DIGESTIBILITY AND ENERGY BALANCE
OF CORN AND MILO
FOR CATTLE

By

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INTRODUCTION

The major grain used for finishing rations in Oklahoma and surrounding areas is milo. Since their introduction into the United States the grain sorghums have become increasingly competitive with other feed grains. Their increased competitiveness is the result of the development of high yielding hybrid varieties that are adapted to a wide range of environmental conditions and the ready adaptation of the grains to modern methods of mechanization.

Feeding and digestion trials in recent years indicate a lower feeding value for milo than for corn or barley. It has been postulated that the chemical composition of milo has changed in recent years because of increased yield per acre which has diluted the nutrients in the grain and that this could account for the fact that earlier feeding values tended to be greater than those obtained more recently.

The purpose of this investigation was to compare corn and milo fed at three levels of intake by the determination of their digestion coefficients, nitrogen retention and digestible and metabolizable energy values.

LITERATURE REVIEW

Composition and Feeding Value

Early work on the composition of milo indicated that it could replace corn on an equal basis for fattening cattle (Francis and Smith, 1916; Texas workers, 1950).

Many researchers have compared corn, milo and barley. Jones et al. (1922), Cave and Fitch (1925), Baker (1943), Weber et al. (1947) and Atkeson and Fountaine (1957) compared the feeding value of ground milo to that of ground corn and found little or no difference between rate of gain and efficiency of gain. Thalman (1943) compared cracked corn with cracked milo and found no significant differences in rate of gain and feed efficiency. However, Totusek et al. (1963) and Foster and Simpson (1916) compared ground corn, ground milo and ground barley and reported that corn gave higher rates of gain and improved feed efficiency over both the milo and barley. Garrett et al. (1964) and Garrett (1965) indicated no difference between the feeding value and net energy for production of milo and barley. Garrett (1965) stated that milo was at least as valuable for feedlot cattle as barley, when compared on a dry basis and fed in a nutritionally adequate ration. However, workers using various processing methods indicated that barley fed animals exceeded the milo fed animals in both rate of gain and feed efficiency (Taylor et al., 1960; Taylor et al., 1961; Hubbert et al., 1962; Pope et al., 1961; Hale et al., 1963; Hale et al., 1964a; Hale et al., 1965b and Hale et al., 1965c). A possible explaination for these varied results may be obtained from a study presented by Hale et al. (1964c) in which several varieties of milo were compared to barley. These workers found that the feeding values of the varieties of milo which they tested varied considerably. They also reported that the feeding value of dry-rolled hegari approached that of steam-rolled barley to a sufficient degree to make hegari economically superior at the prices charged for the two grains.

Morrison (1956) reported average crude protein values of 10.9 percent for milo, 8.7 percent for corn and 8.7 percent for barley. However, more recent work indicates that the crude protein content of milo is approximately 8.5 percent (Hale et al., 1962; Hubbert et al., 1962; Taylor et al., 1960; Taylor et al., 1961; Totusek et al., 1963). Trogdon (1960) compared 67 sorghum varieties in an extensive study of protein content and found a wide variation in crude protein content ranging from 6.68-16.80 percent and averaging 11.74 percent. Trogdon stated that this wide variation was due in part to variation in the areas grown, amount of moisture and amount of nitrogen fertilizer applied. Eng (1965) tested three varieties of sorghum grains each at three levels of nitrogen fertilization and found protein contents of 9.3, 9.9 and 11.4 percent when no nitrogen was used and values of 11.4, 12.9 and 14.0 percent when 54.4 kg. of nitrogen per acre were applied.

Some workers reported that milo was utilized 10 to 16 percent less efficiently than either corn or barley (Hubbert et al., 1962; Taylor et al., 1960; Taylor et al., 1961; Totusek et al., 1963; Hale et al., 1963; Hale et al., 1965b; Pope et al., 1961).

Digestibility

A number of studies have been conducted to compare the nutritive values of milo and barley and the effect of various processing methods on the values of each grain. Hale et al. (1962) conducted six trials using rations containing 56 percent barley or milo. He reported that protein of barley was more digestible than protein of milo (68.4 percent vs. 60.2 percent). When milo or barley was placed in a nylon bag and inserted via a fistula into the rumen fluid, it was observed that 42 percent of the dry matter of barley disappeared in seven hours; whereas, only 14 percent of the dry matter of milo had disappeared in the same length of time. Thus it appears that the digestion of milo in the rumen proceeds at a slower rate than does the digestion of barley. Cadena et al. (1962) confirmed these results in short time studies, however, when the feeds were left in the rumen for 72 hours he found that more milo had disappeared than barley. This worker reported that the total digestible nutrients (T.D.N.) of the barley and milo were 69.0 percent and 67.2 percent, respectively. It was suggested that rate of passage might be a factor if the nutrients of one grain were more readily available to the animal than the nutrients of other grains.

In a trial comparing dry-rolled milo with barley Trei et al. (1964) reported digestion coefficients for protein, nitrogen-free extract (N.F.E.), starch and gross energy of 41.8, 70.4, 79.0 and 63.0, respectively for milo and 66.0, 80.4, 90.7 and 78.1 for barley. In another trial they compared cooked whole milo with dry-rolled milo and reported digestion coefficients for protein and N.F.E. of 33.5 and 76.3 for cooked milo and 41.8 and 70.4 for dry rolled milo, respectively, indicating that the protein was partially denatured by the cooking process but that the availability of the N.F.E. was increased.

