FEEDLOT PERFORMANCE, NET ENERGY AND CARCASS MERIT AS AFFECTED BY HIGH MOISTURE VS. DRY METHODS OF PROCESSING MILO

By

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CHAPTER I

INTRODUCTION

Sorghum grain is the primary source of cereal grain for fattening cattle in the Southwest. With the continued influx of large feedlots into this area, the importance of sorghum grain will be even more pronounced.

Currently considerable emphasis is being placed upon grain processing to increase efficiency of feedlot production. Chemical composition of sorghum grain shows that its potential energy is equal to corn and superior to barley. However, because of the lower starch availability, the energy potential of sorghum grain has not been reached. Many fattening rations contain as much as 85% sorghum grain; any improvement in feeding value of the grain would be of considerable economic importance to the cattle feeding industry.

Previous research indicates that the feeding value of sorghum grain can be improved by both high moisture harvesting and reconstituting. The purpose of this study was to evaluate several methods of high moisture processing of sorghum grain for fattening cattle.

Processing methods were evaluated on the basis of feedlot performance, carcass merit and net energy.

CHAPTER II

REVIEW OF LITERATURE

Methods of Processing

It is generally agreed that some processing of grain is necessary to improve mixing and feeding value over whole grain. The grain coat of milo is extremely resistant to digestion; it is absolutely necessary to rupture the grain before feeding, as cattle apparently chew milo very little in the normal mastication process. This is in contrast to corn which can be fed whole with a fair degree of success, as considerable portions of the grain are broken by chewing prior to swallowing (Hale and Taylor, 1965).

Grain processing methods have been critically reviewed the past few years to determine which methods have the greatest potential for improving rate of gain and feed efficiency for finishing cattle. For this review, the available research data comparing methods of processing have been summarized to allow a concise evaluation of the different methods. The methods of processing to be considered in this review include: grinding, dry rolling, steam rolling, pelleting, steam flaking and high moisture processing.

Grinding

Coarse grinding has been commonly used as a control method to which other processing methods are compared. There is a very large variation in grain designated as coarsely ground; size of hammer mill screens used to produce coarsely ground grain has varied from 3/16 in. to 1/2 in. Grains designated as finely ground were produced by using hammer mill screens that varied from 1/8 in. to 1/4 in.

A summary of 10 trials comparing finely ground milo to coarsely ground milo is shown in Table I. Daily gain was not greatly affected by fineness of grind. Fine grinding milo decreased feed intake 5%; therefore, efficiency of gain was improved by 5%.

TABLE I

MILO: FINE VS. COARSE GRINDING

Processing Method		Percent of Control Method[a]			
Treatment Method	Control Method	No. Trials	Daily Gain	Daily Feed[b]	Feed/lb. Gain[b]
Fine grinding	Coarse grinding	10[c]	101	95	95

[a]Treatment method is expressed as % of the control method.

[b]Feed intake and feed efficiency data on 90% dry matter basis.

[c](1), (10), (16), (46), (53), (54), (59), (67), and (68).

Totusek _et al_. (1964) reported a 5% improvement in feed efficiency with no significant difference in rate of gain when finely ground milo was compared to coarsely ground milo. They concluded that since the finely ground milo was consumed in smaller quantities, the energy in the finely ground milo was more efficiently utilized, and less feed was required to satisfy the daily energy requirement of the calves than was true of the coarsely ground milo.

Fine grinding exposes a tremendous surface area of the starch portion of the grain to rumen microorganisms and digestion in the small intestine. However, finely ground grains are dusty and blowing might be a problem in some areas.

Dry Rolling

Results of three trials (Table II) indicated no advantage for finely rolled milo over coarsely rolled milo. The grain particles resulting from rolling may be multi-fractured and therefore susceptible to the entry of enzyme-containing fluid for digestion (Totusek, 1968). If the same amount of surface area (due to multi-fracturing) is available in dry rolled grains as in finely ground grain, this would explain the similarity in feeding value of the two processing methods. Data summarized from five trials indicated only a slight advantage in efficiency for fine grinding over dry rolling; however, rate of gain was reduced 2% by fine grinding.

TABLE II

COMPARISONS OF ROLLED MILO

Processing Method		Percent of Control Method[a]			
Treatment Method	Control Method	No. Trials	Daily Gain	Daily Feed[b]	Feed/lb. Gain[b]
Fine rolling	Coarse rolling	3[c]	96	97	100
Steam rolling	Dry rolling	4[d]	98	100	102
Steam rolling	Grinding	4[e]	98	99	101
Dry rolling	Fine grinding	5[f]	98	97	99

[a]Treatment method is expressed as % of the control method.

[b]Feed intake and feed efficiency data on 90% dry matter basis.

[c](12) and (13).

[d](6), (61), (64), and (65).

[e](53), (54), and (56).

[f](1), (16), (26), (46), and (59).

Mehen et al. (1966) reported no significant differences in digestion of the important fractions of dry rolled or finely ground milo as seen in Table III.

Conventional steam rolling involves subjecting the grain to steam for about 3 to 5 minutes prior to rolling. Temperatures of approximately 180° F. are obtained in such a process (Hale and Taylor, 1965). A summary of four trials (Table II) indicated that conventional steam rolling is actually inferior to dry rolling in that rate of gain and feed efficiency were 2% lower for steam rolled milo. Conventional steam rolled milo was of slightly lower value than ground milo due to lower efficiency of utilization and reduced rate of gain.

TABLE III

DIGESTIBILITY OF DRY ROLLED VS. FINELY GROUND MILO[a]

Item	Dry Rolled	Finely Ground
	%	%
Dry matter	68.8	70.7
Protein	58.7	59.4
True protein	80.6	81.4
Ether extract	75.6	72.1
Crude fiber	43.3	31.6
Nitrogen free extract	76.3	78.5
Total digestible nutrients	69.3	70.3
Gross energy	67.3	68.8

[a]Mehen et al. (1966).

Pelleting

Pelleting a fattening type milo ration will strikingly improve feed efficiency as indicated by a summary of 12 trials in Table IV. Totusek (1968) reported that pelleting finely ground, coarsely ground and steam rolled milo improved total feed efficiency 5.1%, 9.2%, and 6.8%, respectively, over the unpelleted milo when rations contained 50% milo and 32% roughage. Rate of gain was not affected, but dressing percentage was lowered 1% and carcass grade was decreased slightly by pelleting. Similar results were observed by Perry *et al.* (1961) when a pelleted fattening type corn ration that contained 20% hay was compared to the same ration containing dry rolled corn. Feed efficiency was increased 6% by pelleting; however, carcass grade and dressing percentage were lowered by pelleting.

TABLE IV

COMPARISONS OF PELLETED GRAINS

	Processing Method		Percent of Control Method[a]			
Grain	Treatment Method	Control Method	No. Trials	Daily Gain	Daily Feed[b]	Feed/lb. Gain[b]
Milo	Pelleting	Grinding	8[c]	104	94	91
Milo	Pelleting	Dry rolling	4[d]	105	92	93
Corn	Pelleting	Grinding	3[e]	105	94	89
Corn	Pelleting	Dry rolling	2[f]	101	87	90

[a]Treatment method is expressed as % of the control method.

[b]Feed intake and feed efficiency data on 90% dry matter basis.

[c](36), (53), (54), and (56).

[d](52), (55), (57), and (58).

[e](24), (30), and (69).

[f](24) and (51).

Pelleting of corn has been more advantageous than pelleting of milo. A summary of five trials comparing pelleted corn to both ground and dry rolled corn (Table IV) indicates a 10-11% improvement in feed efficiency and also an improvement in rate of gain due to pelleting.

Steam Flaking

The feeding value of grains definitely can be improved by flaking. Steam flaking is more than just a method of steam rolling; the idea of just applying steam and running the grain through a roller mill apparently will not produce a product that will bring about the advantages of flaking over other methods of grain processing. Data in the past indicated varied responses in feedlot gains and feed utilization due to steam processing grains. Hubbard (1967) contributed these variable responses to different conditions involved in the grain processing. Hale and Taylor (1966) outlined the key points to the steam processing method of flaking milo as follows:

1. Moisture of the grain raised to approximately 20 percent.
2. Grain enters rollers at 212^{o} to 216^{o} F.
3. Approximately 20 lb. pressure in the steam chamber.
4. Cold roller spacing of 0.003 inch.
5. Flake should weigh 25 lb. per bu. (air-dry weight basis).
6. Gelatinization of 30 to 40 percent.

A summary of 17 trials comparing steam flaked to ground grains is shown in Table V. All grains show a consistent improvement in feed efficiency, but a varied response is indicated for daily gain. Milo showed the greatest overall response to steam flaking in that rate of gain was increased 10% and feed efficiency 8% compared to dry coarse grinding.

