 2.35 and 1.37 molar percent for Trials I and III respectively. Finely ground milo decreased the molar percent acetic less than the other processing methods with decreases of 1.90% for Trial I and 1.03% for Trial III, respectively.

Ruminal samples from cattle fed steam process-flaked milo contained the highest molar percent propionic acid with 3.89 molar percent (Trial I) and 9.46 molar percent (Trial III) more than samples from steers fed coarsely ground milo. Reconstituted-rolled milo increased propionic acid production 1.99 molar percent for Trial I and 6.17 molar percent for Trial III; while, fine grinding increased propionic acid production by 2.91 molar percent and 5.50 molar percent in Trail I and Trial III, respectively.

As expected, the acetic:propionic ratio for steam process-flaked milo, 1.96:1 in Trial I and 0.87:1 in Trial III, was markedly more narrow than for coarsely ground milo Trial I 2.51:1 and 1.44:1 in Trial III. The very narrow acetic:propionic ratio for steam process-flaked milo in Trial III is similar to the findings of Phillipson (1952) and Balch and Rowland (1957) when they fed rations high in flaked corn. In Trial I reconstituted-steam process-flaked milo produced an acetic:propionic ratio for 2.04:1 and in Trial III dry rolled and reconstituted-ground produced narrow acetic:propionic ratios of 1.02:1 and 1.32:1, respectively. The greater improvement in VFA proportions for Trial III, as demonstrated in the very narrow acetic:propionic ratios for some processing methods, may have been due to the higher concentrate ration. The rolled processing methods may also have been aided by the fact that a larger, heavier roller mill was used in Trial III.

The relative order according to magnitude of total VFA concentrations produced by processing methods were not similar for Trials I and III. In Trial I steam process-flaked milo produced the highest total VFA concentration, fine grinding produced the lowest and coarse grinding next to the lowest. In Trial III, fine grinding again produced the lowest total VFA concentration; however, coarse grinding produced the highest of the four methods. Total VFA concentrations are very difficult to measure by gas chromatography because of gas loss when the needle of the syringe is withdrawn from the septum and the inability of the technician to inject the exact amount each time. Rumen volume, dilution with water, rate of absorption and strata of the rumen sampled also affect the total concentration of VFA's when sampled *in vivo*.

The results of Trial II suggest that milo and wheat are very similar in VFA production. The acetic:propionic ratios similar for milo and wheat, but wider for the combination of the two grains, with the total VFA concentration largest for $\frac{1}{2}$ milo and $\frac{1}{2}$ wheat. Oltjen *et al*. (1966) compared wheat and corn in all-concentrate rations and reported a significantly higher concentration of total VFA's for rations which contained high amounts of wheat, as compared to rations containing high amounts of corn.

Results of Trial IV, comparing VFA production of cattle fed conventional steam-rolled oats, barley, milo and corn, indicate that barley produced significantly ($P<.025$)

less molar percent propionic acid than the other three but significantly ($P<.005$) more molar percent butyric acid. Total VFA concentration was highest for barley and lowest for milo fed cattle. Theurer et al. (1966) reported an increased production of total VFA's for barley, when comparing barley and milo fermentation *in vitro*. They also reported that there was no significant difference in the production of molar percent of the individual acids. It is interesting to note that, although the difference for acetic:propionic ratio was not significant ($P<.05$) oats had a very narrow ratio (1.29:1) as compared to barley and milo (1.59:1 and 1.57:1). Elliot and Loosli (1959) reported that as crude fiber content increased the acetic:propionic ratio became wider. This study was with dairy rations which are usually lower in grain than the rations in this study. Jorgensen and others(1965) compared pelleted oats and pelleted corn in a 75% concentrate ration with dairy cows and reported that corn maintained a narrower acetic:propionic ratio and a higher concentration of total VFA's than oats. An explanation for this difference not being apparent in Trial IV might be the higher grain content (80%) of the ration, for this reason the fiber content of oats was not an important factor. The oats were of good quality with an average density of 295 gm./l.

The reason for the significant period effect on acetic and propionic acid productions is not clear, but the effect seemed common for all grains during period 2.

Correlations of VFA production with average daily gain were similar in direction for Trials I, II and III. For these trials the average correlation coefficients for average daily gain and propionic acid, acetic:propionic ratio, and total VFA's were 0.39, -0.43 and 0.16, respectively. Weiss et al. (1967) reported simple correlation coefficients for average daily gain and propionic acid (0.50), and for average daily gain and acetic:propionic ratio (-0.54). The correlation coefficients reported for Trials I, II and III were adjusted for treatment effects, which may have reduced their magnitude compared to simple correlations. In Trial II correlations were also obtained for VFA's with feed intake and feed efficiency. Significant (P<.01) negative correlations were obtained for acetic:propionic ratio and average daily intake of total ration and for intake of grain.

In Trial II a significant negative correlation was obtained for feed/kg. gain and total VFA concentration. This suggests that as total VFA concentration increased, feed/kg. of gain decreased.

SUMMARY

Two feeding trials (Trials I and III) were conducted to investigate the effect of method of processing milo on VFA production and feelot performance by feedlot steers. Trial II was conducted to compare the VFA production and feeding value of milo, wheat or a milo-wheat combination. One other trial (Trial IV) was a complete latin square change-over trial conducted to compare the VFA production of oats, barley, milo and corn. Correlations between VFA production and feedlot performance were obtained for Trials I, II and III. In Trial III a high concentrate (90%) ration was fed, while in Trials I and II a basal ration containing approximately 55% roughage was fed to meet maintenance requirements, with grain fed to appetite. A ration of 80% grain and 20% basal ration was fed in Trial IV.

No significant ($P>.05$) differences in individual acids or total VFA production were observed in Trials I and III. In two trial (I and III) *ad libitum* group-fed steers produced similar VFA patterns that paralleled the feedlot performance of the individual processing methods. This is demonstrated by the fact that coarse grinding produced the widest and steam process-flaking the narrowest acetic:propionic ratio in both trials. These differences were not significant, but feed efficiency was significantly improved

due to reconstituting-rolling, reconstituting-steam process-flaking and steam process-flaking.

A significant ($P<.01$) negative correlation was obtained for acetic:propionic ratio and average daily gain in Trials II and III and a significant ($P<.01$) positive correlation was obtained for propionic acid and average daily gain in Trial III. In Trial II significant ($P<.01$) negative correlations were also obtained for acetic:propionic ratio and average daily intake of total ration and intake of grain, and for total concentration of VFA's and feed required/kg. of gain.

In Trial II milo, wheat or the milo-wheat combination failed to significantly ($P>.05$) affect individual acids, acetic:propionic ratio, total VFA or feedlot performance.

Barley produced significantly more butyric acid and less propionic acid than oats, milo or corn in Trial IV. Significant ($P<.005$) period differences were obtained for acetic acid, propionic acid and acetic:propionic ratio. Acetic acid was significantly lower in period 1 and was higher in period 2 than other periods. Propionic acid was significantly lower in period 2; and acetic:propionic ratios were significantly wider in period 2 than other periods. This period effect is not clear, but it seems to be consistent for all treatments.

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