Hale et al. (1964b) reported on digestion studies for dry-rolled milo and barley when they were fed in all concentrate rations. Digestion coefficients on crude protein, N.F.E., starch and gross energy were 55.2, 79.3, 84.2 and 79.3 for milo and 77.1, 90.8, 93.2 and 90.8, respectively for barley, indicating that barley was more digestible than milo when no roughage was added to the ration. However, in a trial where milo and barley were fed in rations with a 50:50 concentrate to roughage ratio they found that the digestibility of milo was equal to that of barley. From this observation it was postulated that the slower rate of passage of milo caused by the high roughage content permitted a longer fermentation time in the rumen. This view is supported by the nylon bag studies discussed previously (Cadena et al., 1962).

Hale et al. (1965a) observed that when milo was steam processed and flaked the digestion coefficients for dry matter, ether extract, N.F.E., gross energy, T.D.N. of the ration and calculated T.D.N. of the grain were significantly increased ($P < .05$) over the corresponding values for dry-rolled milo. Data from feeding trials suggests that the rate of gain and efficiency also favored the steam processed and flaked milo over the dry-rolled grain.

Smith et al. (1949) compared the digestibility of whole, coarsely ground and finely ground milo and reported the following digestion coefficients for the three different methods of processing:

	Whole	Coarse	Fine
Dry matter	48.04	52.34	60.19
Crude protein	42.72	46.81	54.93
Ether extract	50.10	64.68	72.46
Crude fiber	56.42	50.34	50.96
N.F.E.	51.39	57.29	65.05

These results indicated that coarse grinding improved the digestibility of milo over whole milo and that fine grinding improved its digestibility over whole and coarsely ground milo. Further research is needed to establish methods for improving milo utilization.

Texas workers (1950) reported that less feed was required per 100 pounds of gain in cattle when milo was restricted to 80 percent of full feed, however, rate of gain, finish and selling price favored the full fed animals. Anderson et al. (1959), Blaxter et al. (1956) and Eng and Riewe (1963) reported that digestion losses increased with increasing feed intake, and that perhaps a level of intake something less than maximum may produce the optimum feed efficiency.

Preparation

Much research has been conducted for determining the influence of method of preparation upon the utilization of grains by cattle. Ray and Drake (1959) reported that highly significant differences ($P < .01$) occurred in consumption of grains by cattle due to the method of preparation.

Jones et al. (1937) and Black et al. (1937) reported that animals fed ground milo made greater gains and required less feed per 100 pounds of gain than animals fed whole milo. More recent work concerning method of grain preparation has indicated that fine grinding milo produces a greater improvement in feed efficiency with less reduction in average daily gain than pelleting, dry-rolling, steam-rolling or coarse grinding (Totusek et al., 1964; Smith and Parrish, 1953; Baker et al., 1954; Pope et al., 1960 and Pope et al., 1961). However, Pope et al. (1962) and Cox and Smith (1952) found no consistent advantage for fine over coarse ground or rolled milo. Atkeson and Beck (1942) stated that coarse ground milo improved average daily gain and feed efficiency more than either unground or finely ground milo. Hubbert et al. (1962) reported that finely ground milo reduced feed intake, rate of gain and efficiency of gain as compared to dry-rolled milo. Pope et al. (1958), Pope et al. (1959) and Richardson et al. (1961) observed that finely ground and pelleted milo may improve feed efficiency over rolled milo. The value of fine grinding may depend on the type of ration used.

Hale et al. (1964a), Hale et al. (1965b) and Hale et al. (1965c) reported that steam processing (steam heating for 20 minutes followed by flaking) resulted in improved average daily gain and feed efficiency over dry-rolled milo. However, Taylor et al. (1960), Taylor et al. (1961) and Hubbert et al. (1962) found that steam-rolling milo in the conventional manner did not improve rate or efficiency of gain over dry-rolled milo. It has also been found that steam processing (steam-heating ground milo so as to gelatinize its starch or steam-rolled milo) did not affect its utilization or feeding value (Pope et al., 1963a and Pope et al., 1963b).

Another method of grain preparation is that of producing a high-moisture milo. It is produced by harvesting milo at high moisture levels (25-36 percent) with a standard self-propelled combine by slowing the ground speed and maintaining the same cylinder speed as that used for threshing small grains. The high moisture product must be kept as silage to prevent spoilage. Feeding trial results indicate that cattle fed either high- or low-moisture milo made equal gains, but that the feed required per 100 pounds of gain was from 10 to 20 percent less for high-moisture grain when results were expressed on a dry matter basis (Riggs et al., 1959; Brethour and Duitsman, 1962 and Brethour and Duitsman, 1963).

Additives and Supplements

Several studies have been conducted to determine the effect of stilbestrol on performance of cattle fed milo rations. Pope et al. (1958) and Garrett (1965) found that stilbestrol implanted cattle outgained the controls during the fattening period. Pope et al. (1959) found that an increase in the protein level above adequate supplementation gave no improvement in rate of gain or feed efficiency of calves fed stilbestrol. Pope et al. (1961) conducted an experiment in which eight to nine month old calves being fed a milo ration were implanted with either 12 or 24 mg. of stilbestrol. The 24 mg. level improved gains over the controls, but had no overall effect on carcass quality; the 12 mg. level appeared to give less response than the 24 mg. level, but gave some improvement over the controls.