TABLE V

STEAM FLAKED VS. GROUND GRAINS

	Processing Method		Percent of Control Method[a]			
Grain	Treatment Method	Control Method	No. Trials	Daily Gain	Daily Feed[b]	Feed/lb. Gain[b]
Milo	Steam flaking	Coarse grinding	7[c]	110	101	92
Corn	Steam flaking	Grinding	5[d]	98	92	91
Barley	Steam flaking	Coarse grinding	5[e]	100	95	95

[a]Treatment method is expressed as % of the control method.

[b]Feed intake and feed efficiency data on 90% dry matter basis.

[c](20), (46), and (67).

[d](24), (30), (34), and (44).

[e](20).

Steam flaking of corn increased feed efficiency 9%, but reduced rate of gain and feed consumption 2% and 8%, respectively, as compared to coarse grinding of dry shelled corn.

Barley has shown less response to steam flaking than either corn or milo. Steam flaking of barley improved feed efficiency 5%, reduced feed consumption 5%, and did not affect rate of gain compared to dry grinding.

In comparing steam flaked grains to dry rolled grains (Table VI), milo and corn were markedly improved for the economically important traits (i.e., rate of gain and feed efficiency) by steam flaking. Steam flaking of milo increased rate of gain 8%, feed consumption 3%, and feed efficiency 4% over dry rolling of milo as indicated by a summary of six trials.

A summary of eight trials comparing steam flaked corn to dry rolled corn shows an advantage in rate of gain (5%) and feed efficiency (8%) for steam flaked corn. The daily consumption of flaked corn was reduced 3%.

As previously shown in Table V, the feeding value of barley has not been improved to the extent of milo and corn by steam flaking. A summary of five trials comparing steam flaked and dry rolled barley indicated no advantage in feed efficiency for steam flaked barley. Rate of gain was improved 4% and feed consumption was increased 3% by steam flaking barley.

TABLE VI

STEAM FLAKED VS. DRY ROLLED GRAINS

Grain	Processing Method: Treatment Method	Processing Method: Control Method	Percent of Control Method[a]: No. Trials	Daily Gain	Daily Feed[b]	Feed/lb. Gain[b]
Milo	Steam flaking	Dry rolling	6[c]	108	103	96
Corn	Steam flaking	Dry rolling	8[d]	105	97	92
Barley	Steam flaking	Dry rolling	5[e]	104	103	100

[a]Treatment method is expressed as % of the control method.
[b]Feed intake and feed efficiency data on 90% dry matter basis.
[c](19), (21), (22), and (46).
[d](19), (24), (32), (33), and (35).
[e](19), (21), and (22).

Hale *et al.* (1965) reported the flatness of flake was very important to the utilization of steam flaked milo. The results of nylon bag studies to determine the disappearance of dry matter from dry rolled and steam flaked milo samples are shown in Table VII. Matsushima and Montgomery (1967) reported heifers fed "thin" (1/32 in.) corn flakes gained 4.6% faster and 7.8% more efficiently than those fed "thick" (1/12 in.) corn flakes. The two types of flakes were produced by varying the roller spacing.

TABLE VII

EFFECT OF FLATNESS OF FLAKE OF STEAM PROCESSED MILO ON DRY MATTER DISAPPEARANCE FROM NYLON BAGS, %[a]

Hours in Rumen	Dry Rolled	Poorly Rolled	Regular Rolled	Flat Rolled
2	21.4	23.9	44.7	49.1
4	23.2	20.9	37.8	44.8
6	27.0	23.6	44.4	47.4
8	31.9	29.9	41.4	49.4
24	54.5	55.0	66.9	71.6

[a]Hale *et al.* (1965).

Parrott *et al.* (1967) reported that steam flaking of barley does not improve the digestibility of the various proximate fractions on the available TDN. Also, digestibility of barley was not influenced by the degree of flaking.

High Moisture Processing

High moisture processing of grain includes high moisture harvesting and reconstituting of dry grain. The moisture level is normally in a range of 25-35%. High moisture grain must be stored under anaerobic conditions to prevent spoilage. Also, for maximum utilization, the grain must be processed before or after storage.

High moisture processed grains have markedly improved feeding value over dry processed grains as indicated by a summary of 36 feeding trials shown in Table VIII. The improvement in feeding value is consistent for both high moisture harvested grains and reconstituted grains.

TABLE VIII

COMPARISON OF HIGH MOISTURE GRAIN PROCESSING METHODS

Grain	Processing Method: Treatment Method	Processing Method: Control Method	Percent of Control Method[a]: No. Trials	Daily Gain	Daily Feed[b]	Feed/lb. Gain[b]
Milo[c]	Recon.	Dry process	9[c]	101	93	92
Corn[d]	Recon.	Dry process	7[d]	104	104	95
Milo[e]	HMH	Dry process	10[e]	100	90	90
Shelled corn[f]	HMH	Dry process	5[f]	100	93	95
Grd. ear corn[g]	HMH	Dry process	7[g]	103	94	92

[a]Treatment method is expressed as % of the control method.

[b]Feed intake and feed efficiency data on 90% dry matter basis.

[c](37), (46), (47), and (67).

[d](2), (28), and (29).

[e](8), (9), (10), (11), (38), and (47).

[f](2), (7), (35), and (50).

[g](3), (4), (5), (7), (15), (17), and (18).

Reconstituting of corn improved feed efficiency 5% and rate of gain 4% compared to dry processed corn in a summary of seven trials.

The efficiency of gain was improved 8% and rate of gain 1% by reconstituting milo, compared to dry processed milo. A summary of three trials with reconstituted sorghum grain by McGinty _et al_. (1968) indicates:

1. Time of grinding reconstituted sorghum grain is important if maximum benefits of the process are to be obtained. Grinding the dry grain before addition of water gave no improvement in feed efficiency over dry ground grain.
2. _In vivo_ and _in vitro_ results indicated no benefit for sorghum grain reconstituted near freezing temperatures.
3. There was no difference in feed efficiency between reconstituted grain stored 10 or 20 days.
4. Differences in initial water temperatures had no significant influence on efficiency of feed conversion.
5. Cattle fed sorghum grain reconstituted in whole form at warm temperatures required 10-20% less dry matter per pound of gain than did cattle fed dry ground grain.

High moisture harvested milo was utilized 10% more efficiently than dry milo in a summary of 10 trials. The improved efficiency was apparently the result of increased digestibility of the milo as there was no difference in rate of gain. The digestibility of dry matter, organic matter, nonprotein organic matter and energy was significantly higher for reconstituted milo than for finely or coarsely ground milo (Buchanan-Smith et al., 1968).

High moisture harvested shelled corn was utilized 5% more efficiently, with no advantage in rate of gain, as compared to dry shelled corn. Feed consumption was 7% lower for the high moisture harvested shelled corn.

High moisture harvesting has shown more promise for increasing rate of gain and feed efficiency for ear corn than for shelled corn. A summary of seven trials comparing high moisture harvested ground ear corn to dry ear corn indicated an advantage of 3% in rate of gain and 8% in feed efficiency for high moisture harvested ground ear corn.

CHAPTER III

MATERIALS AND METHODS

General

Three trials were conducted to determine the effect of grain processing method on the feeding value of milo for fattening beef cattle. Evaluation of the processing method was by feedlot performance, carcass merit and net energy. The three trials will be identified as follows: Trial I — Stillwater, 1967-68; Trial II — Fort Reno, 1967-68; Trial III — Stillwater, 1968. Experimental procedures common to all three trials will be discussed under the headings of allotment, feeding, grain processing methods, data obtained, and net energy determination, followed by a discussion of procedures specific for each trial under the same headings.

Allotment

Angus, Hereford, crossbred (Angus X Hereford) steers, and Angus and Hereford heifers were used in Trial I. Crossbred (Angus X Hereford) and Hereford steers were used in Trial II. The calves in Trials I and II were from the University experimental herds located at the Fort Reno Station and the Lake Carl Blackwell Range. Hereford, Angus, and crossbred (Angus X Hereford) heifers were used in

Trial III. These heifers were purchased at the Oklahoma City Stockyards. A randomized complete block design was used in all trials. The calves were blocked on the basis of weight, sex and condition score and randomly assigned to treatment within each block.

Feeding

In all three trials, a high concentrate ration of 90% concentrate and 10% roughage was fed *ad libitum*.

All animals had access to an open-sided shed, outside lot and automatic waterers with thermostatically controlled heating during the winter.

Grain Processing Methods

Finely and extra finely ground milo were produced with a hammer mill, using 3.18 and 1.59 mm. screens, respectively. Dry rolled milo was produced by rolling air-dry whole milo with a roller tolerance in excess of 0.076 mm.

Reconstituted milo was obtained by adding water to the air-dry grain to raise the moisture to the appropriate level and then stored in oxygen-free conditions for at least 21 days. Prior to feeding, the high moisture harvested and reconstituted milo were either ground through a 3.18 mm. screen or rolled with approximately 0.076 mm. tolerance between the rollers.

