# THE EFFECT OF MILO PROCESSING METHOD ON FEEDLOT PERFORMANCE, CARCASS MERIT AND NET ENERGY

By

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Bachelor of Science

Texas A & M University

College Station, Texas

1966

Submitted to the
faculty of the Graduate College of the
Oklahoma State University in partial
fulfillment of the requirements
for the degree of
MASTER OF SCIENCE
May, 1968

THE EFFECT OF MILO PROCESSING METHOD ON

FEEDLOT PERFORMANCE, CARCASS

MERIT AND NET ENERGY

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## ACKNOWLEDGMENTS

The author wishes to express his appreciation to Dr. Robert Totusek, Professor of Animal Science, for his guidance and counsel during the course of this study and in the preparation of this thesis.

Further acknowledgment is due Dr. Joe V. Whiteman, Dr. J. E. McCroskey and Dr. I. T. Omtvedt, Professors of Animal Science, and Dr. Donald R. Gill, Extension Animal Nutritionist, for their suggestions in the preparation of this manuscript.

Recognition is also due Dr. Robert D. Morrison, Professor of Mathematics and Statistics, Henry F. Magalit, Graduate Assistant in Mathematics and Statistics on leave from the University of the Phillipines, and John Collier for their valuable assistance in the analysis of data.

Appreciation is also extended to Larry Franks and Vincent Neuhaus, Graduate Assistants in Animal Science; Dwight Stephens, Superintendent, Robert Renbarger, Assistant Superintendent, Bill Basler and other personnel at the Fort Reno Experiment Station, in cooperation with U.S.D.A., A.R.S., A.H.R.D.; and to student workers at Oklahoma State University for their assistance in conducting this study.

Grateful acknowledgment is extended to Farmland Industries for financial support of the research reported herein.

The author is indebted to colleagues in the Graduate College at Oklahoma State University for their encouragement and assistance.

Special acknowledgment is given to the author's parents, whose continuing encouragement and assistance made a course of higher education possible.

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## INTRODUCTION

Milo (sorghum grain) has been the most readily available and cheapest grain for fattening cattle in Oklahoma and throughout the Southwest. The trend toward increased cattle feeding in this area indicates that milo will be even more widely used as a feed grain in the future.

Previous research has shown that the feeding value of milo for cattle is lower than its chemical composition indicates, possibly due to a lower protein digestibility and a lower starch availability compared to corn, barley or wheat. The availability of starch is especially important, since starch comprises 70 - 75% of milo grain, and milo is included in rations primarily as a source of energy. Since many fattening rations today contain as much as 80 - 90% or more milo, any improvement in the feeding value of milo would be of great benefit to the cattle feeding industry.

The most promising method of improving starch availability and the utilization of the energy of milo is by grain processing. The purpose of this study was to evaluate several processing methods of milo for fattening cattle.

Processing methods were evaluated on the basis of feedlot performance, carcass merit and net energy. Net energy was emphasized because it is considered by many to be the optimum measure of the productive value of a feed since it consists only of that energy available for use by the body, after the expenses of utilization have been deducted from gross energy.

## REVIEW OF LITERATURE

### The Feeding Value of Milo Compared to Other Grains

There are conflicting reports in the literature concerning the relative feeding value of the four major feed grains - corn, milo, barley and wheat. The TDN, crude protein and digestible protein of each are shown in Table I. According to these values, the four grains are very similar in value, and should perform similarly when fed in finishing rations to beef cattle.

This has been essentially true in trials at the California station. Except in the case of corn, which produced higher gains and greater feed efficiency, no significant differences were found among the four grains for gain, efficiency, intake, carcass measurements and digestibility (Garrett, 1963; Garrett *et al*., 1966b; McIlroy *et al*., 1967). No sig-

TABLE I

TDN, CRUDE PROTEIN AND DIGESTIBLE PROTEIN OF CORN, MILO, BARLEY AND WHEAT[a]

| Item | #2 corn | milo | barley | wheat (hard red winter) |
|---|---|---|---|---|
| TDN, % | 80.0 | 84.0 | 78.0 | 80.0 |
| Crude protein, % | 8.9 | 11.0 | 11.7 | 13.0 |
| Dig. protein, % | 6.9 | 8.6 | 8.4 | 10.9 |

[a]Taken from N.R.C. 1963.

nificant differences were found in digestible energy (Brown, 1966, 1968) or in net energy (Absher, 1965; Garrett *et al*., 1964; Hall, 1966) between milo and corn.

However, other workers have shown milo to produce 10 to 16% less efficient gains than corn, barley or wheat (Brethour and Duitsman, 1959; Pope *et al*., 1961a; Hubbert *et al*., 1962; Totusek *et al*., 1963; Saba *et al*., 1964; Hale *et al*., 1965; Hale *et al*., 1965; Hale *et al*., 1965; Brown *et al*., 1968).

The disparity in results could be due to variation in composition of the grains (as affected by fertility, irrigation, climate and variety), type of ration, and/or processing method (affecting particle size and gelatinization). Breuer *et al*. (1967), studying 14 different varieties of sorghum grain, found a range in crude protein content of from 8.6 to 13.4%.

## Processing Methods

During the last 6 years, considerable work has been done to reappraise the feeding values of grains for ruminants, especially in finishing rations. The evaluations discussed in this review are for cattle only. The majority of previous grain evaluations were made 25 to 40 years ago (Hale *et al*., 1965).

Processing of grains has received renewed interest and has shown considerable promise for improved rate of gain and feed efficiency of finishing cattle. As the following review of processing methods will point out, grain processing can imply many things, from the production of a very coarse material by cracking in a burr mill to the creation of a flat, flake-like product by rolling after partial cooking in a moist steam environment.

In this review, the following grain processing methods will be discussed: grinding, pelleting, conventional rolling, popping, steam-process-flaking and high moisture processing.

Grinding

It has long been recognized that efficiency of grain utilization could be improved by merely cracking or coarse grinding. This is especially true for milo, since the hard, waxy outer shell is extremely resistant to digestion. Therefore, it is absolutely necessary to rupture the grain before feeding to cattle as they apparently chew whole milo very little prior to swallowing. This is in contrast to whole corn which can be fed with a fair degree of success as considerable portions of the grain are broken by mastication before swallowing (Hale and Taylor, 1965).

Grain can be broken down to varying particle sizes by grinding through a hammer mill with different sized screens. Coarse grinding is a procedure that has been used widely in the past (Hale et al., 1965). There are, of course, varying degrees of coarse grinding; for example, milo may be ground through a 1/2 in. screen down to a 3/16 in. screen, as well as any sizes in between, and still be called coarsely ground.

To describe this point another way, coarsely ground milo may consist of large broken particles, some fine material and quite a bit of whole milo. At the other extreme, coarsely ground milo may be defined as the coarsest product that can be derived, without leaving any whole grains. This product would have more fine material than the one previously described. Coarse grinding has often been used as a control to which other processing methods are compared.

Fine grinding milo through a 1/8 in. screen increased feed efficiency approximately 5% compared to coarse grinding through a hammer mill with no screen (Pope et al., 1961; Pope et al., 1962) or through a 1/2 in. screen (Totusek et al., 1964). A possible explanation, according to these workers, is that fine grinding exposes more surface area to bacterial digestion, resulting in improved utilization. Intake was reduced, compared to coarse grinding, and rate of gain was not significantly affected; therefore, the cattle were apparently eating to a certain level of energy intake. The level of grain in the rations ranged from 40 to 60%. A breakdown of particle sizes is shown in Table II.

Cox and Smith (1952), Baker et al. (1955) and Brethour et al. (1963) observed essentially the same results in comparisons of finely ground and coarsely ground milo. An illustration of the particle sizes produced is shown in Table II.

Hale and Taylor (1965) agreed that feed efficiency was

TABLE II

EFFECT OF PROCESSING METHOD ON PARTICLE SIZE

| Particle Size | Finely Ground Milo | Coarsely Ground Milo | Dry Rolled Milo |
|---|---|---|---|
| | % of each size | | |
| Pope *et al.*, 1961 | | | |
| screen size | | | |
| 10/64 in. | 0 | 0 | -- |
| 6/64 in. | 0 | 4.4 | -- |
| 1/25 in. | 26.1 | 40.6 | -- |
| 1/40 in. | 36.3 | 24.5 | -- |
| through 1/40 in. | 37.2 | 29.8 | -- |
| Pope *et al.*, 1962 | | | |
| screen size | | | |
| 6/64 in. | 0 | -- | 31.9 |
| 1/40 in. | 67.5 | -- | 61.2 |
| through 1/40 in. | 32.0 | -- | 6.9 |
| Brethour *et al.*, 1963 | | | |
| particle diameter | | | |
| 2000 to 4000 microns | trace | -- | 36 |
| 1000 to 2000 microns | 23 | -- | 61 |
| 500 to 1000 microns | 32 | -- | 4 |
| 300 to 500 microns | 11 | -- | 2 |
| 150 to 300 microns | 10 | -- | 1.5 |
| < 150 microns | 24 | -- | 1.5 |
| Mehen *et al.*, 1966 | | | |
| screen size | | | |
| 5 mesh | 0 | -- | 0 |
| 10 mesh | 0.17 | -- | 0.57 |
| 20 mesh | 4.12 | -- | 71.91 |
| 30 mesh | 12.92 | -- | 18.40 |
| 40 mesh | 16.38 | -- | 4.13 |
| over 40 mesh | 66.41 | -- | 5.09 |
| Buchanan-Smith *et al.*, 1968 | | | |
| particle diameter | | | |
| .318 - .476 cm. | 0 | 2.4 | -- |
| .212 - .318 cm. | 1.6 | 9.1 | -- |
| .141 - .212 cm. | 14.4 | 22.4 | -- |
| .102 - .141 cm. | 22.1 | 20.4 | -- |
| .05 - .102 cm. | 27.4 | 22.3 | -- |
| < .05 cm. | 34.5 | 23.4 | -- |

increased by fine grinding milo as compared to coarse grinding. However, they maintain that finely ground rations are dusty and not readily consumed by cattle, particularly in high grain rations. They have observed reduced intake and resulting low rates of gain, which in their opinion, prevent fine grinding from being a desirable processing method. Observations by Ray and Drake (1959) on the effect of grain preparation on animal preference followed this same line.

Mehen et al. (1966) and Buchanan-Smith et al. (1968) reported no advantage in digestibility of finely ground milo over dry rolled and coarsely ground milo, respectively. Fine grinding was accomplished by grinding in a hammermill through a 1/4 in. screen (Mehen et al., 1966) and through a 1/8 in. screen (Buchanan-Smith et al., 1968), producing the particle sizes shown in Table II. Earlier work by Smith et al. (1949) had shown an advantage to finely ground.

Grinding shelled corn increased feed efficiency 7.8% over cracked corn (Hentges et al., 1961).

## Pelleting

Fine grinding and pelleting of milo improved feed conversion from 5 to 10%, with no significant effect on rate of gain, compared to dry rolled milo (Pope et al., 1958; Pope et al., 1959; Pope et al., 1962). The pelleted milo also produced consistently lower dressing percentages. Pope et al. (1962) observed no significant differences in feedlot performance between finely ground (1/8 in. screen) and coarsely ground (no screen) milo rations fed in 5/16 in.

pellets.

McCroskey et al. (1959) found an interaction between pelleting and ratio of milo to roughage. Pelleting a finely ground ration with a milo to roughage ratio of 1:4 increased rate of gain 23%, feed intake 10% and feed efficiency 10%, compared to the same ration in the meal form. However, pelleting a finely ground 4:1 ration decreased rate of gain 9% and intake 12%, and increased efficiency 3% compared to the same ration unpelleted. Digestion trials on similar rations did not reveal any significant differences in the digestibility of the proximate components (McCroskey, 1961).

Pope et al. (1962) concluded that pelleting a fattening type milo ration containing over 65% concentrates will depress feed intake and rate of gain. Reports from the Kansas and Arizona stations support these findings (Richardson et al., 1960; Richardson et al., 1961; Hale and Taylor, 1965).