Pope et al. (1959) found that low levels of a hydroxyzine tranquilizer did not improve feedlot performance of cattle fed milo rations. Low levels of antibiotics (Ilotycin) and two different tranquilizers (Pope et al., 1958) produced only small increases in gain. The addition of vitamin A (1000 I.U. per pound of ration) to a milo ration containing 10 percent alfalfa was of little, if any, benefit (Totusek et al., 1964).

Absher et al. (1965) found that when cottonseed meal was replaced with urea in milo fattening rations a decrease in rate of gain of cattle was observed. The addition of corn oil to a milo-urea ration did not significantly improve performance but the addition of a complex vitamin-trace mineral mix plus corn oil improved rate of gain. Using identical twin calves, Absher *et al.* (1965) found that neither the addition of urea to the cottonseed meal ration nor the replacement of cottonseed meal with soybean meal caused any improvement, however, both the replacement of cottonseed meal with fish meal and the addition of copper to a urea ration significantly improved ($P < .05$) both the rate and efficiency of gain.

MATERIALS AND METHODS

Twelve Hereford steers, with an average initial weight of 297.3 kg., were obtained from the Oklahoma State University experimental beef herd. The steers, which had been on pasture since birth, were placed in drylot and fed prairie hay for approximately two weeks. They were weighed after being held without feed and water for 24 hours and placed in metabolism stalls described by Nelson *et al.* (1954).

Trial I was conducted during the summer of 1964 to determine digestion coefficients on the basal ration, which was fed at a maintenance level. Feed assignment was by the method of Garrett *et al.* (1959) and Absher (1965). The animals were fed twice daily. After the steers were placed in the metabolism stalls, the 10-day collection period was preceded by a 14-day standardization period, during which time the animals became accustomed to their new environment, and a 14-day preliminary period, during which feed intake was kept constant at the same level employed during the collection period. During the collection period feces were taken from the collecting pans four times daily and placed in a covered container. A small amount of thymol crystals was added to minimize bacterial decomposition. At the conclusion of each 24-hour period, the feces in the covered containers were weighed, thoroughly mixed with an electric mixer and a five percent representative sample was taken each day. The composite sample for each animal was kept under refrigeration. The urine was collected in metal containers which contained 40 ml. of a 50 percent solution of hydrochloric acid. Each collection was brought, by the addition of water, up to a constant weight of 22.7 kg. A 300 ml. aliquot was then taken for the composite urine sample which was kept under refrigeration. The pH of the composite urine sample was measured each day and additional hydrochloric acid was added if the pH was above 7.0. At the end of the collection period each composite sample of feces and urine were thoroughly mixed with duplicate representative samples being taken. These duplicate samples were again refrigerated until the proximate analysis and gross energy determinations were made.

Trials II, III and IV were conducted during the fall of 1964 and the spring of 1965 with the only difference between trials being time. In these trials six rations (Table III), three levels of corn and three levels of milo were fed. The rations were allotted to the metabolism stalls and steers at random. Milo or corn were fed at three levels of intake, maintenance, intermediate and high. The maintenance ration consisted of the basal plus corn or milo with the basal and the appropriate grain each supplying one-half of the calculated maintenance requirement. The intermediate ration was composed of the basal, fed at a maintenance level, plus 1.82 kg. of corn or milo. The high level was composed of the basal, fed at maintenance, plus 2.72 kg. of corn or milo. Animals on the intermediate and high levels were gradually adapted to their level by first placing them on the maintenance level and when they were consuming this quantity the amount of feed was increased to the intermediate level. The high level steers were then fed their appropriate feed intake as soon as they would consume it.

The grains, which were ground in a hammer mill with a 31.7 mm. screen, and the basal were weighed to the nearest gram at each feeding and mixed in the individual troughs by hand. No water was available when the animals were eating but they had free access to water at all other times.

The composition of the basal ration is given in Table I and the proximate analysis of corn, milo and the basal ration is listed in Table II.

TABLE I

COMPOSITION OF BASAL RATION

Ingredient	Percent
Dehydrated alfalfa pellets (17 % protein)	35.0
Cottonseed hulls	23.0
Cottonseed meal (41 % solvent)	40.0
Salt	1.0
Dicalcium phosphate (28 % Ca., 18 % P.)	1.0
	100.0
Added Per Ton	
Santoquin	114 gm.
Vit. A supplement (30,000 I.U./gram)	200 gm.

TABLE II

PROXIMATE ANALYSIS OF FEEDS

	Dry Matter %	Ash %	Crude Protein %	Fat %	Fiber %	N.F.E. %
Basal	90.82	8.1	20.3	2.0	24.3	36.1
Corn	88.27	1.3	9.3	4.3	2.1	71.3
Milo	87.87	1.5	8.9	3.0	0.7	73.8

Proximate analyses of feed, feces and urine were conducted by the methods of A.O.A.C. (1960). Digestion coefficients for dry matter, organic matter, protein, ether extract, crude fiber and N.F.E. were calculated for each animal on each trial.