Data Obtained

Performance data obtained were average daily gain, average daily feed intake, and feed per kg. of gain calculated both on a live shrunk weight basis and on an empty body weight basis. Empty body weight gain per kg. of feed and energy gained per kg. of feed were calculated so that a comparison of weight gain and energy gain could be made. Daily feed consumption records were kept. Initial and final weights were taken after a 16-hour shrink off feed and water. Intermediate weights were taken at 28-day intervals with water removed 16 hours prior to weighing.

All animals were slaughtered at the end of the feeding trials. Rumen weights, both intact and empty, were taken to allow calculation of rumen content. Following a 24-hour chill, carcass data obtained included carcass grade, marbling, ribeye area, fat thickness over the ribeye, chilled carcass weight and percent kidney fat. From this data, dressing percentage and cutability were calculated.[1] The right side of the carcass was then quartered, weighed first in air, and then in water to allow calculation of carcass specific gravity.

Dry matter of feeds was determined several times during each 28-day period. These determinations were averaged and used to adjust ration treatments to an equal dry matter

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[1]Cutability, or percent boneless retail cut yield, was estimated by the equation of Murphey <u>et al</u>. (1960), which is:

$$Y=51.34-(5.78 \times A)-(0.462 \times B)+(0.740 \times C)-(0.0093 \times D)$$

where:

Y=boneless retail cuts, as % of carcass
A=average fat thickness over ribeye (in.)
B=% kidney fat
C=ribeye area (sq. in.)
D=chilled carcass weight (lb.)

content. Grains were sieved and weights per bushel were taken to characterize the processed grains as to particle size and density, respectively.

Duncan's New Multiple Range Test (Steel and Torrie, 1960) was used to compare treatment means whenever a significant F value was obtained.

Net Energy Determination

A representative slaughter sample was used to estimate the initial composition of the experimental animals.

The weight of the rumen contents was subtracted from live shrunk weight to obtain empty body weight. Carcass specific gravities were calculated by dividing carcass weight in air by carcass weight in air minus carcass weight in water.

After completing the feeding trial, all animals were slaughtered and subjected to essentially the same procedure as described for the slaughter group.

All net energy calculations and equations used for body composition are the same as those used by Newsom (1968).

The net energy of each type of processed milo was calculated by using the mean values for each animal within each treatment. A computer program was used to make all net energy calculations.

Trial I

Allotment

Fifteen Angus steers, six Hereford steers, three crossbred (Angus X Hereford) steers, six Angus heifers and six Hereford heifers, averaging 187.7 kg., were started on trial November 16, 1967 to compare three types of processed milo fed in a high concentrate ration. The experimental design is shown in Table IX.

TABLE IX

TRIAL I: EXPERIMENTAL DESIGN SHOWING NUMBER OF ANIMALS PER TREATMENT

Blocks	Processed Milo Finely Ground	 Recon.-Ground	 Ground-Recon.	Total Number
1	4	4	4	12
2	4	4	3[a]	11
3	4	4	3[a]	11
	12	12	10	34

[a]One steer died of bloat.

The calves were first separated into groups of three according to sex, breed, weight and age of dam and sire. The treatments were then randomly assigned within these groups of three. The 12 heaviest Angus steers, the 12 heifers and the 12 lightest steers were placed in blocks one, two and three, respectively.

<u>Feeding</u>

The three types of processed milo — finely ground, reconstituted-ground and ground-reconstituted — were fed in a 90% concentrate mixture. The non-milo ingredients in the ration were combined into a premix. The composition of the premix and the complete ration is shown in Table X. The proximate analyses of the premix and the processed milo are shown in Table XI.

TABLE X

TRIAL I: RATION COMPOSITION

Ingredient	Percent
Milo	83.0
Dehydrated alfalfa pellets (17% C.P.)	6.4
Cottonseed hulls	4.2
Cottonseed meal (41% C.P.)	4.2
Urea (45% Nitrogen)	1.0
Salt	0.6
Steamed bonemeal	0.6
	100.0
Added per lb. of ration	
Vitamin A	2040 I.U.
Aureomycin	5 mg.

TABLE XI

TRIAL I: PERCENT PROXIMATE ANALYSES OF FEEDS ON DRY MATTER BASIS

Feedstuff	Dry Matter[a]	Ash[b]	Crude Protein[b]	Ether Extract[b]	Crude Fiber[b]	N.F.E.[c]
Milo						
Finely ground	87.4	1.43	9.92	3.55	2.80	82.30
Recon.-ground	71.8	0.89	8.53	2.70	1.85	86.03
Ground-recon.	67.6	0.95	8.68	3.25	2.00	85.12
Premix	90.5	11.55	29.73	6.35	22.80	29.57

[a]Average of 24 determinations.

[b]Average of two determinations.

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

The calves were started on feed eight days before the trial began. For the first five days of the pretrial feeding period, the calves were on a starter ration consisting of 50.0% finely ground milo, 20.0% dehydrated alfalfa pellets, 5.0% cottonseed meal, 24.0% cottonseed hulls, 0.5% salt and 0.5% bonemeal. The last three days of the pretrial period, the calves were gradually changed over to the test rations.

The three rations were fed daily in quantities to assure availability of feed until the next feeding. Unconsumed feed was weighed back frequently to assure that fresh feed was available at all times. The reconstituted-ground milo was ground daily except that enough was processed on Friday to supply the amount needed over the weekend.

Processing

The ground-reconstituted milo was produced by adding water to the air-dry, finely ground milo to raise the moisture level to 30%. The ground-reconstituted milo was then stored in oxygen-free conditions for at least 21 days prior to feeding.

The reconstituted-ground milo was produced by adding water to the air-dry whole milo to raise the moisture level to 30%. The reconstituted whole milo was then stored in oxygen-free conditions 21 days and then ground just prior to feeding.

All of the reconstituted grain was stored in airtight plastic bags with 40.8 kg. per bag.

All milo used in this study was obtained from the Stillwater Milling Company in one or two ton quantities as needed.

Data Obtained

The experimental animals were slaughtered on May 22, 1968 after 189 days on feed. All variables, including performance data, carcass data and net energy values, were subjected to a hierarchical analysis of variance and an abbreviated Doolittle as described by Newsom (1968). Analyses of variance components are shown in Table XII.

TABLE XII

TRIAL I: ANALYSES OF VARIANCE

Source	df
For Feed Intake, Feed/Kg. Gain and Net Energy Values:	
Total	8
Blocks	2
Treatment	2
Block X Treatment[a]	4
For Average Daily Gain and Carcass Data:	
Total	33
Blocks	2
Treatment	2
Block X Treatment[a]	4
Within pen	25

[a]Error term used to test treatments.

Two calves on the ground-reconstituted milo died during the experiment due to bloat. The feed records were adjusted by subtracting the estimated intake of the dead calves, which was the average intake of the four calves in the pen, from the total pen intake.

After the trial was started, one steer on the finely ground milo was found to have one testicle. His average daily gain and feed required per kg. of gain were adjusted to a steer equivalent.[2]

Table XIII illustrates the relative density and particle size of the processed milo fed in Trial I.

Net Energy Determination

The slaughter group used for estimating initial composition was the same as for Trials III and IV (Newsom, 1968).

For the 34 experimental animals which completed the test in Trial I, rumen weights were taken to the nearest one-fourth lb. The carcass quarters were weighed in air to the nearest one-fourth lb. and the quarters of the right side were weighed in water to the nearest five gm.

The NE_{m+p} and NE_m values of the premix were estimated

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[2]Using data taken from a trial at the Fort Reno station comparing steers, bulls and heifers (Tanner *et al.*, 1967), a correction factor (C.F.) was obtained.

$$\frac{\text{ADG steers}}{\text{ADG bulls}} \quad \frac{1.11 \text{ kg.}}{1.31 \text{ kg.}} = 0.854 \text{ (C.F.)}$$

The actual average daily gain of the animal in question was multiplied by this C.F. to obtain his adjusted ADG. His intake was divided by the adjusted gain to obtain adjusted feed per kg. of gain.

TABLE XIII

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

Process	Screen Size (mm.)						lb. per bu.
	3.18	2.12	1.41	1.02	0.36	thru 0.36	
	Percent Retained on Screen						
Finely ground	0	0.2	8.4	37.2	32.4	21.8	42.7
Recon.-ground	7.1	27.1	28.3	14.6	17.6	5.3	26.4
Ground-recon.	1.5	2.2	17.8	37.9	34.4	6.2	34.9

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

[b]Test weights reported are the average of six determinations and are on a 90% dry matter basis.

to be 918.9 (Morrison, 1959) and 1069.6 (Lofgreen and Garrett, 1967) kcal. per kg., respectively.