Pelleting ground shelled corn has been shown to improve feed efficiency 13.9% (Arnett and Bradley, 1960), 7.7% (Hentges et al., 1961) and 10% (Little et al., 1962), compared to unpelleted ground shelled corn. Significant increases in rate of gain were also reported by Arnett and Bradley (1960) and Little et al. (1962).

Conventional Rolling

Dry rolling of milo has generally been found to give results intermediate between coarse and fine grinding (Cox and Smith, 1952; Baker et al., 1955; Pope et al., 1958; Pope et al., 1959; Richardson et al., 1960; Pope et al., 1961b;

Richardson et al., 1961; Boren et al., 1962).

Conventional steam-rolling of milo has been observed to give similar results as dry rolling. This process usually involved steaming the grain for approximately 3 to 5 min. at a temperature of around 180°F. before coarse rolling (Taylor et al., 1960; Hale and Taylor, 1965). Pope et al. (1961) observed that feed conversion for steam-rolled milo was intermediate between finely ground and coarsely ground milo, although differences were not significant.

Coarsely rolled sorghum grain produced average daily gains and feed efficiencies 4 and 5.4% greater, respectively, than finely rolled milo (Brethour and Duitsman, 1966). Particle sizes produced are shown in Table III.

Popping

Steers fed an all concentrate ration containing 40% popped milo with the rest of the grain consisting of cracked milo required 16.6% less feed per lb. of gain than those fed

TABLE III

EFFECT OF ROLLING PRESSURE ON PARTICLE SIZE

| Particle Diameter in microns | Coarsely Rolled Milo | Finely Rolled Milo |
|---|---|---|
| | % of each size[a] | |
| 2000-4000 (coarse) | 47.0 | 6.5 |
| 1000-2000 (medium) | 41.0 | 54.5 |
| 300-1000 (fine) | 9.0 | 28.5 |
| less than 300 (flour) | 3.0 | 10.5 |

[a]Average of two trials reported by Brethour and Duitsman (1966).

the same ration with cracked milo only (Ellis and Carpenter, 1966). No difference in rate of gain was observed. However, all concentrate rations with popped milo making up the entire grain portion produced no improvement over cracked milo (Durham *et al.*, 1967).

Steam-Process-Flaking

Steam-processing and flaking of milo increased daily gain 9.6%, feed intake 4.6% and feed efficiency 4.7% compared to dry rolled milo, when fed to steers in high concentrate (80-85% concentrate) rations (Hale *et al.*, 1965; Hale *et al.*, 1966). The steam-process-flaked milo was produced by subjecting whole milo to low pressure, high moisture steam for 20-25 min. at temperatures averaging 99°C. (215°F.). The milo was then immediately rolled with no tolerance between the rollers, producing a large, flat flake having approximately one-half the weight per unit volume of the original grain. The milo had an average moisture content after flaking of 17.8% and weighed an average of 32.7 lb. per bu. The weight per bu. of the original whole milo was 58.0 lb.

A conventional digestion trial by Hale *et al.* (1965) showed that steam-processing and flaking of milo significantly increased the digestibility of dry matter, nitrogen free extract, gross energy and total digestible nutrients (TDN), decreased ether extract digestibility and had no effect on protein digestibility, as compared to dry rolled milo. In the same trial, decorticating rather than flaking the steam-processed milo before feeding resulted in a dry matter digestibility very similar to that of dry rolled milo. Mehen et al. (1966) and Husted et al. (1966) found essentially the same results. However, Husted et al. (1966) also found protein digestibility to be significantly higher for the steam-process-flaked milo.

Buchanan-Smith et al. (1968) reported significant increases in digestibilities of non-protein organic matter, starch and sugars combined and energy of flaked over coarsely ground milo. There were no significant differences in nitrogen digestibility or nitrogen retention.

Hale and Taylor (1966) gave some of the key points to successful steam-process-flaking as being:

1) raising moisture level to approximately 20%
2) by leaving in steaming chamber for 15 to 30 min. at a
3) temperature of 212 to 216°F., with
4) approximately 20 lb. pressure in the chamber, then
5) rolling with no tolerance on rollers (or with an 18 x 30 in. roller mill, the cold roller spacing should be 0.003 in.), so as to give
6) a very flat flake, with a
7) weight per bu. of about 25 lb., and
8) starch gelatinization of from 30 to 40%.

Garrett et al. (1966b) reported a significant increase in both empty body weight gains and gross feed efficiencies by steam-pressure-processing milo for 1.5 min. at 20 psi and then rolling, compared to conventional steam-rolled milo.

However, in succeeding trials (Garrett *et al.*, 1966b; 1967) no significant differences were observed.

Steaming milo at 60 psi for 1.5 min. significantly reduced rate of gain and feed consumption compared to milo processed by either of the following methods: pressure-processing for 1.5 min. at 20 psi before rolling, steaming for 20 min. at near atmospheric pressure before rolling, and steaming for 8 min. at near atmospheric pressure before rolling. Dressing percentages were also significantly reduced for the 60 psi pressure-processed milo compared to the 8 min. steamed milo. Rations fed consisted of 64 and 84% milo. No interactions of processing method with level of grain were observed.

Another trial (Garrett *et al.*, 1967) compared conventional steam-rolled milo to milo processed at three levels of pressure-processing (cooking pressure and grinding or rolling pressure were increased together). No significant difference was noted in average daily gain or in carcass merit. Feed intake and feed/lb. gain were decreased in all pressure-processed grain treatments, somewhat in relation to the severity of the steam treatment. Comparison of rolling and grinding the grain after steam treatment indicated a slight but not statistically significant advantage for the rolled over the ground product. No information was given as to the character of the rolled product. Hale *et al.* (1965) indicated that a flat flake was necessary for maximum improvement in milo utilization.

Garrett et al. (1966b) summarized the results of five experiments in which steam-pressure-processed milo was compared with conventional steam-rolled or ground milo as follows:

1) Feed consumption was decreased by steam-pressure-processing.
2) Feed efficiency was improved by an average of 8% by steam-pressure-processing.
3) The optimum time-pressure relationship was in the vicinity of 1.5±0.5 min. at 50±10 psi.
4) Very severe steam treatment (1.5 min. at 60 psi. or above) resulted in less efficient response.
5) Rolling after steaming gave slightly better response than grinding.
6) No significant differences were observed in digestible energy or protein.

Steam-process-flaked milo fed in an all concentrate ration produced rates of gain 11.8% less than for cracked milo (Durham et al., 1967). Cattle fed flaked milo consumed significantly less, with no difference in feed conversion.

Steam-process-flaking barley increased feed intake 9.1%, improved rate of gain 7.9% and had no effect on feed efficiency compared to dry rolled barley (Hale et al., 1965; Hale et al., 1966). Moisture content after flaking averaged 13.8% and weight per bu., 24.1 lb.; whole barley averaged 47.0 lb. per bu. No improvement in digestibility of dry matter (Hale et al., 1965) or proximate components (Parrot *et al*., 1967) was observed. Increasing the flatness of the flake also had no effect on digestibility (Parrot *et al*., 1967). McIlroy *et al*. (1967) reported an improvement in feed efficiency of 12.5% and a 3.5% increase in dry matter digestibility for steam-process-flaking barley compared to grinding through a $\frac{1}{4}$ in. screen.

Steam-pressure-processing barley (1.5 min. at 20 psi or 1 min. at 25 psi) improved feed efficiency an average of 4.4% compared to either conventional steam-rolling or grinding (Garrett *et al*., 1966b; 1967). Rate of gain, carcass merit and digestibility of dry matter, energy and protein were not significantly different.

Steam-process-flaking corn improved feed efficiency by an average of 8% compared to cracking when fed in a 55% concentrate ration (Matsushima *et al*., 1965; Matsushima *et al*., 1967). Consumption was decreased by an average of 10%, with no significant effect on rate of gain. When the two types of corn were fed in an 80% concentrate ration, the flaked corn produced a 13% improvement in feed conversion (Matsushima *et al*., 1965). When cattle were paired on the basis of weight and gain and fed the same quantity, those on flaked corn gained 6.5% faster (Matsushima *et al*., 1965).

Other workers have reported increased feed efficiencies for steam-process-flaked corn of 12.6% (Arnett and Bradley, 1960), 7.5% (Hentges *et al*., 1961) and 7.0% (Little *et al*., 1962). A 5% increase in dry matter digestibility for flaked over cracked corn, fed in 70 and 80% corn rations, was observed by Johnson et al. (1967).

Steam-pressure-processing corn failed to improve rate of gain, feed efficiency or digestibility (Garrett et al., 1966b). This was also true for wheat.

Gelatinization of starch occurs in varying degrees when grain is partially cooked by steaming and/or pressure-processing. What is the optimum level of gelatinization? Pope et al. (1963) reported results of a trial in which milo was almost completely gelatinized by subjecting to a maximum temperature of 270°F., achieved by steam heat and mechanical extrusion, for approximately 10 sec. The "expanded" milo came out in small, hard cubes which were re-ground to the same physical state as the ground, but untreated, milo. Steers receiving the treated milo in a 55% milo ration gained less and consumed less than those receiving the untreated ground milo, which resulted in very similar feed efficiencies. Riley et al. (1965) autoclaved a mixture of rolled milo and barley in equal parts for 30 min. at 17 psi, after mixing the rolled grain with 40% of its weight in water. The grain was then subjected to a 90 min. "cooling off" period, during which time the temperature remained above 94°C. Starch gelatinization was complete in the autoclaved grain and nearly absent in the control. Digestibility of the proximate fractions was decreased by autoclaving. No increase in gain and only a slight increase in feed efficiency was observed when the gelatinized grain was fed to cattle in a fattening ration. The results of these two trials indicate that complete gelatinization of the starch does not improve the feeding value of grain for fattening cattle.

Gelatinized sorghum grain produced by grinding and then processing through an extruder cooker at 300°F. was fed in a 70% milo ration at levels of 0, 25, 50 and 75% of the grain portion (Drake *et al*., 1967). No significant differences were observed in rate of gain. The 75% level produced the most efficient gains, 3.4 and 19% greater than the 0 level for individual and group fed cattle, respectively. Wilson and Woods (1966) reported that up to 45% gelatinized corn in a fattening ration did not significantly affect gain, intake or efficiency. The same workers in a subsequent trial observed that both 50 and 100% gelatinized corn significantly decreased gains, intake and efficiency (Woods and Wilson, 1967). It would appear, from the results of these trials, that the optimum level of gelatinization is different for milo and corn; possibly 75 and 45%, respectively.

*High Moisture Processing*

High moisture milo includes both high moisture harvested milo (also called early harvested milo) and reconstituted milo (resulting from the addition of water to dry milo). In either case, the moisture level is typically around 30%, the grain must be processed before or after storage and it must be stored in oxygen free conditions.

McGinty and Riggs (1967), in a summary of seven experiments involving 273 hd. of cattle, stated that these two types of milo (moisture content ranging from 23 to 32%) lowered milo requirement per lb. of gain (on a dry matter basis) an average of 21%, compared to dry ground milo. Total feed efficiency was improved approximately 15%. Rate of gain was not significantly affected, and the two types of high moisture milo did not differ significantly.

Parrett and Riggs (1966), in a trial comparing dry, reconstituted and early harvested sorghum grain, with moisture levels of 10.3, 29.7 and 28.0%, respectively, observed an 11% improvement in feed efficiency for the two high moisture treatments over the dry milo. Early harvested milo fed with 3.1 lb. cottonseed hulls per day failed to increase efficiency, while the same milo fed in an all concentrate ration produced a 17% increase in efficiency. All grains were rolled and fed *ad libitum*.