Gross energy was also determined on all feed, feces and urine samples by use of the bomb calorimeter. The energy of urine was determined with the aid of a homogenous pellet of cellulose weighing approximately one gram. Five ml. of urine were pipetted into the bomb cup containing the pellet, and the mixture was then dried in a vacuum oven set at 55° C. As soon as the mixture was dry an additional five ml. were added and the drying process was repeated. The sample of dried urine and cellulose was then burned in the bomb. The energy of the cellulose, which was previously determined, was subtracted from the total to obtain the energy value of the urine.

Digestible and metabolizable energy values were calculated. Digestible energy was determined by subtracting fecal energy from gross energy of the feed. Metabolizable energy was calculated by subtracting urine energy plus estimated methane energy from digestible energy. Methane was estimated by the equation of Swift *et al.* (1948).

The design of the experiment is shown in Table III. The treatments were arranged in a 2 x 3 factorial and the statistical analysis was calculated using analysis of variance procedures. Levels were compared using Duncan's New Multiple Range Test (Steel and Torrie, 1960).

TABLE III

EXPERIMENTAL DESIGN

Treatment	Total Animals Per Treatment	Feeding Regime
Basal Maintenance	8	Basal, fed to maintain body weight.
Milo Maintenance	6	Basal, 1/2 amount of basal maintenance plus milo to maintain body wt.
Corn Maintenance	6	Basal, 1/2 amount of basal maintenance plus corn to maintain body wt.
Milo Intermediate	6	Basal at maintenance plus 1.82 kg. of milo per day.
Corn Intermediate	6	Basal at maintenance plus 1.82 kg. of corn per day.
Milo High	6	Basal at maintenance plus 2.72 kg. of milo per day.
Corn High	6	Basal at maintenance plus 2.72 kg. of corn per day.

RESULTS AND DISCUSSION

Digestion coefficients for corn and milo fed at three levels of intake are presented in Table IV. Differences among levels or between grains were not statistically different when compared on the basis of digestibility of dry matter, organic matter, crude fiber or nitrogen-free extract (N.F.E.). A significant interaction ($P < .05$) was found between replications and treatments in the case of crude protein and ether extract, indicating that treatment effects were not the same in all trials. Variations in environmental conditions is a possible explanation. The trials were conducted from early fall 1964 to early spring 1965 and the mean high and low temperatures were approximately 35° and 15° C.

Nitrogen retention data are shown in Table V. Differences between corn and milo were not significant at any level of intake. However, differences between levels of intake within grains were significant. Nitrogen retentions, expressed either as a percent of protein intake or absorbed, were lower ($P < .05$) when the grains were fed at the maintenance level. Differences between the intermediate and high levels were not significant.

Digestible and metabolizable energy determinations for the rations are presented in Table VI. There were no statistically significant differences in digestible or metabolizable energy among levels of feed intake or between the two grains.

TABLE IV

DIGESTION COEFFICIENTS ON COMPONENTS OF CORN AND MILO
FED AT THREE LEVELS OF INTAKE

	Corn			Milo			Standard Error
Ration number	1	2	3	4	5	6	
Ration level	Mainten-ance	Intermed-iate	High	Mainten-ance	Intermed-iate	High	
Number of animals	6	6	6	6	6	6	
Dry matter	67.52	67.29	69.26	68.87	68.82	67.79	±1.57
Organic matter	69.03	68.50	70.49	70.42	69.64	68.98	±1.51
Crude protein	65.14	68.36	68.59	64.06	69.08	64.01	±1.28
Ether extract	74.89	77.52	78.62	71.32	75.94	74.86	±1.94
Crude fiber	32.86	36.60	33.01	31.99	37.21	34.10	±3.38
N-free extract	81.12	80.63	82.18	83.34	81.00	80.90	±1.20

TABLE V

NITROGEN RETENTIONS ON CORN AND MILO
FED AT THREE LEVELS OF INTAKE

	Corn			Milo			Standard Error
Ration number	1	2	3	4	5	6	
Ration level	Mainten-ance	Intermed-iate	High	Mainten-ance	Intermed-iate	High	
Number of animals	6	6	6	6	6	6	
Nitrogen intake (gm.)	959.701	1,830.741	1,901.427	1,009.720	1,742.229	1,953.149	
Fecal nitrogen (gm.)	332.069	576.824	614.072	363.320	557.077	708.717	
Nitrogen digested (gm.)	627.632	1,253.917	1,287.355	646.400	1,185.152	1,244.432	
Nitrogen digested (%)	65.14	68.36	68.59	64.06	69.08	64.01	
Urinary nitrogen (gm.)	545.179	942.427	793.085	540.264	744.565	888.707	
Nitrogen retention (gm.)	82.453	311.491	494.269	106.136	440.587	355.725	
Nitrogen retention as a % of protein intake	7.92[a]	16.33[b]	26.69[c]	10.11[a]	26.96[b]	17.63[c]	±3.73
Nitrogen retention as a % of protein absorbed	11.96[a]	23.77[b]	38.49[c]	15.76[a]	37.97[b]	27.81[c]	±4.42

$a < b$, $a < c$ $(P < .05)$

TABLE VI

ENERGY BALANCES ON CORN AND MILO FED AT THREE LEVELS OF INTAKE (kcal./kg.)