Since feed intake was on a pen basis, net energy values are valid only for a pen of animals. The computer program was designed to use the mean intake of a pen of animals to compare with the caloric gain and maintenance requirement of each animal. The net energy values were then averaged for each treatment.

Trial II

Allotment

Seventy-four Hereford steers and eight crossbred (Angus X Hereford) steers, averaging 230.9 kg., were started on trial December 12, 1967 to compare seven types of processed milo fed in a high concentrate ration. Twelve head were on each treatment, in four pens of three head each, arranged in a randomized block design as shown in Table XIV.

The 84 calves were selected from a total of 90 head. The 90 head were plotted on graph paper with shrunk weight and condition score as the X and Y axes, respectively, and then divided by diagonal lines into two blocks, with the heaviest steers and the highest condition score making up one block and the lightest steers with the lowest condition score making up the second block. The six calves with the lowest condition score and lightest in weight were not put on trial.

TABLE XIV

TRIAL II: EXPERIMENTAL DESIGN SHOWING NUMBER OF ANIMALS PER TREATMENT

Blocks	Processed Milo							Total Number
	Coarsely Rolled	Finely Ground	Extra Finely Ground	HMH-Ground	HMH-Rolled	Recon.-Ground	Recon.-Rolled	
1	6	6	6	6	6	6	5[a]	41
2	6	6	5[a]	5[a]	6	6	6	40
								81

[a]One steer died.

Feeding

The seven types of processed milo were fed in a 90% concentrate mixture. The non-milo ingredients in the ration were combined into a premix. The composition of the premix and the complete ration is shown in Table XV. The proximate analyses of the premix and the processed milo are shown in Table XVI.

TABLE XV

TRIAL II: RATION COMPOSITION

Ingredient	Percent
Milo	83.4
Alfalfa hay, chopped	6.0
Cottonseed hulls	4.0
Cottonseed meal	4.0
Urea (42% Nitrogen)	1.0
Salt	1.0
Bonemeal	0.6
	100.0
Added per lb. of ration	
Vitamin A	1500 I.U.
Aureomycin	5 mg.

TABLE XVI

TRIAL II: PERCENT PROXIMATE ANALYSES OF FEEDS ON DRY MATTER BASIS

Feedstuff	Dry Matter[a]	Ash[b]	Crude Protein[b]	Ether Extract[b]	Crude Fiber[b]	N.F.E.[c]
Milo						
Coarsely rolled	85.3	1.37	8.86	3.85	1.95	83.97
Finely ground	85.5	1.16	9.35	3.00	2.10	84.39
Extra finely ground	85.5	1.31	10.28	3.65	1.95	82.81
HMH-ground	70.1	0.94	8.36	2.30	1.10	87.30
HMH-rolled	68.9	0.91	8.06	1.80	0.85	88.38
Recon.-ground	74.3	1.27	8.77	3.40	1.45	85.11
Recon.-rolled	73.4	1.03	9.05	2.90	1.40	85.62
Premix	90.9	10.82	36.70	6.05	25.29	21.14

[a]Average of 24 determinations.

[b]Average of two determinations.

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

The steers were started on feed six days before the trial began. The initial ration consisted of eight lb. of test ration and four lb. of cottonseed hulls per head per day. The test ration was increased gradually until the steers were receiving 13 lb. of test ration on the sixth day following initial feeding.

The four "wet" grains, high moisture harvested-ground, high moisture harvested-rolled, reconstituted-ground and reconstituted-rolled, were processed daily, with the exception that enough was processed on Friday to feed over the weekend.

The coarsely rolled, finely ground and extra finely ground grains were processed, combined with premix, and stored in one ton quantities.

The steers were fed once daily in sufficient quantities to assure availability of feed until the next feeding. Feed was weighed to the nearest pound. Unconsumed feed was weighed back and removed as necessary to assure fresh feed. Dry matter determinations were taken every 28 days and used to adjust all rations to an equivalent dry matter content.

Processing

The extra finely ground milo used in this trial was produced by grinding dry milo through a hammer mill with a 1.59 mm. screen. The coarsely rolled milo was produced by rolling dry milo through a roller mill to allow approximately 25% of the grain to fall through unbroken.

The reconstituted milo was produced by adding water to air-dry milo as it was augered into a 4.3 X 8.2 m. Harvestore glass-lined, airtight silo. The moisture content was raised from 14 to 28%.

The high moisture harvested milo was combined at approximately 32% moisture. After harvesting, it was stored in a 4.3 X 8.2 m. Harvestore glass-lined, airtight silo.

All milo used in this study was of the variety Northrup King 222 and was grown on the Fort Reno station.

Data Obtained

The steers were slaughtered on two different days after an average of 174 days on feed.

Three steers died due to bloat during the feeding trial, one each on reconstituted-rolled, high moisture harvested-ground and extra finely ground milo. The feed records were adjusted by subtracting the estimated intake of the deceased steer, which was the average intake of the three calves in the pen, from the total pen intake.

Analysis of variance procedures were the same as those for Trial I (page 24). Variance components are shown in Table XVII.

The relative density and particle size of the processed milo are shown in Table XVIII.

Net Energy Determination

The slaughter group and the procedures for net energy determination were the same as those used for Trial I (page 25).

The NE_{m+p} and NE_m values of the premix were estimated to be 839.3 (Morrison, 1959) and 970.4 (Lofgreen and Garrett, 1967) kcal. per kg., respectively.

TABLE XVII

TRIAL II: ANALYSES OF VARIANCE

Source	df
For Feed Intake, Feed/Kg. Gain and Net Energy Values:	
Total	13
Blocks	1
Treatments	6
Block X Treatment[a]	6
For Average Daily Gain and Carcass Data:	
Total	81
Blocks	1
Treatment	6
Block X Treatment[a]	6
Within pen	68

[a]Error term used to test treatments.

TABLE XVIII

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

Process	Screen Size (mm.) 4.76	3.18	2.12	1.41	1.02	0.36	thru 0.36	lb. per bu.
	Percent Retained on Screen							
Coarsely rolled	0	33.40	59.80	5.80	0.62	0.17	0.18	53.3
Finely ground	0	0.14	0.90	9.64	18.10	32.60	38.60	44.7
Extra finely ground	0	0.12	0.12	0.39	4.17	28.60	66.60	40.8
HMH-ground	0	0.56	1.90	5.90	9.00	18.30	64.30	31.3
HMH-rolled	6.20	26.60	19.80	7.80	3.30	9.00	27.20	27.8
Recon.-ground	0	0.19	1.00	11.60	14.70	22.80	49.70	37.6
Recon.-rolled	4.60	27.20	24.30	10.90	3.80	7.20	22.00	30.1

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

[b]Test weights reported are the average of four determinations and are on 90% dry matter basis.

Trial III

Allotment

Twenty-two Angus, twenty Hereford and eight crossbred (Angus X Hereford) heifers were started on trial July 2, 1968 to compare five types of processed milo in a high concentrate ration. The initial weight of the heifers was 170.9 kg. The experimental design is shown in Table XIX.

TABLE XIX

TRIAL III: EXPERIMENTAL DESIGN SHOWING NUMBER OF ANIMALS PER TREATMENT

Blocks	Processed Milo					Total Number
	Dry Rolled	Recon.- 22%	Recon.- 30%	Recon.- 38%	Recon.- 38%-1-day	
1	5	5	5	5	5	25
2	5	5	4[a]	5	5	24
						49

[a]One heifer died after completion of performance data; pen average used in calculating net energy values and carcass data.

The three groups (Angus, Hereford and crossbred heifers) were blocked independently into two blocks based on weight and condition, using the same method that was used in Trial II (page 27). Two Angus heifers were selected at random to put in the crossbred group.

Feeding

The five types of processed milo were fed in a 90% concentrate mixture. The non-milo ingredients in the ration were combined into a premix. The composition of the premix and the complete ration is shown in Table XX. The proximate analyses of the premix and the processed milo are shown in Table XXI.

TABLE XX

TRIAL III: RATION COMPOSITION

Ingredient	Percent
Milo	84.00
Dehydrated alfalfa pellet crumbles (17% C.P.)	4.93
Cottonseed hulls	4.93
Soybean meal crumbles (44% C.P.)	4.30
Urea (45% Nitrogen)	0.64
Salt	0.60
Bonemeal	0.60
	100.0
Added per lb. of ration	
Vitamin A	1600 I.U.
Aureomycin	5 mg.