Franke *et al.* (1960), comparing early harvested milo to dry milo (both ground through a 5/16 in. screen) found a 10% increase in efficiency over a 112 day growing period and a 17.6% increase in a subsequent 140 day fattening period. The two periods combined showed a 13% advantage for the high moisture milo. Riggs *et al.* (1959) reported steers fed ground early harvested (23% moisture) milo in a conventional finishing ration required 18% less dry matter from the grain and 12% less total dry matter per 100 lb. of gain than similar steers fed ground dry milo. High moisture milo fed in the unground form failed to produce satisfactory gain and the grain requirement per 100 lb. gain was 60% higher than for the ground high moisture milo. These workers stated that sorghum grain was harvested successfully at moisture levels of 25 to 30% with standard self-propelled combines by slowing the ground speed and maintaining cylinder speed at that used for threshing small grains. The moist milo was then stored without spoilage or loss in an air-tight, glass-lined silo. Franke _et al_. (1960) reported that grain sorghum harvested at 31% yielded 4,964 lb. per acre compared to 4,228 lb. per acre for grain harvested at 10% moisture. Parrett and Riggs (1966) obtained reconstituted milo by spraying the milo with water as it was augured into the air-tight structure, where it remained for 90 days before feeding. They recommended a minimum of 21 days fermentation time before feeding, although a shorter period might suffice.

A summary of these trials, comparing high moisture milo to dry milo, indicates the following points:

1) High moisture milo produced a consistent improvement in feed efficiency (10 to 15%), with
2) no significant differences in rate of gain.
3) High moisture milo must be stored in oxygen-free conditions and
4) ground or rolled before feeding to cattle.
5) High moisture milo produced a greater increase in feed efficiency when fed in an all concentrate ration as compared to one with 3.1 lb. of cottonseed hulls per day, and
6) a greater increase in efficiency when fed to fattening cattle than when fed to growing cattle.

Early harvested milo, stored whole and ground before feeding, produced improvements in feed efficiency of 12.7% (Brethour and Duitsman, 1961) and 10.0% (Brethour and Duitsman, 1962) compared to coarsely ground dry milo, fed in a conventional fattening ration containing silage. Early harvested milo (42% moisture) ground before storing in a trench silo produced 7% more efficient gains than 42% moisture early harvested milo ensiled and fed in the whole form (Brethour and Duitsman, 1961).

High moisture harvested milo (36% moisture), ground before ensiling in the trench, was utilized slightly more efficiently than the same grain stored whole and ground before feeding (Brethour and Duitsman, 1963). Considerably less spoilage occurred in the ground milo during storage. Sorghum grain harvested, ground and ensiled in a trench at 36% moisture produced a small increase in efficiency compared to milo harvested at 27% moisture, but a decrease in yield of dry matter per acre of the higher moisture milo was also observed (Brethour and Duitsman, 1963). Feed efficiency of the two combined was 12% higher than for dry rolled milo, although rate of gain was significantly less for the high moisture milo. However, in a subsequent trial, rate of gain, intake and efficiency were not significantly affected by harvesting milo at 26% moisture, grinding and ensiling in a trench, compared to dry rolling (Brethour and Duitsman, 1964). A summary of these trials indicated about a 10% increase in feed efficiency, with little to no effect on rate of gain, for early harvested milo.

Soaking whole milo for 16 hr. to bring the moisture level up to 35% before cutting in a decorticator increased the digestibility of gross energy (2%), N.F.E. (6%) and protein (4%), compared to dry rolled milo (Husted et al., 1966). However, Ely and Duitsman (1967) reported reductions in rate of gain (4.6%), intake (5.9%) and feed efficiency (1.4%) for soaked milo (50% moisture) that was cold rolled before feeding, compared to dry rolled milo.

Significant increases in digestibility of both the starch and protein portions of high moisture milo, as compared to dry ground or rolled milo, have been found in digestion trials (McGinty et al., 1966, 1967; McGinty and Riggs, 1967). Components studied and average percent increases are as follows: dry matter, 24.2; protein, 19.3; organic matter, 22.8; and non-protein organic matter, 23.2. Apparent digestibility averages are shown in Table IV.

Apparent digestibility of dry matter, organic matter, non-protein organic matter and gross energy by cattle was significantly higher for reconstituted milo than for coarsely or finely ground milo (Buchanan-Smith et al., 1968). However, no significant improvement in protein digestibility or nitrogen retention was found. Digestibility figures are shown in Table IV.

King (1962), in a detailed comparison, found no significant differences in any of the standard carcass measurements between cattle fed high moisture and dry milo.

TABLE IV

APPARENT DIGESTIBILITIES OF RECONSTITUTED AND DRY MILO

| | McGinty and Riggs (1967) | | Buchanan-Smith et al. (1968) | |
|---|---|---|---|---|
| Proximate Component | Dry Milo (Coarsely Grd.)[a] | Reconstituted (Coarsely Grd.)[a] | Dry Milo (Coarsely Grd.)[b] | Reconstituted (Rolled) |
| Dry matter | 64.73 | 80.40 | 76.00 | 81.64 |
| Organic matter | 67.71 | 83.13 | 76.98 | 82.84 |
| Non-protein organic matter | 70.14 | 86.41 | 79.11 | 85.24 |
| Protein | 47.34 | 56.46 | 66.35 | 71.04 |

[a]Ground in hammermill through 5/16 in. screen.

[b]Ground in hammermill through 1/4 in. screen.

Early harvested corn, ranging in moisture from 24 to 32%, has shown improvements in feed efficiency from essentially none to 15% over air dry corn (Beeson and Perry, 1958; Heaberger et al., 1959; Larson et al., 1966; Matsushima and Stenquist, 1967). Beeson et al. (1956) and Beeson and Perry (1958) reported a 10 and 15% increase in feed efficiency, respectively. Culbertson et al. (1957) observed an increase in efficiency of feed conversion of 8%. No significant difference in rate of gain was found in this trial or the two previous ones, and all three were comparing early harvested ground ear corn to regular ground ear corn.

Heaberger et al. (1959) reported a 4% increase in efficiency with gains slightly higher and intake slightly lower for high moisture corn (24 and 29% moisture). However, corn ensiled at 36% moisture produced gains 20% less than for dry shelled corn, while both consumption and feed efficiency were 14% lower for the high moisture corn. Percent losses in the silo were least for the 36% and highest for the 29% corn (the 24% was intermediate). Rolled high moisture corn produced the same rate of gain as ground high moisture corn (29-32% moisture), but on 7.4% less feed, resulting in 4% greater efficiency (Matsushima and Stenquist, 1967). Compared to cracked corn, the rolled high moisture corn produced a 4.8% reduction in rate of gain, but on 20.7% less feed, resulting a 5.7% improvement in feed conversion. Larson et al. (1966) found no significant differences in gain or efficiency of steers fed reconstituted corn (28% moisture) compared to those fed dry corn, when fed twice daily. A 5.4% improvement in efficiency was noted for the reconstituted corn when the rations were fed once daily.

Digestion trials have shown no significant differences between high moisture and dry corn (Hodge *et al*., 1959; Mohrman *et al*., 1959).

## Net Energy

### Utility

The use of net energy values of feedstuffs in practical production situations has increased tremendously in the last few years. This has been especially true for finishing cattle. This rise in popularity is understandable, since net energy is an expression of the actual usefulness of a ration for a certain purpose, as opposed to the energy standards of TDN and digestible and metabolizable energy which only indicate a feed's potential usefulness. However, net energy has some limitations which in the past have limited its use to principally fundamental research under intensive experimental control (Kriss, 1943). This will be discussed further.

Actually, the concept of net energy, defined as the energy left after deducting energy losses in the feces, combustible gases, urine and work of digestion (heat increment), is not new. Early in this century Armsby (1914), Armsby and Fries (1916) and Kellner (1915) published feeding standards based on the principle of net energy. Other systems using the net energy concept have been devised. Hansson's Scandinavian feed unit system used barley as the reference standard (Woll, 1912). Mollgaard's production unit is the net energy of fattening which will produce 100 cal. of milk energy (Preston, 1965). Frap's (1931) productive energy values were obtained from feeding trials and calculated using the chemical composition of a particular feed and the corresponding production coefficient. Morrison's (1959) estimated net energy values were obtained principally by calculation, using results from many sources. He used an assumed caloric value per unit of TDN in converting TDN to net energy. Brody (1945) proposed an energy value of 1914 kcal. digestible energy per lb. of TDN. Schneider (1947) suggested a figure of 1987 kcal. of digestible energy per lb. of TDN, and this was endorsed by Maynard (1953). An average of 2000 kcal. per lb. of TDN is most widely used at the present time (Crampton, 1956; Crampton _et al_., 1957; Swift, 1957). Net energy has been estimated to be approximately 45% of digestible energy (Garrett _et al_., 1959).

Limitations in the utility of many of these earlier systems were due to two false assumptions, namely (1) that feeds are utilized equally well for maintenance and for production of tissue, and (2) that a feed has the same relative nutritive value for various productive purposes, such as lactogenesis or lipogenesis (Blaxter, 1962). The refutation of the first assumption will be discussed in the next section. As for the second assumption, energy is utilized approximately

10% more efficiently for milk production than for body gain (Reid, et al., 1966).

Energy-Intake Relationships

The assumption that the utilization of feeds for maintenance and for tissue deposition are simple multiples of one another has been essentially refuted. As early as 1930, Forbes et al. reported that the net energy value of a feed for maintenance was approximately 20% greater than when fed at higher levels. Other workers have confirmed this general observation (Mitchell et al., 1932; Kriss, 1943; Lofgreen et al., 1963; Garrett et al., 1964; Absher, 1965; Hall, 1966). Lofgreen and Garrett (1967a) maintain that the ratio of $NE_m$ to $NE_p$ varies according to crude fiber content; that is, roughages are of more value for maintenance than for production, compared to concentrates. However, the relationship between net energy and level of intake for production above maintenance has not been so definitely established.

Forbes et al. (1928) and Forbes et al. (1930) reported that the heat production from a ration fed at levels from fasting to three times the maintenance requirement was a gentle, reversed"S" curve. The curve was prominent from fasting to maintenance, reflecting the inefficiency of catabolism, and slight from maintenance to full feed. The heat increment per unit of feed was therefore more constant when maintenance was used as a base line rather than when fasting was used. Other workers have also recommended the use of maintenance as a base line (Blaxter, 1962; Reid et al., 1966).

Kriss (1943) and Reid et al. (1966) concluded that the gentle curve above maintenance could practically be taken as a straight line. Blaxter (1956) reviewed much of the literature pertaining to net energy values and is of the opinion that the relationship between intake and energy retention is curvilinear.

Kleiber (1961), on the other hand, states that the "law of diminishing returns does not properly fit the conditions of animal feeding" and that "there is neither sufficient empirical evidence for the theory that partial efficiency decreases with increasing food intake, nor is the theoretical strength of this argument impressive." Furthermore, a constant net energy value for each succeeding increment of a given feed above maintenance has been obtained by Marston (1948), Lofgreen et al. (1963), Garrett et al. (1964), Absher (1965) and Hall (1966).

Lofgreen and Otagaki (1960) studied the net energy for production of various increments of molasses. Molasses fed as 10% of the ration had a higher $NE_p$ than molasses at levels of 25 or 40% of the ration. Companion digestion trials showed that the loss in energy was not due to fecal loss. A partial explanation for this may lie in the fact that rations are fed below maximum consumption in conventional digestion trials. Reid et al. (1966) has reported a decline in digestibility of 4% for each succeeding maintenance unit of intake. If, however, the digestibility of energy as determined in the digestion trial is a good measure of digestibility of the rations when fed ad libitum, the increase in energy loss on the higher levels of molasses must occur after digestion. This means there would have to be an increase in the energy loss in the urine, combustible gas or in the heat increment. If the heat increment truly was greater when molasses was fed at the higher levels, the relationship between energy retention and intake could well be curvilinear.

Garrett et al. (1959) reported the partial efficiency of food utilization to be independent of intake, body size and sex. Thus, one relationship between energy intake and energy gain was assumed to express the energy requirements of both sheep and cattle (steers and heifers) for all rates of energy gain. However, Lofgreen and Garrett (1967b) in a revision of their $NE_p$ requirements, listed separate requirements for steers and heifers and incorporated an increase in $NE_p$ requirement per unit of gain.