	Corn			Milo			Standard Error
Ration number	1	2	3	4	5	6	
Ration level	Mainten-ance	Intermed-iate	High	Mainten-ance	Intermed-iate	High	
Number of animals	6	6	6	6	6	6	
Digestible energy	2,703.68	2,721.88	2,702.55	2,719.85	2,680.18	2,696.88	±20.54
Metabolizable energy	2,486.30	2,466.35	2,475.72	2,511.33	2,434.63	2,475.22	±20.48

A comparison of the digestion coefficients of corn and milo without regard to level of feed intake is presented in Table VII. Interactions between replications and treatments for crude protein and ether extract were statistically significant and these data were not included in the comparisons shown in Table VII. In the comparisons shown, differences between the two grains were not statistically significant.

Digestion coefficients for corn and milo at three levels of intake as determined by difference are presented in Table VIII. Data from Trial I in which all 12 animals were fed the basal ration at a maintenance level were used to account for the basal components of the rations containing basal plus corn or milo. There were no statistically significant differences in dry matter digestibility among levels or between grains. However, digestibility of organic matter was significantly higher in corn than milo ($P < .05$). Also, protein of corn was significantly more digestible ($P < .01$) than protein of milo. The protein digestibility of corn was significantly greater ($P < .05$) when fed at the intermediate than at the high level of intake while the protein digestibility of milo was greater ($P < .05$) at the maintenance and intermediate than at the high level of feed intake. These data may be confounded since the animals which received the all basal ration at a maintenance level in Trial I were not the same animals used in the rest of the trials. Also, Trial I was conducted in relatively hot (35°-38° C.) weather and the rest of the trials were conducted during the fall, winter and spring.

The digestibility of dry matter in milo obtained in the present study compares favorably with those reported by Hale et al. (1964b) and Smith et al. (1949). Protein digestibility was higher than in

TABLE VII

NUTRIENT AND ENERGY BALANCES ON CORN AND MILO
WITHOUT REGARD TO INTAKE

	Corn	Milo	Standard Error
Number of animals	18	18	
Digestion coefficients			
Dry matter	68.02	68.49	± 1.57
Organic matter	69.34	69.68	± 1.51
Crude fiber	34.16	34.43	± 3.38
Nitrogen-free extract	81.31	81.74	± 1.20
Nitrogen retention as a			
% of protein intake	16.98	18.24	± 3.73
% of protein absorbed	24.76	27.18	± 4.42
Energy balance (kcal./kg.)			
Digestible energy	2,709.37	2,698.97	±20.54
Metabolizable energy	2,476.12	2,473.73	±20.48

TABLE VIII

DIGESTION COEFFICIENTS ON COMPONENTS OF CORN AND MILO AT THREE LEVELS OF INTAKE AS DETERMINED BY DIFFERENCE

	Corn			Milo			Standard Error
Ration number	1	2	3	4	5	6	
Ration level	Maintenance	Intermediate	High	Maintenance	Intermediate	High	
Number of animals	4	4	4	4	4	4	
Dry matter	84.90	86.94	77.85	80.73	79.78	77.66	±2.56
Organic matter[a]	85.68	86.74	78.98	81.94	79.27	78.12	±2.32
Crude protein[b]	52.34	63.98[c]	43.86[d]	42.56[e]	39.30[f]	30.28[g]	±5.10

[a]Corn was significantly ($P < .05$) greater than milo.
[b]Corn was significantly ($P < .01$) greater than milo.
$c > d$ ($P < .05$).
$e > g$, $f > g$ ($P < .05$).

previous results reported by Trei et al. (1964), Hale et al. (1964b) and Smith et al. (1949). When attempting to explain these apparently divergent results, it must be kept in mind that in the present study there was a significant interaction ($P < .05$) between treatments and replications. Digestibility of N.F.E. was approximately the same as that found by Hale et al. (1964b) but was much higher than that found by Trei et al. (1964) and Smith et al. (1949).

These results are in accord with those of other work indicating no differences between the net energy values of corn and milo (Absher, 1965). Also, Jones et al. (1922), Cave and Fitch (1925), Baker (1943), Weber et al. (1947) and Atkeson and Fountaine (1957) found little or no difference in rate or efficiency of gain between ground corn and ground milo in feeding trials. However, Foster and Simpson (1916) and Totusek et al. (1963) reported that ground corn gave higher rates of gain and improved feed efficiency over ground milo and ground barley.

Nitrogen retention, when expressed as a percent of protein intake or absorbed, was significantly higher ($P < .05$) at the intermediate and high than at the maintenance level; differences between the intermediate and high levels were not significant in the case of either grain. This may be attributed to the low energy level in the maintenance ration to the extent that dietary protein was used as an energy source. Also, an animal fed at a maintenance level would be expected to have a zero nitrogen balance in contrast to a positive balance at the intermediate and high levels. The fact that urinary nitrogen (a) as a percent of intake at the maintenance, intermediate and high levels of corn was 56.8, 51.5 and 41.7, (b) as a percent of absorbed at these same levels was 86.9, 75.2 and 61.6, respectively, is in accord with this idea.

Differences among levels or between grains in the digestible or metabolizable energy values were not significant. These data support the results of Hale et al. (1964b) who found no statistically significant difference between the digestible energy of milo and barley in all grain rations. However, the digestible energy value which Hale et al. (1964b) reported for milo was higher than that found in the present study.