TABLE XXI

TRIAL III: PERCENT PROXIMATE ANALYSES OF FEEDS ON DRY MATTER BASIS

Feedstuff	Dry Matter[a]	Ash[b]	Crude Protein[b]	Ether Extract[b]	Crude Fiber[b]	N.F.E.[c]
Milo						
Dry rolled	86.9	1.34	10.84	3.11	1.52	83.19
Recon.-22%	77.3	1.08	10.51	3.08	1.50	83.83
Recon.-30%	68.6	0.77	7.74	2.79	1.11	87.59
Recon.-38%	62.0	0.61	8.45	2.41	1.02	87.51
Recon.-38%-1-day	64.7	0.64	7.75	2.41	0.90	88.30
Premix	89.9	7.53	37.46	2.31	18.48	34.22

[a] Average of 16 determinations.

[b] Average of two determinations.

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

The calves were put on a starter ration consisting of 40% dehydrated alfalfa pellets, 10% cottonseed meal, 48% cottonseed hulls, 1% salt and 1% bonemeal for 20 days prior to the start of the trial. At this point, the processed milo was introduced into the ration at the rate of 10%. The milo was increased 5% per day until the calves were on full feed.

The five rations were processed and fed daily in quantities to assure availability of feed until the next feeding. Unconsumed feed was weighed back daily and removed to assure fresh feed was available at all times.

Processing

The 22 and 30% reconstituted milo was produced by adding the necessary amount of water to air-dry milo and mixing in a cement mixer. The 38% reconstituted milo was produced by soaking the air-dry whole milo approximately 10 hours. The 22, 30 and 38% reconstituted whole milo was then stored under oxygen-free conditions in airtight plastic bags for 21 days or more.

The reconstituted-1-day milo was produced by soaking whole air-dry milo 12 hours and then letting it set in a 0.91 m. X 0.60 m. X 0.30 m. open container for 24 hours prior to rolling and feeding.

All milo used in this study was obtained from the Stillwater Milling Company in one or two ton quantities as needed.

Data Obtained

Performance data was summarized after an average of 112 days on feed. The heifers were then subjected to measurement by the K^{40} counter and ultrasonic equipment prior to slaughter. The cattle were removed in two different groups, with the heavy block being slaughtered first.

One heifer died of heat stress following the K^{40} and ultrasonic measurement. Her data is included in feedlot performance, but a pen average was used in net energy and carcass data. All variables were subjected to a factorial analysis of variance. The analyses of variance components are shown in Table XXII.

TABLE XXII

TRIAL III: ANALYSES OF VARIANCE

Source	df
For Feed Intake, Feed/Kg. Gain and Net Energy Values:	
Total	9
Blocks	1
Treatment	4
Block X Treatment[a]	4
For Average Daily Gain and Carcass Data:	
Total	48
Blocks	1
Treatment	4
Block X Treatment[a]	4
Within pen	39

[a]Error term used to test treatments.

The relative density and particle size of the processed milo are shown in Table XXIII.

Net Energy Determination

Six calves were slaughtered to estimate the initial caloric content of the experimental heifers in Trial III. The slaughter group was selected at random from the 56 head.

The procedures used for net energy calculations and body composition were the same as used by Newsom (1968).

The NE_{m+p} and NE_m values of the premix were estimated to be 978.9 (Morrison, 1959) and 1108.9 (Lofgreen and Garrett, 1967) kcal. per kg., respectively.

TABLE XXIII

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

Process	Screen Size (mm.) 4	2	1	0.5	0.25	0.125	thru 0.125	lb. per bu.
	Percent Retained on Screen							
Dry rolled	0.3	30.9	61.8	3.0	3.0	0.5	0.5	40.7
Recon.-22%	42.8	43.8	6.1	2.8	3.1	1.4	0	27.2
Recon.-30%	41.4	35.5	8.6	9.3	4.9	0.3	0	24.5
Recon.-38%	50.2	38.7	5.9	4.2	1.0	0	0	22.3
Recon.-38%-1-day	0.3	43.3	41.6	8.2	4.5	2.1	0	23.1

[a]Particle size: Four 100 gm. samples of each grain were seived.

[b]Test weights reported are the average of six determinations and are on a 90% dry matter basis.

CHAPTER IV

RESULTS

Trial I

Feedlot Performance

Feedlot performance of the calves fed the three types of processed milo is shown in Table XXIV. Significant F values were obtained for average daily gain ($P<.05$) and feed/kg. empty body weight gain ($P<.05$). Comparison of treatment means indicated the calves on reconstituted-ground milo gained significantly ($P<.05$) faster than those on ground-reconstituted milo. The calves on the reconstituted-ground milo ration required significantly ($P<.05$) less feed per kg. of empty body weight gain than those on the ground-reconstituted milo ration; the calves on the finely ground milo ration were intermediate between the other two treatments. The average daily intake of the total ration and grain was almost identical for the three treatments. Although the differences in feed/kg. of gain of total ration were not significant ($P<.05$) on a shrunk weight basis, the calves on reconstituted-ground milo required 9.0% less feed/kg. of gain than those on the finely ground treatment.

Net Energy

Net energy values of the three types of processed milo

TABLE XXIV

TRIAL I: FEEDLOT PERFORMANCE (189 DAYS)

Item	Finely Ground[a]	Recon.-Ground[b]	Ground-Recon.[c]	$s_{\bar{x}}$[d]	F[e]
No. steers	12	12	10		
Initial live shrunk wt., kg.	185.90	188.80	189.90		
Final live shrunk wt., kg.	386.50	408.40	385.80		
Average daily gain, kg.[g]	1.02[1,2]	1.14[2]	1.00[1]	0.04	7.40[f]
Average daily intake (total ration), kg.	6.64	6.63	6.70	0.14	0.04
Average daily intake (grain), kg.	5.48	5.51	5.50	0.11	0.08
Feed/kg. gain (total ration), kg.	6.34	5.77	6.56	0.19	3.86
Feed/kg. gain (grain), kg.	5.23	4.79	5.39	0.14	2.56
Initial empty body wt., kg.	174.90	177.70	178.70		
Final empty body wt., kg.	366.50	387.60	367.80		
Average daily EBW gain, kg.	1.01	1.11	1.00	0.04	5.92
Feed/kg. EBW gain (total ration), kg.[g]	6.64[1,2]	6.02[1]	6.80[2]	0.17	7.27[f]
Feed/kg. EBW gain (grain), kg.	5.47	5.00	5.58	0.13	6.39

[a]Dry milo ground through 3.18 mm. screen.

[b]Dry milo was reconstituted whole, stored 21 days, and ground through 3.18 mm. screen just prior to feeding.

[c]Dry milo was ground through a 3.18 mm. screen, reconstituted, stored for 21 days and then fed.

[d]Standard error of treatment means.

[e]Calculated F value from analysis of variance.

[f]Significant (P<.05).

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

are shown in Table XXV. Differences in net energy values were nonsignificant (P>.05). The NE_p value of finely ground milo was 114.8 megcal./100 kg. The NE_p values of ground-reconstituted and reconstituted-ground milo were 3.0% and 13.9% greater, respectively, than the NE_p of finely ground milo.

Carcass Merit

Apparently treatment had no affect on carcass merit for the criteria shown in Table XXVI. None of the F values for any of the carcass traits approached significance (P>.05).

Trial II

Feedlot Performance

Feedlot performance of the calves fed the seven types of processed milo is shown in Table XXVII. Significant (P<.05) F values were obtained for average daily intake of both total ration and grain. Differences in total ration/kg. of gain and grain/kg. of gain were also significant (P<.05). Comparison of treatment means indicated that the calves on high moisture harvested-ground milo consumed significantly less total ration and grain than those on the other six treatments. The feed consumption of the calves on extra finely ground, high moisture harvested-rolled and reconstituted-ground milo was very similar. The feed intake of coarsely rolled and finely ground milo was significantly higher than that of the other five treatments. Feed/kg. of

TABLE XXV

TRIAL I: NET ENERGY VALUES OF PROCESSED MILO

Net Energy Value	Finely Ground	Recon.-Ground	Ground-Recon.	$s_{\bar{x}}$[a]	F[b]
	--------Megcal./100 kg.----------				
NE_{m+p} of total ration[c]	140.7	157.2	148.5	5.41	2.64
NE_{m+p} of milo[d]	158.7	170.5	160.8	6.55	2.38
NE_m of milo[e]	172.2	196.0	177.5	--	--
NE_p of milo[f]	114.8	130.7	118.3	8.15	2.69

[a]Standard error of treatment means.

[b]Calculated F value from analysis of variance.

[c]Energy for gain and maintenance ÷ intake of total ration.

[d](Energy for gain and maintenance - energy attributed to basal) ÷ intake of milo.

[e]NE_p X 1.50, (1.50 = ratio of NE_m to NE_p on basis of av. crude fiber content).

[f]Determined by dividing maintenance requirement and energy gained between milo and premix on basis of ratio in ration (83% milo, 17% premix).