Thus, the relationship of level of intake and net energy for production still has not been firmly established. Net energy has also been criticized for being a measure of what a feed might accomplish and not a description of that feed (Tillman, 1967). Further, net energy is influenced by factors which affect heat production that are completely independent of the nutritive value of the ration, such as weather, insect annoyance and activity.

However, it must be pointed out that the other measures of energy, such as TDN and digestible and metabolizable energy, are also subject to the variations in heat loss plus other losses in the feces, urine and fermentation (methane).

As stated before, digestibility declines with increased intake (Reid et al., 1966). Losses in the urine and combustible gases tend to decrease with succeeding levels of intake (Blaxter, 1962). Thus, it is difficult to logically dispute the theoretical preference of net energy as a measure of useful feed energy (Lofgreen and Otagaki, 1960).

Methods of Determination

According to the "Law of Hess," only the initial and final chemical states of matter need to be known in order to determine energy balances (Maynard and Loosli, 1962). This is the underlying principle for the use of respiration chambers and the comparative slaughter technique for indirect determination of net energy values. Mitchell et al. (1932), Marston (1948) and Armstrong (1960) used the respiration chamber method. Armsby and Fries (1916), Forbes et al. (1928) and Forbes et al. (1930) used a respiration calorimeter, which measures actual heat production, to derive net energy values.

The technique that is currently receiving considerable attention is the comparative slaughter technique developed and improved at the California station (Garrett et al., 1959; Lofgreen et al., 1962; Lofgreen et al., 1963; Garrett et al., 1964; Absher, 1965; Hall, 1966; Garrett et al., 1967). This technique involves slaughtering cattle for the estimation of body caloric content at the start and finish of a feeding trial and attributing the gain in energy to the ration fed. The slaughtering process appears to be mandatory until a suitable method is found to determine body water in the live animal (Lofgreen and Otagaki, 1960). The major difficulty in obtaining the *in vivo* measure is rumen fill (Garrett *et al*., 1959). Lofgreen *et al*. (1962b) developed equations to estimate empty body weight from warm carcass weight.

This technique involves the use of specific gravity to estimate the percent body water, from which the body fat and protein percentages can be estimated. Rathbun and Pace (1945) conducted the first analysis relating specific gravity to body composition, in this case, with body fat content in guinea pigs. DaCosta and Clayton (1950) used rats in a similar analysis and found that specific gravities could also be used effectively as indices of body water content. Brown *et al*. (1951) and Whiteman *et al*. (1953) applied the specific gravity measurement to pork carcasses. Kraybill *et al*. (1952) extended the use of specific gravity to cattle, in the estimation of separable fat and body water. Reid *et al*. (1955) developed an equation for predicting total body fat from body water.

Lofgreen and Otagaki (1960) explained in detail the use of the above procedures in determining net energy values of feeds. This technique can be used for determining $NE_{m+p}$ of a feed by use of a reference standard (Lofgreen *et al*., 1962a) or $NE_p$ by the increment method (Lofgreen *et al*., 1963; Garrett *et al*., 1964). $NE_m$ values are obtained by extrapolation (Garrett *et al*., 1959).

Net Energy of Milo

Morrison's (1959) estimated net energy values place milo almost on a par with corn and show it to be superior to barley. His values for the three grains, converted to megcal. per 100 kg. feed, are 174, 177 and 155, respectively. Net energy values obtained by Garrett *et al*. (1964), Absher (1965), Garrett (1965) and Hall (1966), using the slaughter method are shown in Table V. No significant differences in net energy value of these grains were observed by these workers.

TABLE V

EXPERIMENTALLY OBTAINED NET ENERGY VALUES OF MILO, BARLEY AND CORN

| Reference | Net Energy used for | Milo | Barley | Corn |
|---|---|---|---|---|
| Garrett *et al.* (1964) | Maintenance | 202[a]±7[b] | 185±7 | ---- |
| | Production | 131±8 | 123±8 | ---- |
| | Maint. + Prod. | 157±7 | 141±7 | ---- |
| Absher (1965) | Maintenance | 169±11 | ---- | 171±11 |
| | Production | 133±15 | ---- | 120±13 |
| | Maint. + Prod. | 155±6 | ---- | 152±6 |
| Garrett (1965) | Production | 143 | 131 | ---- |
| Hall (1966) | Maintenance | 164±11 | ---- | 168±9 |
| | Production | 91±22 | ---- | 89±54 |
| | Maint. + Prod. | 109±6 | ---- | 110±17 |
| Garrett *et al.* (1967) | Maintenance | 190 | 196 | ---- |
| | Production | 124 | 130 | ---- |

[a]Megcal. per 100 kg.

[b]Standard error

# MATERIALS AND METHODS

## General

Four trials were conducted to determine the effect of grain processing method on the feeding value of milo for growing and fattening beef cattle, evaluated by feedlot performance, carcass merit and net energy. Identification of the four trials will be as follows: Trial I - Fort Reno, 1965-66; Trial II - Stillwater, 1965-66; Trial III - Fort Reno, 1966-67; Trial IV - Stillwater, 1966-67. Experimental procedures common to all four 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

Hereford steer calves were used in all four trials, the majority of which were raised on the Fort Reno Station.[1] Experimental designs used were randomized complete block (Trials I, III and IV) and stratified randomization (Trial II). Where the randomized complete block was used, the calves were blocked on the basis of shrunk weight and condition score

[1]The calves were approximately 10 months old at the start of each trial, which was in December in all cases. February and March are calving months at Ft. Reno.

and randomly assigned to treatment within each block. In Trial II, the calves were grouped according to shrunk weight and randomly assigned to treatment within each stratification. However, statistical analyses were run as for a completely random design.

Feeding

In Trials I, II and IV, a basal ration was fed to meet the maintenance requirements of the steers. The amount of TDN required for maintenance was calculated using an equation derived by Garrett et al. (1959), that is, kg. of TDN for maintenance = 0.065 $W^{.75}$, where W is the weight of the animal in kg. The estimated TDN of the basal ration was divided into the kg. of TDN required to obtain the kg. of basal required per day for maintenance. Grain was fed for productive purposes above maintenance, that is, growth and fattening.

In Trial III, a high concentrate ration (90% concentrate, 10% roughage) was fed ad libitum.

All steers had access to an open-sided shed, an outside lot and automatic waterers with thermostatically controlled warming.

Grain Processing Methods

Coarsely and finely ground milo were produced with a hammer mill, using 4.76 and 3.18 mm. screens, respectively. Dry rolled milo was produced by rolling air-dry whole milo with a roller tolerance in excess of 0.076 mm. Conventional steam-rolled milo and wheat were obtained from the Stillwater Milling Co. The whole grains were steamed for 3-4 min. and then rolled.

Steam-process-flaked milo was obtained by using the procedure reported by Hale et al. (1966) at the Arizona station. Whole milo was subjected to steam in an unpressurized steam chamber for approximately 20 min. at $96^{\circ}$ C., then rolled immediately with no tolerance between the rollers.

Reconstituted milo was obtained by adding water to the air-dry whole grain to raise the moisture level to 25-30% and then storing in oxygen-free conditions for 21 days or more. Before feeding, the milo was either rolled, with approximately 0.076 mm. tolerance between the rollers, or ground through a 3.18 mm. screen.

Data Obtained

Performance data obtained included average daily gain, average daily intake and feed per kg. of gain, on a live shrunk weight basis. In Trials I, II and IV, where a basal ration was fed to meet maintenance requirements and grain was fed for production, average daily intake and feed per kg. of gain were calculated both for the total ration (basal + grain) and for the grain only. These same performance data were calculated on an empty body weight basis, which cancels out the effect of variable fill. Also, empty body weight gain per kg. of feed and energy gained per kg. of feed were calculated to allow a direct comparison of the two "efficiency" terms, i.e., weight gain and energy gain. For these purposes, daily consumption records were kept. Initial and final weights were taken after a 16 hr. shrink without feed or water. Intermediate weights were taken at 21 day intervals, removing water only for 16 hr. prior to weighing.

All steers were slaughtered at the termination of the feeding trials. Carcass data obtained were carcass grade, marbling, ribeye area, fat thickness over the ribeye, chilled carcass weight, dressing percentage and cutability.[2] Rumen weights, both intact and empty, were taken to allow calculation of rumen content. All carcasses were quartered after a 24 hr. chill and weighed first in air and then in water to allow calculation of carcass specific gravities.

Grains were sieved and weights per bushel were taken to characterize the processed grains as to particle size and density, respectively. Dry matter determinations were obtained for each grain at the end of each 21 day period and used to adjust ration treatments to an equal dry matter content.

Appropriate statistical analyses were run using a high speed computer and, in most cases, checked with results obtained using a desk calculator. Duncan's New Multiple Range Test (Steel and Torrie, 1960) was used to compare treatment

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[2]Cutability, or percent boneless retail cut yield, was estimated by the equation of Murphey et al. (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.)

means whenever a significant F value was obtained.

Net Energy Determination

At the start of each trial, a representative slaughter sample was selected on the basis of shrunk weight and condition score. Slaughter sample size expressed as a percentage of the total number of steers at the start of each trial, ranged from 10 to 20%.

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

The specific gravities of the empty bodies were obtained by using a regression formula derived by Kraybill et al. (1952),

$$Y = 0.9955\ X - 0.0013,$$

where Y is the estimated empty body specific gravity and X is the carcass specific gravity. The percent body water was estimated using another formula from Kraybill et al. (1952),

$$W = 100\ (4.008 - \frac{3.620}{Y})$$

where W is the percent body water and Y is again the estimated empty body specific gravity. Body fat and protein were then estimated using formulas derived by Reid et al. (1955) and modified by Garrett and Lofgreen (1967),

$$F = 337.88 + 0.2406\ W - 188.91\ (\log W), \text{ and}$$

$$P = \frac{[80.80 - (0.00078Z)\ (100 - (W + F)]}{100}$$

where F represents the percent body fat, W the percent body water, P the percent body protein and Z the age of the animals in days.[3] The 100 - (W + F) portion of the equation for percent protein represents the percent fat free dry matter. The percentages of fat and protein were then multiplied times the empty body weight to obtain the kg. of fat and protein.

Factors of 9367 kcal. per kg. of fat (Blaxter and Rook, 1953) and 5686 kcal. per kg. of protein (Lofgreen and Otagaki, 1960) were used to convert the estimated kg. of fat and protein in the empty body to their respective caloric values. The average total kcal. per kg. of empty body weight of the slaughter group was then used to estimate the initial caloric content of the steers remaining on test, hereafter referred to as the experimental group.

Upon completion of each feeding trial, the experimental steers were slaughtered and subjected to essentially the same procedure as described for the slaughter group. The initial empty body weights of the experimental steers were estimated by a prediction equation developed from the slaughter group data. The estimated initial empty body weight of each steer was multiplied by the average kcal. per kg. of the slaughter group to obtain initial caloric content. This was subtracted from the final total kcal. to obtain caloric gain. Since the maintenance requirement for energy is proportional to metabolic body size (Brody, 1945; Kleiber, 1932), average daily gain in kcal. and average daily intake

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[3]The exact age of each steer was used except where calving date was not availabe. In these cases, the average age of the calves in the respective trial was used.

were placed on a mean test weight$^{.75}$ basis. The maintenance requirement was assumed to be 77 kcal. per kg. $W^{.75}$[4] (Lofgreen and Garrett, 1967a) and was added to the estimated daily gain in kcal. to obtain the energy used by a steer for maintenance and production. This was divided by the average daily intake per kg. of $W^{.75}$ to obtain net energy ($NE_{m+p}$) of the total ration (grain + basal). In order to determine the calories coming specifically from the grain in the ration, a correction was made for the energy of the basal consumed. The $NE_{m+p}$ values of the basal rations were calculated using the values of Morrison (1959) for each of the ingredients. The basal $NE_{m+p}$ value was multiplied by the kg. of basal consumed by each of the experimental steers to determine the kcal. provided by the basal. By subtracting this product from the kcal. provided by the total ration, the kcal. attributed to the grain were estimated. This was divided by the amount of grain consumed to determine the net energy for maintenance and production ($NE_{m+p}$) of the grain.