The results of the present study indicate that milo is equal to corn in terms of digestibility of proximate components, energy and nitrogen retention.

SUMMARY

Finely ground milo was compared to finely ground corn in digestion and metabolism trials in which steers were the experimental animals. In the first trial, the digestibility of ration components, energy and the retention of nitrogen were determined on a basal diet, which was common to all subsequent treatments; the diet was fed at a maintenance level to 12 steers. In Trials II, III and IV, milo or corn was combined with the basal diet and fed at three levels of intake, maintenance, intermediate and high. In the maintenance ration corn or milo furnished one-half of the energy requirements when the formula T.D.N. = $.036W^{.75}$ was used to estimate the maintenance requirement of each animal. The protein, mineral and vitamin requirements were also met. The basal diet supplied the maintenance needs for protein and energy and the grain was added to obtain the appropriate intermediate or high level of intake. Conventional methods were used in the digestion and metabolism trials.

Differences in the digestibilities of proximate components were not significant between grains or among levels but the interaction between treatments and replications for the digestibilities of crude protein and ether extract were significant ($P < .05$). It was suggested that differences in environmental temperatures between replications accounted for the interactions.

Nitrogen retention expressed as a percent of protein intake or as a percent of absorbed, was significantly higher ($P < .05$) for the intermediate and high levels than for the maintenance level.

Differences in digestible and metabolizable energy values were not significant among levels or between grains.

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APPENDIX

TABLE IX

DRY MATTER DIGESTION COEFFICIENTS OF MILO AND CORN AT THREE LEVELS OF INTAKE

	Maintenance	Intermediate	High
Corn	64.68	68.38	70.99
	67.38	69.86	82.52
	70.31	67.86	64.40
	67.34	63.73	64.40
	67.71	66.83	66.01
	67.70	67.08	67.25
Milo	71.74	83.74	71.95
	72.59	71.32	72.93
	68.91	65.40	64.35
	66.74	64.60	64.15
	69.67	62.75	66.89
	63.56	65.10	66.47

TABLE X

ANALYSIS OF VARIANCE OF DRY MATTER DIGESTION COEFFICIENTS AT THREE LEVELS OF INTAKE

Source	df	Mean Square
Total	35	
Reps.	2	150.445**
Treatment	5	4.073
Grain	1	1.974
Level	2	0.704
Gr. x L.	2	8.492
Reps. x treat.	10	22.552
Sampling error	18	10.396
Pooled error	28	14.737

**(P $<$ .01).

TABLE XI

ORGANIC MATTER DIGESTION COEFFICIENTS OF MILO AND CORN AT THREE LEVELS OF INTAKE

	Maintenance	Intermediate	High
Corn	66.71	69.79	71.62
	68.99	71.58	83.80
	71.43	69.29	66.60
	68.99	65.38	65.78
	68.96	67.14	67.06
	69.09	67.84	68.07
Milo	73.79	84.11	73.34
	74.13	72.68	74.33
	69.91	66.46	65.62
	68.76	65.67	65.53
	70.89	62.88	67.96
	65.06	66.03	67.09

TABLE XII

ANALYSIS OF VARIANCE OF ORGANIC MATTER DIGESTION COEFFICIENTS AT THREE LEVELS OF INTAKE

Source	df	Mean Square
Total	35	
Reps.	2	161.010**
Treatment	5	4.003
Grain	1	1.041
Level	2	1.736
Gr. x L.	2	7.751
Reps. x treat.	10	20.277
Sampling error	18	9.960
Pooled error	28	13.645

**($P < .01$).

TABLE XIII

CRUDE PROTEIN DIGESTION COEFFICIENTS OF MILO AND CORN AT THREE LEVELS OF INTAKE

	Maintenance	Intermediate	High
Corn	61.26	66.56	72.31
	64.02	68.89	80.41
	67.98	69.20	61.90
	65.95	65.09	64.35
	66.02	70.07	65.80
	65.58	70.35	66.79
Milo	64.06	83.48	68.54
	64.50	69.92	67.93
	66.47	65.14	59.39
	62.10	64.38	62.04
	66.34	65.16	64.13
	60.91	66.40	62.03

TABLE XIV

ANALYSIS OF VARIANCE OF CRUDE PROTEIN DIGESTION COEFFICIENTS AT THREE LEVELS OF INTAKE

Source	df	Mean Square
Total	35	
Reps.	2	74.773
Treatment	5	34.187
Grain	1	24.354
Level	2	51.456
Gr. x L.	2	21.834
Reps. x treat.	10	30.706*
Sampling error	18	9.819

*($P < .05$).

TABLE XV

ETHER EXTRACT DIGESTION COEFFICIENTS OF MILO AND CORN AT THREE LEVELS OF INTAKE

	Maintenance	Intermediate	High
Corn	73.63	82.88	83.82
	77.54	82.80	90.11
	76.59	73.09	72.90
	76.16	67.42	75.05
	76.33	82.17	76.11
	69.11	76.73	73.75
Milo	54.74	87.23	81.93
	74.48	78.51	81.67
	77.37	77.00	75.98
	71.58	72.91	72.33
	79.93	71.05	68.78
	69.82	68.92	68.49

TABLE XVI

ANALYSIS OF VARIANCE OF ETHER EXTRACT DIGESTION COEFFICIENTS AT THREE LEVELS OF INTAKE

Source	df	Mean Square
Total	35	
Reps.	2	116.837
Treatment	5	38.698
Grain	1	79.418
Level	2	52.648
Gr. x L.	2	4.387
Reps. x treat.	10	63.937*
Sampling error	18	22.647

*(P <.05).