TABLE XXVI

TRIAL I: CARCASS MERIT

Item	Finely Ground	Recon.-Ground	Ground-Recon.	$s_{\bar{x}}$[a]	F[b]
No. steers	12	12	10		
Dressing %[c]	61.29	61.72	61.89	0.58	1.67
Carcass grade[d]	10.54	10.05	9.87	0.28	0.72
Ribeye area, sq. in.[e]	10.24	11.14	10.66	0.19	0.69
Fat thickness, in.[f]	0.67	0.81	0.80	0.05	2.81
Marbling[g]	13.67	13.50	14.00	0.60	0.19
Cutability, %[h]	49.04	48.51	48.35	0.22	3.15

[a]Standard error of treatment means.

[b]Calculated F value from analysis of variance.

[c]Calculated on basis of final live shrunk weight and chilled carcass weight.

[d]U.S.D.A. grades converted to following numerical designations: high prime-15, av. prime-14, low prime-13, high choice-12, av. choice-11, low choice-10, high good-9, av. good-8, low good-7.

[e]Determined by measurements of ribeye tracings at the 12th rib.

[f]Average of three measurements on ribeye tracings.

[g]Marbling scores, 1=devoid minus to 30=abundant plus, with 3 scores per classification (minus, average, plus).

[h]Percent of boneless trimmed retail cuts on carcass basis=51.78 - 5.78 (fat thickness) - 4.62 (% kidney fat) + .740 (ribeye area) - .0093 (chilled carcass wt.).

TABLE XXVII

TRIAL II: FEEDLOT PERFORMANCE

Item	Coarsely Rolled	Finely Ground	Extra Finely Ground	HMH-Ground	HMH-Rolled	Recon.-Ground	Recon.-Rolled	$s_{\bar{x}}$[a]	F[b]
No. steers	12	12	11	11	12	12	11		
No. days on feed	174	174	175	175	174	174	173		
Initial live shrunk wt., kg.	232.80	233.20	234.80	224.50	232.80	229.60	233.80		
Final live shrunk wt., kg.	409.30	421.70	412.00	401.60	440.60	411.60	444.90		
Average daily gain, kg.	1.01	1.06	0.99	0.99	1.17	1.02	1.19	0.05	2.52
Average daily intake (total ration), kg.[c]	7.65[4]	7.61[4]	6.65[2]	6.08[1]	6.87[2,3]	6.80[2,3]	7.11[3]	0.12	8.66[d]
Average daily intake (grain, kg.[c]	6.31[4]	6.29[4]	5.49[2]	5.03[1]	5.66[2,3]	5.68[2,3]	5.92[3]	0.10	8.53[d]
Feed/kg. gain (total ration), kg[c]	7.60[4]	7.12[3,4]	6.64[3]	6.47[2,3]	5.78[1]	6.60[3]	5.92[1,2]	0.20	8.62[d]
Feed/kg. gain (grain), kg.[c]	6.27[4]	5.88[3,4]	5.48[2,3]	5.35[2,3]	4.76[1]	5.51[3]	4.92[1,2]	0.16	8.50[d]
Initial empty body wt., kg.	218.70	219.10	220.60	211.00	218.70	215.70	219.60		
Final empty body wt., kg.	394.50	405.10	393.00	382.80	423.40	393.80	427.30		
Average daily EBW gain, kg.	1.01	1.06	0.99	0.98	1.17	1.02	1.19	0.05	2.77
Feed/kg. EBW gain (total ration), kg.	7.61	7.20	6.82	6.66	5.86	6.73	6.01	0.32	3.77
Feed/kg. EBW gain (grain), kg.	6.28	5.95	5.63	5.51	4.82	5.62	5.00	0.27	3.66

[a]Standard error of treatment means.

[b]Calculated F value from analysis of variance.

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

[d]Significant (P<.05).

gain for the high moisture harvested-rolled and reconstituted-rolled grains was significantly lower than that for the dry processed grains. Feed/kg. of gain of high moisture harvested-ground and reconstituted-ground milo was significantly lower ($P<.05$) than on coarsely rolled milo.

Although differences in rate of gain were not significant ($P>.05$), calves fed high moisture harvested-rolled and reconstituted-rolled milo gained 10.3 and 12.0% faster, respectively, than calves fed finely ground milo. Rates of gain were very similar for the other treatments.

Net Energy

Calculated net energy values of the seven types of processed milo are shown in Table XXVIII. Significant F values ($P<.05$) were obtained for NE_{m+p} of total ration, NE_{m+p} of milo and NE_p of milo. Comparison of treatment means indicated that extra finely ground, high moisture harvested-ground, high moisture harvested-rolled and reconstituted-rolled milo were significantly ($P<.05$) higher than coarsely rolled and finely ground milo for all three net energy values. Also, reconstituted-ground milo was significantly ($P<.05$) higher than coarsely rolled milo for all three values.

Coarsely rolled milo produced an estimated NE_p value of 90.4 megcal./100 kg. Increases in NE_p for the six other processing methods, compared to coarsely rolled milo, were as follows: finely ground, 5.4%; reconstituted-ground, 24.8%; extra finely ground, 30.6%; reconstituted-rolled,

TABLE XXVIII

TRIAL II: NET ENERGY VALUES OF PROCESSED MILO

Net Energy Value	Coarsely Rolled	Finely Ground	Extra Finely Ground	HMH-Ground	HMH-Rolled	Recon.-Ground	Recon.-Rolled	$s_{\bar{x}}$[a]	F[b]
	-----------------	Megcal./100 kg.	-----------------						
NE_{m+p} of total ration[c,g]	130.6[1]	134.4[1,2]	151.3[3]	157.1[3]	157.3[3]	147.2[2,3]	156.1[3]	3.83	8.64[h]
NE_{m+p} of milo[d,g]	140.6[1]	145.0[1,2]	165.6[3]	172.5[3]	173.0[3]	159.7[2,3]	170.6[3]	4.58	8.74[h]
NE_m of milo[e]	135.6	143.0	177.2	188.4	192.5	169.2	191.6	--	--
NE_p of milo[f,g]	90.4[1]	95.3[1,2]	118.1[3]	125.6[3]	128.3[3]	112.8[2,3]	127.7[3]	5.74	7.59[h]

[a]Standard error of treatment means.

[b]Calculated F value from analysis of variance.

[c]Energy for gain and maintenance ÷ intake of total ration.

[d](Energy for gain and maintenance - energy attributed to basal) ÷ intake of milo.

[e]NE_p X 1.50, (1.50 = ratio of NE_m to NE_p on basis of av. crude fiber content).

[f]Determined by dividing maintenance requirement and energy gained between milo and premix on basis of ratio in ration (83% milo, 17% premix).

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

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

41.3%; and high moisture harvested-rolled, 41.9%.

Carcass Merit

The seven types of processed milo fed in this trial produced carcasses that were not significantly (P<.05) different for any of the criteria shown in Table XXIX.

Trial III

Feedlot Performance

Feedlot performance of the steers fed the five types of processed milo is shown in Table XXX. Significant (P<.05) F values were obtained for total ration/kg. of gain and grain/kg. of gain. Comparison of treatment means indicated that the feed efficiency of the reconstituted 30 and 38% milo was significantly improved over dry rolled, 22 and 38%-1-day milo.

Although differences in rate of gain were not significant (P>.05), 22% milo produced gain 8.0% higher than dry rolled milo. Rates of gain for the 30, 38 and 38%-1-day reconstituted milo were 2.4, 7.6 and 2.4% lower, respectively, than dry rolled milo. The heifers on 30 and 38% milo consumed 15.0 and 19.1% less feed, respectively, but because of similar gain, were 11.8 and 12.5% more efficient in utilizing feed than the heifers on dry rolled milo. Feed intake and feed efficiency were similar for the cattle on dry rolled, 22 and 38%-1-day milo.

Feed efficiency values expressed as total ration or grain/kg. of empty body weight gain produced results

TABLE XXIX

TRIAL II: CARCASS MERIT

Item	Coarsely Rolled	Finely Ground	Extra Finely Ground	HMH-Ground	HMH-Rolled	Recon.-Ground	Recon.-Rolled	$s_{\bar{x}}$[a]	F[b]
No. steers	12	12	11	11	12	12	11		
Dressing %[c]	59.63	59.29	59.07	61.43	60.22	59.12	59.94	2.26	0.91
Carcass grade[d]	9.16	9.67	9.00	9.45	9.75	9.25	9.82	0.31	1.07
Ribeye area, sq.in.[e]	10.55	10.45	10.68	10.32	11.21	10.25	10.70	0.17	3.63
Fat thickness, in.[f]	0.62	0.72	0.63	0.60	0.67	0.64	0.72	0.59	0.67
Marbling[g]	12.08	13.08	11.91	12.55	13.42	12.17	14.64	0.39	0.62
Cutability, %[h]	49.52	48.68	49.58	49.48	49.28	49.31	49.87	0.41	0.74

[a]Standard error of treatment means.