Net energy for production above maintenance ($NE_p$) of the grain was estimated by "difference," that is, the increase in energy gained due to an increase in feed intake above maintenance. The lower level of feeding was that level that would theoretically maintain energy balance and the higher level was free choice, or approaching it.

It was necessary to first determine the net energy for

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[4] Value before revision was 63.3 kcal. per kg. $W^{.75}$ (Garrett *et al.*, 1959).

maintenance ($NE_m$) of the basal ration, by dividing the kg. of basal consumed by each of the steers on the basal maintenance ration[5] into the kcal. used for maintenance (77 kcal./kg. $W^{.75}$) minus the average daily loss in kcal. per kg. $W^{.75}$.[6]

$NE_p$ values of the grains were then calculated by three different methods.

(1) The experimental steers were fed basal at the same rate as the basal maintenance steers, that is, to theoretically meet their maintenance requirements, and were fed grain for production above maintenance. Therefore, the average daily grain intake per kg. $W^{.75}$ was divided into the average daily gain in kcal. per kg. $W^{.75}$ of the experimental steers plus the average loss in kcal. of the corresponding basal group, to obtain $NE_p$ values.

(2) The portion of the maintenance requirement provided by the basal was determined by multiplying the previously determined $NE_m$ of the basal times the average daily intake of basal per kg. $W^{.75}$ by each of the experimental steers. The remainder of the maintenance requirement was provided with milo, using an $NE_m$ value for milo of 1719.5 kcal. per kg. (Lofgreen and Garrett,

[5]Nine steers in both Trial I and Trial II were fed the basal ration only to meet their maintenance requirements.

[6]It was impossible to maintain the basal fed steers at an exact energy equilibrium. In Trial I, they lost an average of 7.30 kcal/day/kg. $W^{.75}$ and in Trial II, the average loss was 10.03. In both cases, they were slightly below maintenance; thus, the net energy values of the basals are for maintenance.

1967a). The amount of grain left after subtracting that used to complete the maintenance requirement was divided into the kcal. gained, thereby obtaining the $NE_p$ of the grain.

(3) The third method was used for Trial III only and is described in the Trial III net energy section.

Net energy for maintenance ($NE_m$) of the processed milo was estimated by multiplying the previously determined $NE_p$ values times the ratio of $NE_m$ to $NE_p$, which was calculated using the equation,

$$Y = 1.52 - 0.00921\ X + 0.00171\ X^2$$

where X is the percent crude fiber in the milo (Lofgreen and Garrett, 1967a). The correlation between percent crude fiber and the ratio of $NE_m$ to $NE_p$ was reported to be 0.93 (Lofgreen and Garrett, 1967a).

The net energy of each type of processed milo was then calculated by taking the mean of the values for each steer within each treatment. A computer program was constructed to handle all net energy calculations. All net energy values were subjected to the appropriate analysis of variance and treatment means were compared by Duncan's New Multiple Range Test (Steel and Torrie, 1960).

## Trial I

### Allotment

Trial I, comparing five types of processed milo, was initiated on December 6, 1965. The treatments, consisting of processed milo fed with a basal mix, were as follows: coarsely ground, finely ground, steam-process-flaked, reconstituted-rolled and reconstituted-steam-process-flaked. Nine calves were on each of these treatments, in pens of three. In addition, nine steers were fed the basal ration only. The experimental design is shown in Table VI. The average initial weight was 224 kg.

### Feeding

The composition of the basal ration is shown in Table VII. Table VIII contains the proximate analyses of the basal and the five types of processed milo. Processed milo was full fed in addition to the basal mix, which was fed to meet maintenance requirements. Since the estimated TDN con-

TABLE VI

TRIAL I: EXPERIMENTAL DESIGN

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

TABLE VII

TRIAL I: COMPOSITION OF BASAL RATION

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

TABLE VIII

TRIAL I: PROXIMATE ANALYSES[a]

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

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

[b]Dry matters are average of four determinations.

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

tent of the basal was 56.5%, 0.1152 kg. of basal per kg. $W^{.75}$ were required per steer per day. Enough milo was fed with the basal once a day to assure availability of feed until the next feeding. Basal was weighed to the nearest tenth of a lb. and milo to the nearest lb. Excess feed was weighed back when necessary.

Processing

Reconstituted milo was produced in 0.86 m. X 1.58 m. X 4.09 m. tanks. Whole milo was soaked in the tanks for 1 to 2 hr., after which time excess water was drained off and the tank sealed by covering the top with plastic and then dirt. Fermentation time was 20 days or more.

The steaming chamber used was 0.51 X 0.76 m. and the Davis rollers were 0.15 X 0.46 m., with no corrugations.

Reconstituted-steam-process-flaked milo was produced by steaming the whole reconstituted milo for about five min., reaching a maximum temperature in the chamber of 88°C., and then rolling with no tolerance between the rollers. The standard steam-process-flaking procedure, when used on reconstituted whole milo, raised the moisture level and degraded the starch to an extent that made rolling impossible.

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

Data Obtained

One steer on the finely ground milo treatment was slaughtered 11 days early because of urinary calculi. His gain and intake for that period were estimated. The weight of his rumen content and carcass weights in air and water were estimated by using the averages of the remaining 53 steers (excluding the basal steers). The steers were slaughtered on three different days, with the number of days on feed being 168, 170 and 175.

A factorial analysis of variance was run on pen averages for feed per kg. of gain and average daily intake of the total ration, feed per kg. of gain and average daily intake of the milo only, and net energy values. For the following variables, average daily gain, dressing percentage, carcass grade, ribeye area, fat thickness, marbling and cutability, a factorial analysis of variance was run with observations for all steers, as shown in Table IX.

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

Net Energy Determination

The slaughter group for this trial consisted of nine hd., or 14% of the total number of steers. Rumens, intact and empty, were weighed to the nearest lb. The weights of the four quarters of each carcass in air were taken to the nearest lb., and, in water, to the nearest five gm. When the experimental steers were slaughtered, rumen weights were taken to the nearest one-half lb. and carcass quarters were weighed to the nearest one - fourth lb. in air and to the nearest 5 gm. in water.

The $NE_{m+p}$ of the basal was estimated to be 1020 kcal.

TABLE IX

TRIAL I: ANALYSIS OF VARIANCE

| Source[a] | df |
|---|---|
| Total | 14 |
| Blocks | 2 |
| Treatment | 4 |
| Block X Treatment[b] | 8 |

| Source[c] | df |
|---|---|
| Total | 44 |
| Blocks | 2 |
| Treatment | 4 |
| Block X Treatment[b] | 8 |
| Within pen | 30 |

[a]For feed intake, feed/kg. gain and net energy values.

[b]Error term used to test treatment.

[c]For average daily gain and carcass data.

TABLE X

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

| Process | Screen Size (mm.) 7.15 | 6.35 | 4.76 | 3.18 | 2.12 | 1.41 | 1.02 | 0.36 | thru 0.36 | lb. per bu. |
|---|---|---|---|---|---|---|---|---|---|---|
| | % retained on screen | | | | | | | | | |
| Recon.-Rolled | 0 | 0.15 | 10.86 | 38.00 | 18.19 | 15.92 | 4.52 | 6.50 | 8.55 | 26.6 |
| Recon.-Steam-Process-Flaked | 0.27 | 2.45 | 17.37 | 17.30 | 9.99 | 9.21 | 7.50 | 14.70 | 18.80 | 25.7 |
| Steam-Process-Flaked | 5.67 | 16.44 | 42.49 | 23.93 | 5.21 | 2.18 | 0.86 | 0.90 | 0.09 | 22.8 |
| Steam-Process-Flaked (very flat flake) | 4.68 | 12.51 | 49.27 | 27.30 | 3.90 | 0.98 | 0.43 | 0.39 | 0.48 | 20.7 |
| Coarsely Ground | -- | -- | -- | -- | -- | -- | -- | -- | -- | 48.2 |
| Finely Ground | -- | -- | -- | -- | -- | -- | -- | -- | -- | 44.7 |
| Whole Dry | -- | -- | -- | -- | -- | -- | -- | -- | -- | 55.7 |
| Whole Recon. | -- | -- | -- | -- | -- | -- | -- | -- | -- | 42.3 |

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

[b]Test weights reported are averages of 14 - 22 determinations, and are on 90% dry matter basis. To prevent confusion, values were not converted to the metric system.

per kg. (Morrison, 1959).

Feed intake was on a pen basis since there were three steers per pen; therefore, net energy values are valid for a pen of steers and not for each steer. However, for ease of calculation in the computer program, the average intake (pen intake ÷ 3) was used to compare with the caloric gain and maintenance requirement of each steer. The resulting net energy values were then averaged for each treatment.

## Trial II

### Allotment

Twenty-seven Hereford steer calves, averaging 231 kg., were started on test on December 8, 1965 in a trial comparing conventional steam-rolled milo and wheat. Nine hd. were placed on each of the following treatments for an average of 180 days: milo, wheat, $\frac{1}{2}$ milo $\frac{1}{2}$ wheat, as shown in Table XI.

An additional nine hd. were fed a basal maintenance ration. The treatments were balanced according to shrunk weight, by a stratified randomization procedure. The 45 calves available initially, including the slaughter group,

TABLE XI

TRIAL II: EXPERIMENTAL DESIGN

| Basal | Milo | Wheat | $\frac{1}{2}$ Milo $\frac{1}{2}$ Wheat |
|---|---|---|---|
| | Conventional Steam-Rolled | | |
| 9 | 9 | 9 | 9 |
| | | | Total = 36 hd. |

were divided into three groups of 15 each. The calves were then assigned to treatment randomly within each group.

Feeding

The composition of the basal ration used in Trial II is shown in Table XII. The proximate analyses of the basal, milo and wheat are shown in Table XIII. The basal ration was estimated to contain 58.2% TDN; therefore, 0.1120 kg. of basal were required per kg. $W^{.75}$ for maintenance. Grain (milo,

TABLE XII

TRIAL II: COMPOSITION OF BASAL RATION

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

TABLE XIII

TRIAL II: PROXIMATE ANALYSES[a]

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

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

wheat, or ½ milo ½ wheat) was mixed with the basal in sufficient quantity to allow each steer to consume all he wanted in a period of approximately 1 hr. The calves were fed twice daily in individual stalls measuring 3.0 x 0.75 m. No water was available during the feeding period. During the remainder of the day they had free access to water in four outside pens. Feed was weighed out to the nearest one-eighth lb. and mixed at each feeding. Refused feed was removed, weighed and recorded.

Processing

Conventional steam-rolled milo and wheat were prepared at the Stillwater Milling Co. by steaming the whole grains for 3-5 min. before coarse rolling.

Data Obtained

The experimental steers were slaughtered on 3 different days (12 hd. each day) after an average of 181 days on feed. All variables, including performance data, carcass data and net energy values, were subjected to a hiearchal analysis of variance, as shown in Table XIV.

TABLE XIV

TRIAL II: ANALYSIS OF VARIANCE[a]

| Source | df |
|---|---|
| Total | 26 |
| Treatment | 2 |
| Error | 24 |

[a]Used for all variables.

## Net Energy Determination

Nine calves out of a total of 45 (20%) comprised the slaughter group for Trial II. Weighing conditions for the slaughter group and the experimental steers were the same as for Trial I (refer to page 45).

The $NE_{m+p}$ of the basal was estimated to be 1145 kcal. per kg. (Morrison, 1959). Since intake was on an individual basis, net energy values ($NE_{m+p}$ amd $NE_p$) were calculated for each of the 27 experimental steers.

# Trial III

## Allotment

Seventy-two Hereford steer calves, averaging 243 kg., were started on trial on December 28, 1966 to compare six types of processed milo fed in a high concentrate ration. Twelve hd. were on each treatment, in four pens of three hd. each, arranged in a randomized complete block design as shown in Table XV.