TABLE XVII

CRUDE FIBER DIGESTION COEFFICIENTS OF MILO AND CORN AT THREE LEVELS OF INTAKE

	Maintenance	Intermediate	High
Corn	29.49	44.62	29.95
	32.04	39.13	62.81
	39.51	44.99	34.48
	34.41	35.64	31.18
	33.63	25.76	20.86
	28.10	29.44	18.77
Milo	38.47	67.60	37.17
	38.12	42.67	39.69
	36.42	39.16	37.53
	34.51	32.40	33.49
	27.71	19.70	33.21
	16.72	21.75	23.50

TABLE XVIII

ANALYSIS OF VARIANCE OF CRUDE FIBER DIGESTION COEFFICIENTS AT THREE LEVELS OF INTAKE

Source	df	Mean Square
Total	35	
Reps.	2	885.963**
Treatment	5	27.436
Grain	1	0.698
Level	2	65.099
Gr. x L.	2	3.144
Reps. x treat.	10	82.193
Sampling error	18	61.171
Pooled error	28	68.679

**($P < .01$).

TABLE XIX

NITROGEN FREE EXTRACT DIGESTION COEFFICIENTS OF MILO AND CORN AT THREE LEVELS OF INTAKE

	Maintenance	Intermediate	High
Corn	79.96	80.06	84.28
	82.11	84.35	91.46
	82.32	84.57	78.02
	80.44	76.63	76.53
	79.73	78.93	80.25
	82.14	79.24	82.54
Milo	87.60	90.25	85.62
	87.12	84.61	86.29
	80.82	76.66	76.37
	81.28	78.37	76.89
	83.97	75.56	79.25
	79.23	80.52	80.96

TABLE XX

ANALYSIS OF VARIANCE OF NITROGEN FREE EXTRACT DIGESTION COEFFICIENTS AT THREE LEVELS OF INTAKE

Source	df	Mean Square
Total	35	
Reps.	2	132.575**
Treatment	5	6.426
Grain	1	1.695
Level	2	6.001
Gr. x L.	2	9.216
Reps. x treat.	10	12.111
Sampling error	18	6.678
Pooled error	28	8.619

**(P <.01).

TABLE XXI

NITROGEN AS A PERCENT OF PROTEIN INTAKE VALUES FOR CORN AND MILO AT THREE LEVELS OF INTAKE

	Maintenance	Intermediate	High
	-.51	8.09	19.36
	3.55	8.11	43.61
	11.44	24.96	20.93
Corn	12.58	14.96	20.47
	10.64	24.44	34.13
	9.84	17.43	21.64
	7.43	56.27	10.10
	.79	13.24	12.78
Milo	11.93	27.20	13.32
	13.08	18.01	22.26
	16.80	29.34	24.17
	10.60	17.71	23.13

TABLE XXII

ANALYSIS OF VARIANCE OF NITROGEN AS A PERCENT OF PROTEIN INTAKE VALUES FOR CORN AND MILO AT THREE LEVELS OF INTAKE

Source	df	Mean Square
Total	35	
Reps.	2	67.808
Treatment	5	386.029**
Grain	1	14.050
Level	2	665.222**
Gr. x L.	2	292.826*
Reps. x treat.	10	75.682
Sampling error	18	87.644
Pooled error	28	83.372

*(P <.05).
**(P <.01).

TABLE XXIII

NITROGEN AS A PERCENT OF PROTEIN ABSORBED VALUES FOR CORN AND MILO AT THREE LEVELS OF INTAKE

	Maintenance	Intermediate	High
Corn	- .83	12.16	26.78
	5.55	11.77	54.23
	16.84	36.06	33.82
	19.08	22.98	31.81
	16.11	34.89	51.87
	15.01	24.77	32.40
Milo	11.59	67.41	14.74
	1.22	18.94	18.82
	17.95	41.76	22.43
	21.07	27.98	35.87
	25.33	45.03	37.69
	17.40	26.67	37.29

TABLE XXIV

ANALYSIS OF VARIANCE OF NITROGEN AS A PERCENT OF PROTEIN ABSORBED VALUES FOR CORN AND MILO AT THREE LEVELS OF INTAKE

Source	df	Mean Square
Total	35	
Reps.	2	326.798
Treatment	5	731.081**
Grain	1	53.509
Level	2	1,332.828**
Gr. x L.	2	468.122*
Reps. x treat.	10	92.874
Sampling error	18	130.865
Pooled error	28	117.296

*(P < .05).
**(P < .01).

TABLE XXV

DIGESTIBLE ENERGY VALUES FOR CORN AND MILO AT THREE LEVELS OF INTAKE (kcal./kg.)