[b]Calculated F value from analysis of variance.

[c]Calculated on basis of final live shrunk weight and chilled carcass weight.

[d]U.S.D.A. carcass grades converted to following numerical designations: high prime=15, av. prime=14, low prime=13, high choice=12, av. choice=11, low choice=10, high good=9, av. good=8, low good=7.

[e]Determined by measurements of ribeye tracings at the 12th rib.

[f]Average of three measurements on ribeye tracings.

[g]Marbling scores, 1=devoid minus to 30=abundant plus, with 3 scores per classification (minus, average, plus).

[h]Percent of boneless trimmed retail cuts on carcass basis=51.34 - 5.78 (fat thickness) -4.62 (% kidney fat) + .740 (ribeye area) - .0093 (chilled carcass wt.).

TABLE XXX

TRIAL III: FEEDLOT PERFORMANCE (112 DAYS)

Item	Dry Rolled	Recon.-22%	Recon.-30%	Recon.-38%	Recon.-38%-1-day	$s_{\bar{x}}$[a]	F[b]
No. heifers	10	10	10	10	10		
Initial live shrunk wt.,kg.	172.10	170.30	173.00	166.00	172.80		
Final live shrunk wt.,kg.	299.40	308.20	297.80	289.60	296.70		
Av. daily gain, kg.	1.14	1.23	1.11	1.05	1.11	0.05	1.65
Av. daily intake, kg.[g]	7.63	7.90	6.48	6.17	7.29	0.39	4.00
Av daily intake, kg.[h]	6.41	6.62	5.43	5.18	6.16	0.33	4.02
Feed/kg. gain, kg.[e,g]	6.78[2]	6.51[1,2]	5.98[1]	5.96[1]	6.62[2]	0.16	6.42[c]
Feed/kg. gain, kg.[e,h]	5.70[2]	5.46[1,2]	5.01[1]	5.00[1]	5.60[2]	0.13	6.68[c]
Initial empty body wt.,kg.	158.20	156.50	159.00	152.60	158.80	--	--
Final empty body wt.,kg.	287.10	295.80	286.50	278.00	283.00	--	--
Av. daily EBW gain, kg.	1.15	1.24	1.13	1.07	1.11	0.05	1.61
Feed/kg. EBW gain, kg.[e,g]	6.70[2]	6.44[2]	5.80[1]	5.88[1]	6.62[2]	0.11	15.26[c]
Feed/kg. EBW gain, kg.[f,h]	5.62[2]	5.40[2]	4.86[1]	4.93[1]	5.59[2]	0.09	16.71[d]

[a]Standard error of treatment means.

[b]Calculated F value from analysis of variance.

[c]Significant (P<.05).

[d]Significant (P<.01).

[e]Any 2 means without a common number differ significantly (P<.05).

[f]Any 2 means without a common number differ significantly (P<.01).

[g]Total ration.

[h]Grain.

similar to those previously discussed on a shrunk weight basis.

Net Energy

The calculated net energy values of the five types of processed milo are shown in Table XXXI. Significant F values were obtained for NE_{m+p} of the total ration and NE_{m+p} of the milo. Comparison of the treatment means indicated that the NE_{m+p} of the total ration and the milo was significantly higher for 30 and 38% milo than for dry rolled and 22% milo.

Dry rolled milo produced an estimated NE_p value of 109.4 megcal./100 kg. Comparison of the other four processing methods with dry rolled indicated increases in NE_p as follows: 38%-1-day milo, 6.4%; 22% milo, 7.8%; 30% milo, 34.8%; and 38% milo, 39.3%.

Carcass Merit

The five types of processed milo fed in this trial produced carcasses that were not significantly different for any of the criteria shown in Table XXXII.

TABLE XXXI

TRIAL III: NET ENERGY VALUES OF PROCESSED MILO

Net Energy Value	Dry Rolled	Recon.-22%	Recon.-30%	Recon.-38%	Recon.-38%-1-day	$s_{\bar{x}}$[a]	F[b]
	---------------Megcal./100 kg.---------------						
NE_{m+p} of total ration[c,g]	131.3[1]	135.8[1]	157.1[2]	156.6[2]	136.6[1]	5.04	6.68
NE_{m+p} of milo[d,g]	137.6[1]	143.1[1]	168.7[3]	167.7[2,3]	143.6[1,2]	6.04	6.70
NE_m of milo[e]	164.1	176.9	221.3	228.6	174.6	--	--
NE_p of milo[f]	109.4	117.9	147.5	152.4	116.4	9.71	4.58

[a]Standard error of treatment means.

[b]Calculated F value from analysis of variance.

[c]Energy for gain and maintenance ÷ intake of total ration.

[d](Energy for gain and maintenance - energy attributed to basal) ÷ intake of milo.

[e]NE_p X 1.50, (1.50 = ratio of NE_m to NE_p on basis of av. crude fiber content).

[f]Determined by dividing maintenance requirement and energy gained between milo and premix on basis of ratio in ration (84% milo, 16% premix).

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

TABLE XXXII

TRIAL III: CARCASS MERIT

Item	Dry Rolled	Recon.-22%	Recon.-30%	Recon.-38%	Recon.-38%-1-day	$s_{\bar{x}}$[a]	F[b]
No. heifers	10	10	9	10	10		
Dressing %[c]	59.30	59.39	59.42	58.80	59.21	0.640	0.150
Carcass grade[d]	9.80	9.90	9.30	10.20	9.80	0.130	0.620
Ribeye area, sq. in.[e]	9.08	9.46	9.59	8.57	9.08	0.415	0.850
Fat thickness, in.[f]	0.60	0.63	0.56	0.61	0.61	0.064	0.184
Marbling[g]	13.70	14.30	13.80	15.10	13.60	0.406	1.270
Cutability, %[h]	50.00	50.22	50.41	49.64	50.24	1.890	0.760

[a]Standard error of treatment means.

[b]Calculated F value from analysis of variance.

[c]Calculated on basis of final live shrunk weight and chilled carcass weight.

[d]U.S.D.A. grades converted to following numerical designations: high prime-15, av. prime-14, low prime-13, high choice-12, av. choice-11, low choice-10, high good-9, av. good-8, low good-7.

[e]Determined by measurements of ribeye tracings at the 12th rib.

[f]Average of three measurements on ribeye tracings.

[g]Marbling scores, 1=devoid minus to 30=abundant plus, with 3 scores per classification (minus, average, plus).

[h]Percent of boneless trimmed retail cuts on carcass basis=51.78 - 5.78 (fat thickness) - 4.62 (% kidney fat) + .740 (ribeye area) - .0093 (chilled carcass wt.).

CHAPTER V

DISCUSSION

The air-dry milo, both ground and rolled, averaged 86.2% dry matter for the three trials. The moisture level of the reconstituted treatments for all trials varied from 22.7% for the reconstituted-22% milo to 38% for the reconstituted-38% milo in Trial III. The moisture level of the reconstituted milo in Trial I averaged 30.3%, while in Trial II the average was 26.1%. The high moisture harvested milo fed in Trial II averaged 30.5% moisture. It is interesting to note that efficiency improved as moisture was increased from 22 to 30% in Trial III. Previous *in vitro* work by Neuhaus (1968) indicated an increase in digestibility as moisture increased to 38%. The results of this feeding trial showed no advantage for increasing the moisture level from 30 to 38%; the available energy of the reconstituted-38% milo was similar to that of reconstituted-30% milo. The difference in results between the feeding trial and *in vitro* trial could possibly be due to the lower gain of the cattle on the reconstituted-38% milo compared to 30% milo (Table XXX). The process of reconstituting milo to these different moisture levels is of great practical significance. It is a relatively simple matter to raise the moisture level of milo to 22%, but raising it to 30% requires more elaborate equipment and much longer exposure to water before or during the ensiling process. A further increase to 38% moisture actually requires prolonged soaking of the grain for approximately 10 hours and would increase expense of processing.

The results of Trial II indicated that particle size is an important factor in processing dry milo. The extra finely ground milo improved utilization appreciably over finely ground and coarsely rolled milo. Previous feeding trial results comparing coarsely ground to finely ground milo showed a consistent advantage for the finer particles if the grain had been ground through a hammer mill (Baker et al, 1955, Smith et al., 1953 and Newsom, 1968). On the other hand, rolled grain consisting of very large particles is utilized as efficiently as grain which has been finely ground through a hammer mill (Smith and Parrish, 1953, Baker et al., 1955 and Newsom, 1968). Apparently the rolling of dry grain, as in the case of steamed grain, imparts some characteristic to milo which is beneficial to its utilization. However, the kernels must be broken; results of Trial II showed that very coarse rolling, with many (25%) kernels unbroken, resulted in decreased efficiency compared to finely ground grain.