The 72 calves were selected from a total of 154, 40 of which went on Trial IV, 12 were slaughtered, and 30 were sold. The 154 hd. were plotted on graph paper with shrunk weight and condition score as the X and Y axes and then divided by diagonal lines into five blocks. The lowest block (the 30 thinnest-fleshed, lightest-weight calves) were marketed.

## Feeding

The six types of processed milo -- finely ground,

TABLE XV

TRIAL III: EXPERIMENTAL DESIGN

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

[a]Steers died or were otherwise removed from the data.

coarsely ground, dry rolled, steam-process-flaked, reconstituted-rolled and reconstituted-ground -- were fed in an isonitrogenous, 90% concentrate ration. All ingredients other than milo were combined into a premix. The composition of the ration and premix is shown in Table XVI. Proximate analyses of the premix and the processed milo are shown in Table XVII.

The calves were started on feed 4 weeks before the trial began. The starter ration consisted of 48.5% coarsely ground milo, 10.0% cottonseed meal, 10.0% chopped alfalfa hay, 30.0% cottonseed hulls, 1.0% salt and 0.5% bonemeal. The calves were gradually changed over to the test rations, which they were on when the trial began.

The three "wet" grains, steam-process-flaked, reconstituted-rolled and reconstituted-ground, were processed daily, with the exception that enough was processed on Friday to

TABLE XVI

TRIAL III: COMPOSITION OF RATION AND PREMIX

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

[a]Dry matter basis.

feed over the weekend.

Finely ground and coarsely ground milo were processed, combined with premix and stored in one ton quantity. The three rolled products were combined with the premix by hand in the feed trough to preserve the character of the grain as produced by the processing methods. The cattle were fed once daily in sufficient quantity to assure availability of feed until the next feeding. Feed was weighed to the nearest one-half lb., and unconsumed feed was weighed and removed frequently, to assure freshness of feed. Dry matter determinations, taken every 21 days, were used to adjust all ra-

TABLE XVII

TRIAL III: PROXIMATE ANALYSES[a]

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

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

[b]Average of seven determinations.

[c]One determination.

[d]Average of three determinations.

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

tions to an equivalent dry matter content. Water was available to the calves at all times.

Processing

Reconstituted milo was produced in a 4.3 X 8.2 m. glass-lined, air-tight Harvestore silo. Water was added to the whole grain as it was augured into the silo, raising the moisture level from 14% to 22%.

The steaming chamber used had a capacity of 226.8 kg., with dimensions of 0.31 X 0.61 X 1.52 m. The rollers on the Ross roller mill were 0.46 m. in diameter and 0.61 m. long. The rollers were corrugated for the first 32 days of the trial, at which time they were smoothed.

Dry whole milo was stored in another 4.3 X 8.2 m. silo. The variety of milo used in this trial was Northrup King 222, grown on the Fort Reno station.

Data Obtained

Performance data were summarized at 149 days, because the steers were subjected to ultrasonic determination and rumen sampling following this period. Ration treatments were continued until time of slaughter, which was on 3 successive days after an average of 160 days on feed.

The influence of processing method on the particle size and density of the milo grain is illustrated in Table XVIII.

Four steers died during the course of this experiment. Two were on the reconstituted-ground milo and one each on the reconstituted-rolled and dry rolled milo. Two of the steers were thought to have died of bloat, and the other two

TABLE XVIII

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

| Process | Screen Size (mm.) | | | | | | | | | lb. per bu. |
|---|---|---|---|---|---|---|---|---|---|---|
| | 7.15 | 6.35 | 4.76 | 3.18 | 2.12 | 1.41 | 1.02 | 0.36 | thru 0.36 | |
| | % retained on screen | | | | | | | | | |
| Recon.-ground | 0 | 0 | 0 | 0.24 | 1.94 | 16.30 | 20.04 | 26.79 | 34.69 | 40.7 |
| Finely ground | 0 | 0 | 0 | 0.25 | 1.94 | 13.78 | 20.13 | 34.14 | 29.76 | 47.4 |
| Coarsely ground | 0 | 0 | 0 | 2.93 | 9.34 | 23.69 | 18.19 | 23.71 | 22.14 | 49.7 |
| Dry rolled | 0.02 | 0.30 | 0.34 | 3.11 | 18.14 | 27.89 | 16.38 | 21.12 | 12.69 | 38.8 |
| Recon.-rolled | 0.44 | 1.09 | 5.49 | 24.69 | 26.89 | 14.39 | 6.24 | 11.60 | 9.17 | 28.4 |
| Steam-process-flaked | 13.65 | 19.08 | 40.25 | 17.55 | 4.35 | 2.15 | 0.90 | 1.28 | 0.79 | 23.3 |
| Steam-process-flaked (ran through mixer) | | | | | -- | -- | -- | -- | -- | 35.7 |
| Whole dry | -- | -- | -- | -- | -- | -- | -- | -- | -- | 58.6 |
| Whole reconstituted | | -- | -- | -- | -- | -- | -- | -- | -- | 49.8 |

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

[b]Test weights reported are on 90% dry matter basis and are averages of several determinations throughout the trial. Considerably lower values were obtained at times for S.P.F. and recon.-rolled (lowest values: S.P.F. - 16.6, recon.-rolled - 26.6 lb./bu.). To prevent confusion, values were not converted to the metric system.

died of undetermined causes. The feed records were adjusted by subtracting the estimated intake of the deceased steer, which was the average intake of the three steers in the pen, from the total pen intake.

One steer on steam-process-flaked milo was removed from the records because he was a chronic bloater and sick during most of the trial (he gained only 56.7kg. in 149 days), and his condition was deemed unrelated to the ration treatment. His intake was estimated by using the factor 0.065 kg. TDN per kg. of $W^{.75}$ (Garrett et al., 1959) to estimate the maintenance requirement and the factors of Knott et al. (1954) to estimate the TDN required for gain and equivalent to loss (kg. gained x 1.60, kg. lost x 1.24). The TDN of the ration was estimated to be 73.6%.

Another steer on steam-process-flaked milo was found to have one testicle after the trial was initiated. His average daily gain and feed required per kg. of gain were adjusted to a steer equivalent.[7]

A factorial analysis of variance using unweighted pen averages was conducted for average daily intake of the total ration, feed per kg. of gain and net energy values. An ab-

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

$$\frac{\text{ADG steers}}{\text{ADG bulls}} \quad \frac{1.11 \text{ kg.}}{1.31 \text{ kg.}} = .854 \text{ (C.F.)}$$

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.

breviated Doolittle analysis was used to obtain block, adjusted treatment and error sums of squares for all other variables, including average daily gain and carcass data. A hiearchal analysis of variance was used to obtain within pen sum of squares, which was subtracted from the error sum of squares obtained from the Doolittle to derive block x treatment sum of squares. Block x treatment mean square was used to test blocks and adjusted treatment for significance. This type of analysis adjusts for unequal subclass numbers. Adjusted treatment means were derived by adding the treatment effects (which summed to zero) to the overall mean. Standard errors were calculated for each mean by the following method:

$$\sqrt{(C_{ii} + C_{jj} + 2C_{ij})\ \text{EMS}}$$

where,

$C_{ii}$ = diagonal element for overall mean.

$C_{jj}$ = diagonal element for specific treatment.

$C_{ij}$ = off diagonal element corresponding to overall mean and specific treatment.

EMS = error mean square

The diagonal and off diagonal elements were taken from the inverse matrix. The average standard error for a variable was used to obtain the least significant range for Duncan's New Multiple Range Test. Analysis of variance tables are shown in Table XIX.

Net Energy Determination

Twelve calves were slaughtered to estimate the initial caloric content of the experimental steers in Trial III and

TABLE XIX

TRIAL III: ANALYSIS OF VARIANCE

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

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

[a]For feed intake, feed/kg. gain and net energy values, using unweighted pen averages.

[b]Error term used to test treatment.

[c]For average daily gain and carcass data.

[d]Treatment adjusted for disproportionate data.

IV. This amounted to 10% of a total of 124 hd. (72 hd. in Trial III and 40 hd. in Trial IV). Three hd. were selected from each of the four blocks obtained by graphing, as described in allotment procedure for Trial III, page 51.

Due to an error by slaughter plant personnel, carcasses were not identified, and rumen weights were not obtained. The weight of the rumen contents was estimated by using the average for the 1964 and 1965 slaughter groups (three groups totaling 28 hd.), which was 15.7 kg. The average live shrunk weight of the 12 steers was 245.3 kg. Thus, the average empty body weight of the Trial III and IV slaughter group was estimated to be 229.6 kg., derived by subtracting 15.7 from 245.3. The four quarters of each carcass were weighed in air to the nearest one-tenth lb. and in water to the nearest gm.

For the 67 experimental steers which completed the test in Trial III (four died, one was removed), rumen weights were taken to the nearest one-fourth lb. Three rumens were condemned or accidentally punctured. The average weight of the rumen contents of the other 64 steers, 15.0 kg., was substituted for the missing data. Carcass quarters were weighed in air to the nearest one-fourth lb. and in water to the nearest 5 gm.

Again, as in Trial I, the average feed intake of a pen was used for calculation purposes (refer to Trial I Net Energy Determination, page 48.).

The $NE_{m+p}$ and $NE_m$ values of the premix were estimated to be 816 (Morrison, 1959) and 930 (Lofgreen and Garrett, 1967a) kcal. per kg., respectively.

Since the steers were not fed basal to meet maintenance, $NE_p$ values were calculated by a different method. The maintenance requirement (77 kcal./kg. $W^{.75}$ daily) and the gain in kcal. were divided between the premix and milo on the basis of the ratio of each in the ration (16.6% premix, 83.4% milo). The energy gained attributed to milo was divided by the kg. of milo remaining after meeting the fraction of the maintenance requirement assigned to milo, to obtain the $NE_p$ of the milo.

## Trial IV

### Allotment

Trial IV, comparing four types of processed milo, was initiated on December 28, 1966. Forty Hereford steer calves, averaging 237 kg., were used in a randomized complete block design, as shown in Table XX. Refer to Trial III Allotment, page 51, for discussion of selection and assignment of calves.

### Feeding

The four types of processed milo -- coarsely ground, finely ground, steam-process-flaked and reconstituted-rolled-- were fed in addition to a basal ration which was fed to meet maintenance requirements. The basal, shown in Table XXI, was estimated to contain 54.4% TDN (Absher, 1965); therefore, 0.1197 kg. of basal was fed daily per kg. of weight$^{.75}$.

TABLE XX

TRIAL IV: EXPERIMENTAL DESIGN

| | Processed Milo | | | |
|---|---|---|---|---|
| Blocks | Coarsely Ground | Finely Ground | Steam-Process-Flaked | Reconstituted-Rolled |
| 1 | 1[a] | 2 | 2 | 2 |
| 2 | 2 | 2 | 2 | 1[a] |
| 3 | 1[a] | 1[a] | 2 | 2 |
| 4 | 2 | 2 | 2 | 2 |
| 5 | 2 | 2 | 2 | 1[a] |
| | 8 | 9 | 10 | 8 |
| | | | Total = 35 hd. | |

[a]Steers died.

TABLE XXI

TRIAL IV: COMPOSITION OF BASAL RATION

| Ingredient | Percent |
| --- | --- |
| Alfalfa (17%; dehydrated, pelleted and crumbled) | 35.0 |
| Cottonseed hulls | 23.0 |
| Cottonseed meal crumbles (41% C.P., expeller) | 40.0 |
| Salt | 1.0 |
| Dicalcium phosphate | 1.0 |
| | 100.0 |
| Added per ton: | |
| Vitamin A (30,000 I.U./gm.) | 340 gm. |
| Santoquin | 227 gm. |

Proximate analyses of the basal and processed milo are shown in Table XXII.