	Maintenance	Intermediate	High
Corn	2788.0	2853.8	2702.6
	2856.0	2773.6	2922.6
	2612.6	2739.7	2638.7
	2641.8	2627.3	2589.2
	2683.3	2704.6	2710.9
	2640.4	2632.3	2651.3
Milo	2804.2	2684.7	2787.6
	2803.4	2729.5	2829.1
	2661.4	2636.5	2671.1
	2672.1	2696.3	2622.7
	2677.9	2647.8	2634.2
	2700.1	2686.3	2636.6

TABLE XXVI

ANALYSIS OF VARIANCE OF DIGESTIBLE ENERGY VALUES FOR CORN AND MILO AT THREE LEVELS OF INTAKE

Source	df	Mean Square
Total	35	
Reps.	2	74,383.90**
Treatment	5	1,429.14
Grain	1	973.50
Level	2	524.30
Gr. x L.	2	2,561.80
Reps. x treat.	10	2,200.73
Sampling error	18	2,715.46
Pooled error	28	2,531.63

**(P < .01).

TABLE XXVII

METABOLIZABLE ENERGY VALUES FOR CORN AND MILO AT THREE LEVELS OF INTAKE (kcal./kg.)

	Maintenance	Intermediate	High
Corn	2569.7	2596.4	2481.3
	2638.4	2522.6	2700.2
	2384.2	2479.8	2404.7
	2418.7	2363.4	2352.2
	2475.2	2453.5	2485.9
	2431.6	2382.4	2430.0
Milo	2596.3	2441.8	2565.6
	2591.7	2475.3	2610.4
	2442.9	2384.3	2432.1
	2460.1	2433.9	2387.5
	2476.3	2430.4	2418.0
	2500.7	2442.1	2437.7

TABLE XXVIII

ANALYSIS OF VARIANCE OF METABOLIZABLE ENERGY VALUES FOR CORN AND MILO AT THREE LEVELS OF INTAKE

Source	df	Mean Square
Total	35	
Reps.	2	78,013.00**
Treatment	5	3,783.14
Grain	1	51.60
Level	2	7,008.55
Gr. x L.	2	2,423.50
Reps. x treat.	10	2,313.98
Sampling error	18	2,629.89
Pooled error	28	2,517.064

**(P <.01).

TABLE XXIX

DRY MATTER DIGESTION COEFFICIENTS OF MILO AND CORN AT THREE LEVELS OF INTAKE AS DETERMINED BY DIFFERENCE

	Maintenance	Intermediate	High
Corn	90.61	92.35	75.02
	82.69	77.47	74.83
	83.14	88.40	78.86
	83.16	89.53	82.67
Milo	85.06	83.03	75.00
	79.73	80.45	74.68
	86.79	73.36	81.44
	71.34	82.29	79.53

TABLE XXX

ANALYSIS OF VARIANCE OF DRY MATTER DIGESTION COEFFICIENTS AT THREE LEVELS OF INTAKE AS DETERMINED BY DIFFERENCE

Source	df	Mean Square
Total	23	
Reps.	1	3.832
Treatment	5	58.029
Grain	1	88.281
Level	2	76.457
Gr. x L.	2	24.476
Reps. x treat.	5	23.449
Sampling error	12	27.384
Pooled error	17	26.227

TABLE XXXI

ORGANIC MATTER DIGESTION COEFFICIENTS OF MILO AND CORN AT THREE LEVELS OF INTAKE AS DETERMINED BY DIFFERENCE

	Maintenance	Intermediate	High
Corn	89.87	92.10	77.71
	83.63	78.72	75.42
	84.43	86.77	79.89
	84.80	89.37	82.90
Milo	84.40	82.06	75.30
	81.73	79.64	75.26
	87.80	72.17	82.44
	73.83	83.19	79.47

TABLE XXXII

ANALYSIS OF VARIANCE OF ORGANIC MATTER DIGESTION COEFFICIENTS AT THREE LEVELS OF INTAKE AS DETERMINED BY DIFFERENCE

Source	df	Mean Square
Total	23	
Reps.	1	5.246
Treatment	5	53.948
Grain	1	97.285*
Level	2	64.245
Gr. x L.	2	21.983
Reps. x treat.	5	15.406
Sampling error	12	24.065
Pooled error	17	21.519

*($P < .05$).

TABLE XXXIII

CRUDE PROTEIN DIGESTION COEFFICIENTS OF MILO AND CORN AT THREE LEVELS OF INTAKE AS DETERMINED BY DIFFERENCE

	Maintenance	Intermediate	High
Corn	39.23	59.20	37.39
	36.56	61.46	42.63
	71.77	82.21	41.49
	61.80	53.06	53.93
Milo	43.23	22.41	29.44
	16.89	30.37	19.92
	64.62	54.75	29.56
	45.51	49.65	42.18

TABLE XXXIV

ANALYSIS OF VARIANCE OF CRUDE PROTEIN DIGESTION COEFFICIENTS AT THREE LEVELS OF INTAKE AS DETERMINED BY DIFFERENCE

Source	df	Mean Square
Total	23	
Reps.	1	1,869.135**
Treatment	5	535.945**
Grain	1	1,539.202**
Level	2	450.238*
Gr. x L.	2	120.023
Reps. x treat.	5	98.954
Sampling error	12	105.909
Pooled error	17	103.864

*($P < .05$).
**($P < .01$).

VITA

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Candidate for the Degree of

Master of Science

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