All of the high moisture processing methods decreased the density of milo as compared to the respective dry control in each trial. In Trial I, the ground-reconstituted and reconstituted-ground milo grains were 18.0 and 38.0% less dense, respectively, than dry ground milo. There was considerably less fine material in the reconstituted-ground milo as compared to the other treatments. In Trial II the extra finely ground and the high moisture harvested-ground milo grains were very similar in particle size, but the fluffy nature of the high moisture grain was very evident as shown by the test weight per bushel (density) of the two processed grains, 40.8 and 31.3 lb. per bushel, respectively, for extra finely ground and high moisture harvested-ground milo. With the exception of ground-reconstituted milo in Trial I, feed efficiency improved as density was decreased. This same trend has been noted in steam flaking of milo (Hale et al., 1965) and steam flaking of corn (Matsushima and Montgomery, 1967) where a very flat flake was utilized more efficiently than a thick flake. In most cases, a decrease in density involves an increase in surface area which apparently is conducive to greater utilization of the grain. In the case of the 22, 30 and 38% reconstituted milo in Trial III, feed efficiency improved as moisture increased, with little change in particle size. These results indicated that density (pounds per bushel) is a more accurate indicator of utilization of high moisture processed grains than is particle size. Work by Neuhaus (1968) indicated that as particle size of dry milo decreased in vitro digestibility increased, but particle size of high moisture milo had no affect on in vitro digestibility.

Rolling of the high moisture processed grains markedly improved feed efficiency as compared to grinding the same high moisture processed grains in Trial II. This is consistent with results reported by Newsom (1968). The marked increase in rate of gain of the high moisture processed-rolled milo was not observed in previous trials (Newsom, 1968), and the increased rate of gain observed for high moisture processed-rolled grains in Trial II was not repeated in Trial III. Also, the improvement in efficiency for the reconstituted-rolled milo in Trial III was not as great as in Trial II. The roller mill used in Trial III was considerably lighter in weight and therefore could not exert as much pressure on the milo kernel. A decrease in roller pressure might result in less surface area of the grain being exposed and hence a lower digestibility of the grain. Neuhaus (1968) showed that as roller spacing decreased (and consequently pressure increased) the in vitro digestibility of high moisture grain improved. Roller pressure is also extremely important in increasing the digestibility of steam-flaked milo. Hale et al. (1965) reported a flat rolled product was distinctly superior to poorly rolled grain.

The results of Trial I indicated that reconstituting milo in the ground form at a moisture level of approximately 30% did not improve utilization compared to finely ground dry milo. Apparently the germination process is initiated in reconstituted whole grain, which causes a reduction of starch to simpler, more readily available carbohydrates.

The enzymatic pathways would be destroyed by grinding before reconstituting and this would prevent any beneficial effect from the reconstituting process. Penic et al. (1968) reported an improvement in feed efficiency of 11% for reconstituted whole milo as compared to dry ground milo; ground-reconstituted milo did not improve utilization compared to dry grain. Since high moisture whole milo cannot be stored in a trench silo without considerable spoilage, an airtight, upright structure is apparently needed for the successful reconstituting of milo.

In Trial II, it is interesting to note the similarity in feeding value of the high moisture harvested and reconstituted milo. The ground "wet" grains and the rolled "wet" grains improved feed efficiency approximately the same magnitude compared to dry finely ground milo. It is possible that the carbohydrates in high moisture harvested milo are intercepted before conversion from a more soluble form to starch, and would compare to the carbohydrates resulting from the partial hydrolysis of starch when limited germination occurs in reconstituted grain.

The intake and utilization of reconstituted milo are at least partially dependent on moisture level and time of storage, as shown by the results of Trial III. Feed consumption decreased and feed efficiency improved as the moisture was increased from 22 to 38% (milo was stored 21 days). Since rate of gain was not significantly affected by moisture level of milo, the heifers were apparently eating to a constant energy level. Energy was apparently available from both 30 and 38% reconstituted milo to a similar degree.

Preliminary *in vitro* work showed considerable improvement in dry matter disappearance for reconstituted milo exposed to the atmosphere for one day. When this procedure was incorporated into a feeding trial (Trial III), the improvement was not of the magnitude observed in the *in vitro* trials. *In vitro* digestibility determinations on samples taken from the grain actually processed for the feeding trial showed little benefit from reconstitution, as was observed in the feeding trial. It is possible that the laboratory technique of using a small sample of milo allowed more complete germination than was possible when a larger quantity was reconstituted for the feeding trial and sprouting occurred only in the top 10 to 13 cm. of the grain mass.

With the exception of ground-reconstituted milo in Trial I, all NE_p values obtained for processed milo in these trials were related to feed efficiency; as feed efficiency improved, NE_p values increased. The difference in relationship of the NE_p values and feed/kg. of gain in Trial I was probably due to chance, as the values were very similar. The mean NE_p value for the finely ground milo (Trials I and II) and dry rolled milo (Trial III) was 106.5 megcal./100 kg., which corresponds to a value of 108.0 megcal./100 kg. reported for Southwest milo by Lofgreen and Garrett (1967). NE_p values reported by Newsom (1968) for finely ground, reconstituted-rolled and reconstituted-ground milo were 124.3, 152.5 and 124.3 megcal./100 kg., respectively, as compared to 95.3, 127.7 and 112.8 megcal./100 kg. for the same treatments in Trial II. The reason for the difference in NE_p values is not apparent. Similar differences were reported by Hall *et al.* (1968), who pointed out that NE determinations are subject to such variations.

The increased NE_p of the high moisture processed grains and the extra finely ground milo in Trial II, and of the reconstituted-30 and -38% milo in Trial III, was probably partly due to increased digestibility. An increase in milo digestibility due to high moisture processing has been observed by Buchanan-Smith *et al.* (1968) and McGinty and Riggs (1967). Smith *et al.* (1949) reported an increase in digestibility of dry matter, crude protein, ether extract and nitrogen free extract when finely ground milo was compared to coarsely ground milo.

CHAPTER VI

SUMMARY

Three feeding trials were conducted to investigate the factors influencing the utilization of high moisture processed milo. Coarse rolling, fine grinding and extra fine grinding of dry milo were also compared in one feeding trial. Evaluation was on the basis of feedlot performance, net energy and carcass merit.

Reconstituted-ground milo (reconstituted in whole form, stored 21 days, then ground) significantly ($P<.05$) increased rate of gain compared to ground-reconstituted milo (ground, then reconstituted and stored 21 days), and feed/kg. of gain was markedly reduced by reconstituted-ground milo compared to dry finely ground and ground-reconstituted milo. Feed intake was almost identical for the three treatments in this trial. Net energy for production (NE_p) was not significantly affected by processing method. It is apparent from the results of this trial that milo must be reconstituted in the whole form to benefit from the reconstituting process.

Grinding dry milo through a 1.59 mm. screen (extra fine grinding) improved feed efficiency 6.7% over grinding milo through a 3.18 mm. screen (fine grinding); the floury texture of the extra finely ground milo did not appreciably

reduce intake. Coarsely rolled milo, which contained approximately 25% unbroken kernels, reduced feed efficiency 6.7% and decreased rate of gain slightly compared to finely ground milo. The NE_p value of extra finely ground milo was significantly ($P<.05$) higher than that of finely ground and coarsely rolled milo, indicating that particle size is an important factor affecting energy utilization.

With the exception of the ground-reconstituted milo, all high moisture processing methods improved utilization of milo compared to fine grinding and dry rolling. Reconstituted-22% moisture milo increased consumption compared to dry rolling; however, all other high moisture processing methods reduced feed intake as compared to the respective dry controls. Although not significant ($P>.05$), rolling of the high moisture processed grains increased rate of gain 10.5% as compared to grinding. High moisture harvesting and reconstituting produced similar improvements in feed efficiency. All high moisture methods significantly ($P<.05$) increased NE_p over coarsely rolled milo.

Milo reconstituted to moisture levels of 30 and 38% significantly ($P<.05$) improved efficiency over dry rolled milo. Feed/kg. of gain was reduced as the moisture level of reconstituted milo was increased from 22 to 30% for milo stored 21 days. The storage of reconstituted milo for one day was not sufficient to improve utilization appreciably. Differences in NE_p were not significant ($P>.05$) for the milo grain reconstituted at different moisture levels, but NE_p

was increased 34.9 and 39.3%, respectively, for 30 and 38% reconstituted milo compared to dry rolled milo. The improvements in NE_p were consistent with improvements in feed efficiency.

Feed efficiency expressed as feed/kg. gain of live shrunk weight was almost identical to feed efficiency expressed as feed/kg. of empty body weight gain, indicating that variable fill was not a problem under the conditions imposed in this study.

Carcass merit, as measured by dressing percent, carcass grade, ribeye area, fat thickness and cutability, was not significantly (P>.05) affected by processing method in these trials.

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