TABLE XXII

TRIAL IV: PROXIMATE ANALYSES[a]

| Feedstuff | % Dry Matter[b] | % Ash[c] | % Crude Protein[d] | % Ether Extract[d] | % Crude Fiber[c] | % N.F.E.[e] |
| --- | --- | --- | --- | --- | --- | --- |
| Basal | 89.7 | 9.61 | 23.92 | 5.33 | 16.70 | 44.44 |
| Coarsely ground | 87.4 | 1.61 | 8.84 | 5.13 | 1.95 | 82.47 |
| Finely ground | 87.6 | 1.40 | 9.22 | 5.15 | 1.85 | 82.38 |
| Recon.-rolled | 71.2 | 1.18 | 9.67 | 3.66 | 1.74 | 83.75 |
| Steam-proc.-flaked | 83.3 | 1.62 | 8.33 | 4.89 | 1.79 | 83.37 |

[a]All values are on a dry matter basis.
[b]Average of seven determinations.
[c]One determination.
[d]Average of three determinations.
[e]100 - (sum of values reported for ash, crude protein, ether extract and crude fiber).

Processed milo and basal were weighed to the nearest one-eighth lb., mixed by hand and fed to the calves twice daily in individual stalls measuring 3.0 by 0.75 m. The calves were confined in the stalls for approximately 1 hr. at each feeding, and unconsumed feed was removed and weighed. Water was not available in the stalls.

Processing

Reconstituted milo was produced by soaking whole milo for 2 hr. in 208 l. drums, draining off excess water, flushing with $CO_2$ and covering with plastic weighted down with dirt. Milo was allowed to remain in the drums a minimum of 21 days before being fed.

The steaming chamber and rolling mill were the same as used in Trial I (page 44).

Coarsely and finely ground milo was obtained from the Stillwater Milling Co., as was the whole milo used to produce the steam-process-flaked and reconstituted-rolled products. Each load of milo was divided evenly among the four treatments.

Data Obtained

The experimental steers were slaughtered on June 12, 1967 after 166 days on feed. All variables, including performance data, carcass data and net energy values, were subjected to a hiearchal analysis of variance and an abbreviated Doolittle, as described for Trial III on page 58. Variance components are shown in Table XXIII.

Five steers died during the course of this trial, all

TABLE XXIII

TRIAL IV: ANALYSIS OF VARIANCE[a]

| Source | | df |
| --- | --- | --- |
| Total | | 34 |
| Blocks | | 4 |
| Treatment (adjusted)[b] | | 3 |
| Error[c] | | 27 |
| B x T | 12 | |
| Exp. error | 15 | |

[a]Used for all variables.

[b]Treatment adjusted for disproportionate data.

[c]Error term used to test treatment. In no cases was block x treatment interaction significantly different than experimental error; thus, they were combined.

presumably due to bloat. Two were on coarsely ground, two were on reconstituted-rolled and one was on finely ground milo. Three other calves developed abscesses in the jaw and throat regions, diagnosed as infections of <u>Corynebacterium</u>. The infections were apparently spread by equipment used for drenching for internal parasites. Several other calves were suspected to have subclinical infections.

The influence of processing method on the particle size and density of the milo grain is shown in Table XXIV.

<u>Net Energy Determination</u>

The slaughter group was the same as for Trial III, as were the weighing conditions for rumens and carcasses of the experimental steers (refer to pages 58, 59 and 60).

The $NE_{m+p}$ and $NE_m$ values of the basal were estimated to

TABLE XXIV

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

| Process | Screen Size (mm.) | | | | | | | | | lb. per bu. |
|---|---|---|---|---|---|---|---|---|---|---|
| | 7.15 | 6.35 | 4.76 | 3.18 | 2.12 | 1.41 | 1.02 | 0.36 | thru 0.36 | |
| | % retained on screen | | | | | | | | | |
| Finely ground | 0 | 0 | 0 | 0.04 | 0.93 | 7.97 | 19.83 | 28.46 | 40.90 | 47.7 |
| Coarsely ground | 0 | 0 | 0 | 2.59 | 8.34 | 20.71 | 18.72 | 25.49 | 23.42 | 50.5 |
| Reconstituted-rolled | 0.57 | 0.48 | 7.52 | 11.93 | 12.88 | 14.09 | 9.76 | 17.47 | 20.36 | 27.7 |
| Steam-process-flaked | 4.24 | 3.56 | 21.14 | 33.89 | 26.05 | 7.53 | 3.01 | 3.33 | 3.73 | 24.1 |

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

[b]Test weights reported are average of four determinations, and are on 90% dry matter basis. To prevent confusion, values were not converted to the metric system.

be 1130 (Morrison, 1959) and 1393 kcal. per kg. (Absher, 1965), respectively. The Trial IV basal ration was of the same composition as that used by Absher (1965). Using his energy gain and basal intake data and the revised maintenance requirement (77 kcal./kg. $W^{.75}$), the aforementioned $NE_m$ value was obtained.

The average daily loss in kcal. per kg. $W^{.75}$ of the Trial I and Trial II basal maintenance steers, 8.67, was added to the average daily gain in kcal. per kg. $W^{.75}$ of the Trial IV experimental steers to estimate the gain attributed to the milo. This value was used, instead of Absher's (1965), because the cattle were more nearly the same age, weight and condition.

Intake was on an individual basis, allowing calculation of $NE_{m+p}$ and $NE_p$ values for each of the 35 experimental steers.

# RESULTS

## Trial I

### Feedlot Performance

Feedlot performance of the steers fed the five types of processed milo is shown in Table XXV. Significant F values were obtained for milo/kg. gain ($P<.05$), average daily intake of the total ration ($P<.05$) and average daily intake of milo ($P<.01$). Comparison of treatment means indicated that the steers on reconstituted-steam-process-flaked milo and finely ground milo required significantly less milo/kg. of gain than those fed coarsely ground and steam-process-flaked milo. Steers fed reconstituted-steam-process-flaked milo consumed significantly less milo and total ration than those fed coarsely ground and steam-process-flaked milo. Consumption of steam-process-flaked milo was significantly higher, as was the total ration, than finely ground and reconstituted-rolled milo. No significant ($P<.05$) differences in average daily gain or total ration/kg. gain were observed.

A summary of feedlot performance using coarsely ground milo as the basis for comparison is shown in Table XXVI. Although differences were non-significant, rate of gain was 3.29% higher for finely ground milo and 8.23% higher for steam-process-flaked milo than for coarsely ground milo. Consumption of steam-process-flaked milo was 6.71% higher

TABLE XXV

TRIAL I: FEEDLOT PERFORMANCE

| Item | Coarsely Ground | Finely Ground | Recon.-Rolled | Recon.-Steam-Process-Flaked | Steam-Process-Flaked | $s_{\bar{x}}$ [c] | F [d] |
|---|---|---|---|---|---|---|---|
| No. steers | 9 | 9 | 9 | 9 | 9 | | |
| No. days on feed | 170 | 170 | 170 | 170 | 170 | | |
| Initial live shrunk wt., kg. | 227.1 | 222.3 | 221.8 | 222.5 | 225.8 | -- | -- |
| Final live shrunk wt., kg. | 415.7 | 416.6 | 411.4 | 410.1 | 429.8 | -- | -- |
| Average daily gain, kg. | 1.10 | 1.14 | 1.11 | 1.10 | 1.19 | 0.042 | 0.90 |
| Av. daily intake (total ration), kg. [a] | 8.74 [1,2] | 8.33 [2,3] | 8.31 [2,3] | 8.07 [3] | 9.11 [1] | 0.160 | 6.80 [e] |
| Av. daily intake (grain), kg. [b] | 4.80 [1,2] | 4.45 [2,3] | 4.45 [2,3] | 4.21 [3] | 5.12 [1] | 0.106 | 11.51 [f] |
| Feed/kg. gain (total ration), kg. | 7.92 | 7.32 | 7.49 | 7.35 | 7.64 | 0.088 | 1.63 |
| Feed/kg. gain (grain), kg. [a] | 4.35 [1] | 3.91 [2] | 4.01 [1,2] | 3.84 [2] | 4.29 [1] | 0.048 | 4.73 [e] |
| Initial empty body wt., kg. | 209.5 | 204.9 | 204.4 | 205.1 | 208.2 | -- | -- |
| Final empty body wt., kg. | 405.9 | 405.5 | 400.5 | 398.7 | 417.5 | -- | -- |
| Av. daily EBW gain, kg. | 1.15 | 1.18 | 1.15 | 1.13 | 1.22 | 0.040 | 0.78 |
| Feed/kg. EBW gain (total ration), kg. | 7.82 | 7.15 | 7.27 | 7.23 | 7.47 | 0.226 | 1.41 |
| Feed/kg. EBW gain (grain), kg. [a] | 4.29 [1] | 405.5 | 3.89 [1,2] | 3.78 [2] | 4.19 [1,2] | 0.123 | 3.59 |

[a] Any 2 means without a common number differ significantly ($P<.05$).
[b] Any 2 means without a common number differ significantly ($P<.01$).
[c] Standard error of treatment means.
[d] Calculated F value from analysis of variance.
[e] Significant ($P<.05$).
[f] Significant ($P<.01$).

TABLE XXVI

TRIAL I: FEEDLOT PERFORMANCE USING COARSELY GROUND MILO AS A BASIS FOR COMPARISON[a]

| Item | Coarsely Ground | Finely Ground | Recon.-Rolled | Recon.-Steam-Process-Flaked | Steam-Process-Flaked |
|---|---|---|---|---|---|
| | kg. | -- % change compared to coarsely-- ground milo | | | |
| Av. daily gain | 1.10 | 3.29 | 0.82 | -0.41 | 8.23 |
| Av. daily intake (total ration) | 8.74 | -4.72 | -4.98 | -7.73 | 4.26 |
| Av. daily intake (milo) | 4.80 | -7.37 | -7.37 | -12.19[b] | 6.71 |
| Feed/kg. gain (total ration) | 7.92 | -7.58 | -5.43 | -7.20 | -3.54 |
| Feed/kg. gain (milo) | 4.35 | -10.11[c] | -7.82 | -11.72[c] | -1.38 |

[a]Data taken from Table XXV. Gain is on shrunk weight basis.
[b]Significantly (P<.01) different than value for coarsely ground milo.
[c]Significantly (P<.05) different than value for coarsely ground milo.

than coarsely ground milo, resulting in a 1.38% decrease in milo/kg. gain. Reduction in consumption of milo was identical for the finely ground and reconstituted-rolled grains (7.37%), and decreases in milo/kg. gain were 10.11 and 7.82%, respectively. The greatest reduction in consumption was due to reconstituting-steam-process-flaking (12.19%), with rate of gain only 0.41% less than for coarse grinding, resulting in an 11.72% increase in efficiency (considering milo only).

Analysis of feed/kg. gain on an empty body weight basis (Table XXV) gave very similar results to those previously discussed on a shrunk weight basis. Reconstituted-steam-process-flaked and finely ground milo produced significantly

(P<.05) more efficient gains (considering milo only) than coarsely ground milo, with increases of 11.19 and 11.89%, respectively. Differences in total ration/kg. gain were again non-significant (P<.05).

Carcass Merit

There were no significant (P<.05) differences between the five types of processed milo in dressing percentage, carcass grade, ribeye area, fat thickness, marbling or cutability. Treatment means are shown in Table XXVII.

Net Energy

Calculated net energy values of the five types of processed milo are shown in Table XXVIII. Significant (P<.05) F values were obtained for $NE_{m+p}$ of the total ration and $NE_{m+p}$ and $NE_p$ of the milo. Comparison of treatment means indicated that finely ground, reconstituted-rolled and reconstituted-steam-process-flaked milo were significantly higher in $NE_{m+p}$ of the total ration and $NE_p$ of the milo than coarsely ground milo. Steam-process-flaked milo was not significantly different than coarsely ground milo for these two net energy values. $NE_{m+p}$ of the milo was significantly higher for reconstituted-steam-process-flaked milo than for coarsely ground and steam-process-flaked milo. Reconstituted-rolled and finely ground milo were also significantly higher in $NE_{m+p}$ than coarsely ground milo.

A value of 95.5 megcal./100 kg. was obtained for coarsely ground milo, with increases in $NE_p$ of 10.8, 14.8, 16.8 and 22.0% for steam-process-flaked, finely ground, reconsti-

TABLE XXVII

TRIAL I: CARCASS MERIT

| Item | Coarsely Ground | Finely Ground | Recon.-Rolled | Recon.-Steam-Process-Flaked | Steam-Process-Flaked | $s_{\bar{x}}$[a] | F[b] |
|---|---|---|---|---|---|---|---|
| No. steers | 9 | 9 | 9 | 9 | 9 | | |
| Dressing %[c] | 60.82 | 61.37 | 61.37 | 60.58 | 61.11 | 0.478 | 0.52 |
| Carcass grade[d] | 9.56 | 9.33 | 9.44 | 9.33 | 9.67 | 0.157 | 0.85 |
| Ribeye area, sq. in.[e] | 10.47 | 11.03 | 10.73 | 10.72 | 11.26 | 0.339 | 0.81 |
| Fat thickness, in.[f] | 0.50 | 0.49 | 0.58 | 0.52 | 0.64 | 0.050 | 1.51 |
| Marbling[g] | 12.67 | 12.44 | 12.33 | 12.67 | 13.33 | 0.495 | 0.62 |
| Cutability, %[h] | 51.00 | 51.45 | 50.76 | 51.15 | 50.55 | 0.463 | 0.56 |

[a] Standard error of treatment means.
[b] Calculated F value from analysis of variance. None were significant (P<.05).
[c] Calculated on basis of final live 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 measurement 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). 11=slight, 12=slight plus, 13=small minus, 14=small, 15=small plus.
[h] Boneless trimmed retail cuts from the major wholesale cuts, as % of carcass=51.34 (fat thickness) -0.462 (% kidney fat) +0.740 (ribeye area) -0.0093 (chilled carcass wt.)

TABLE XXVIII

TRIAL I: NET ENERGY VALUES OF PROCESSED MILO

| Net Energy Value | Coarsely Ground | Finely Ground | Recon.-Rolled | Recon.-Steam-Process-Flaked | Steam-Process-Flaked | $s_{\bar{x}}$[g] | F[h] |
|---|---|---|---|---|---|---|---|
| | -----------Megcal./100 kg.----------- | | | | | | |
| $NE_{m+p}$ of total ration[a,f] | 115.5[1] | 123.6[2] | 124.6[2] | 127.0[2] | 120.6[1,2] | 1.91 | 5.36[i] |
| $NE_{m+p}$ of milo[b,f] | 126.6[1] | 142.6[2,3] | 149.9[3] | 149.9[3] | 135.1[1,2] | 3.65 | 4.48[i] |
| $NE_m$ of milo[c] | 144.2 | 165.5 | 168.4 | 175.9 | 159.8 | -- | -- |
| $NE_p$ of milo[d,f] | 100.9[1] | 114.1[2] | 115.9[2] | 120.0[2] | 110.6[1,2] | 3.80 | 3.62 |
| $NE_p$ of milo[e,f] | 95.5[1] | 109.6[2] | 111.5[2] | 116.5[2] | 105.8[1,2] | 3.67 | 4.61[i] |

[a]Energy for gain and maintenance ÷ intake of total ration.
[b](Energy for gain and maintenance − energy attributed to basal) ÷ intake of milo.
[c]$NE_p$[e] X 1.51, (1.51 = ratio of $NE_m$ to $NE_p$ on basis of av. crude fiber content).
[d](Energy gained − av. loss in energy of basal steers) ÷ intake of milo.
[e]Energy gained ÷ (Milo intake − milo used to meet maintenance requirement not met by basal).
[f]Any two values without a common number differ significantly ($P<.05$).
[g]Standard error of treatment means.
[h]Calculated F value from analysis of variance.
[i]Significant ($P<.05$).

tuted-rolled and reconstituted-steam-process-flaked milo, respectively.

Comparison of efficiency on the basis of empty body weight gain/kg. total ration and energy gain/kg. total ration, shown in Table XXIX, revealed no significant ($P<.05$) differences in either method. The ranking of means by the two methods was somewhat different; steam-process-flaked milo was relatively higher and finely ground milo was relatively lower in the comparison of energy gain than for empty body weight gain.

An average value of 2302.9 kcal./kg. of empty body weight was used to estimate the initial caloric content of the 54 experimental steers, calculated from slaughter group data shown in Table XLVI (appendix). Prediction equations used to estimate initial empty body weight and composition of the experimental steers are shown in Table XLIX. Table LI contains the corresponding correlations.

The $NE_m$ of the basal ration was calculated to be 1351.9 kcal./kg., as shown in Table LIII. Terminal carcass composition and components of gain of the 45 steers fed processed milo are shown in Table LV. No significant ($P<.05$) differences were obtained.

The procedure for calculating $NE_{m+p}$ of the milo is shown in Table LX, using Table LIX as a key. The two methods of calculating $NE_p$, shown in Table LXIV, gave very similar relative values. However, the second method gave slightly lower values in all cases. This method is probably more

TABLE XXIX

TRIAL I: EFFICIENCY OF WEIGHT AND ENERGY GAIN

| Term | Coarsely Ground | Finely Ground | Recon.-Rolled | Recon.-Steam-Process-Flaked | Steam-Process-Flaked | $s_{\bar{x}}$[a] | F[b] |
|---|---|---|---|---|---|---|---|
| Empty body wt. gain/kg. feed, kg. | 0.131 | 0.141 | 0.138 | 0.140 | 0.134 | 0.0031 | 1.74 |
| Energy gain/kg. feed, megcal. | 0.491 | 0.543 | 0.555 | 0.560 | 0.560 | 0.0212 | 1.88 |

[a]Standard errors of treatment means.

[b]Calculated F values from analysis of variance, both non-significant ($P<.05$).

accurate, since it recognizes a higher $NE_m$ for the milo than the basal, while the first method assumes they are the same. Actually, only 6-7 kcal. of the maintenance requirement (77 kcal./kg. $W^{.75}$ daily) were involved. Values calculated by the second method were used in the treatment comparisons previously discussed.

## Trial II

### Feedlot Performance

Feedlot performance of the steers fed conventional steam-rolled milo, wheat and ½ milo ½ wheat is summarized in Table XXX. There were no significant (P<.05) differences in gain, intake or efficiency.

Although differences were non-significant, rate of gain was highest for milo and nearly identical for wheat and the combination of milo and wheat. Intake was highest for milo, lowest for the milo-wheat combination, with wheat intermediate between the two. Feed efficiency was highest for milo, with wheat and the milo-wheat combination being very similar.

Comparisons of rate of gain and feed/kg. gain on an empty body weight basis (Table XXX) were almost identical to the ones previously discussed on a shrunk weight basis.

### Carcass Merit

A summary of the carcass merit of the steers in this trial is shown in Table XXXI. No significant (P<.05) differences were obtained.

TABLE XXX

TRIAL II: FEEDLOT PERFORMANCE

| Item | Milo | Wheat | ½ milo ½ wheat | $s_{\bar{x}}$[a] | F[b] |
|---|---|---|---|---|---|
| | (conventional steam-rolled) | | | | |
| No. steers | 9 | 9 | 9 | | |
| No. days on feed | 180 | 180 | 180 | | |
| Initial live shrunk wt., kg. | 229.6 | 231.1 | 231.1 | -- | -- |
| Final live shrunk wt., kg. | 414.3 | 402.9 | 400.2 | -- | -- |
| Av. daily gain, kg. | 1.02 | 0.94 | 0.93 | 0.068 | 0.52 |
| Av. daily intake (total ration), kg. | 6.76 | 6.52 | 6.33 | 0.338 | 0.41 |
| Av. daily intake (grain), kg. | 3.08 | 2.93 | 2.79 | 0.257 | 0.57 |
| Feed/kg. gain (total ration), kg. | 6.65 | 6.96 | 7.08 | 0.295 | 0.58 |
| Feed/kg. gain (grain), kg. | 3.02 | 3.05 | 3.00 | 0.133 | 0.05 |
| Initial empty body wt., kg. | 215.6 | 217.0 | 217.2 | -- | -- |
| Final empty body wt., kg. | 400.4 | 387.3 | 385.5 | -- | -- |
| Av. daily EBW gain, kg. | 1.02 | 0.93 | 0.92 | 0.067 | 0.63 |
| Feed/kg. EBW gain (total ration), kg. | 6.65 | 7.03 | 7.10 | 0.296 | 0.66 |
| Feed/kg. EBW gain (grain), kg. | 3.02 | 3.07 | 3.00 | 0.122 | 0.12 |

[a]Standard error of treatment means.

[b]Calculated F value from analysis of variance. All were non-significant (P<.05).

TABLE XXXI

TRIAL II: CARCASS MERIT

| Item | Milo | Wheat | ½ Milo ½ Wheat | $s_{\bar{x}}$[a] | F[b] |
|---|---|---|---|---|---|
| | ----conventional------ steam-rolled | | | | |
| No. steers | 9 | 9 | 9 | | |
| Dressing %[c] | 58.79 | 57.29 | 57.89 | 0.721 | 1.10 |
| Carcass grade[d] | 8.89 | 8.11 | 8.56 | 0.462 | 0.72 |
| Ribeye area, sq. in.[e] | 11.38 | 11.01 | 11.57 | 0.378 | 0.57 |
| Fat thickness, in.[f] | 0.337 | 0.288 | 0.257 | 0.045 | 0.79 |
| Marbling[g] | 10.67 | 9.33 | 10.33 | 0.882 | 0.62 |
| Cutability[h] | 51.47 | 51.83 | 52.39 | 0.402 | 1.33 |

[a]Standard error of treatment means.
[b]Calculated F value from analysis of variance. None were significant (P<.05).
[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 measurement 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). 11=slight, 12=slight plus, 13=small minus, 14=small, 15=small plus.
[h]Boneless trimmed retail cuts from the major wholesale cuts, as % of carcass = 51.34 (fat thickness) -0.462 (% kidney fat) +0.740 (ribeye area) -0.0093 (chilled carcass wt.).

Net Energy

Calculated net energy values of the milo, wheat and milo-wheat combination are shown in Table XXXII. No significant (P<.05) differences in $NE_{m+p}$ of the total ration, $NE_{m+p}$ of the grain or $NE_p$ of the grain were obtained.

Comparison of two efficiency terms, empty body weight gain/kg. total ration and energy gain/kg. total ration, is

TABLE XXXII

TRIAL II: NET ENERGY VALUES OF MILO AND WHEAT

| Net Energy Value | Milo | Wheat | ½ Milo ½ Wheat | $s_{\bar{x}}$[f] | F[g] |
|---|---|---|---|---|---|
| | ----(conventional steam-rolled)-------- | | | | |
| | ---------Megcal./100 kg.--------------- | | | | |
| $NE_{m+p}$ of total ration[a] | 127.0 | 128.3 | 126.6 | 1.89 | 0.24 |
| $NE_{m+p}$ of grain[b] | 142.2 | 147.8 | 144.8 | 5.77 | 0.24 |
| $NE_m$ of grain[c] | 153.7 | 150.6 | 139.8 | -- | -- |
| $NE_p$ of grain[d] | 113.7 | 111.3 | 105.7 | 4.10 | 0.98 |
| $NE_p$ of grain[e] | 101.8 | 99.7 | 92.6 | 5.49 | 0.77 |

[a]Energy for gain and maintenance ÷ intake of total ration.
[b](Energy for gain and maintenance - energy attributed to basal) ÷ intake of milo.
[c]$NE_p$[e] X 1.51, (1.51 = ratio of $NE_m$ to $NE_p$ on basis of av. crude fiber content).
[d](Energy gained - av. loss in energy of basal steers) ÷ intake of milo.
[e]Energy gained ÷ (Milo intake - milo used to meet maintenance requirement not met by basal).
[f]Standard error of treatment means.
[g]Calculated F values from analysis of variance; all non-significant ($P<.05$).

## TABLE XXXIII

## TRIAL II: EFFICIENCY OF WEIGHT AND ENERGY GAIN

| Term | Milo | Wheat | ½ Milo ½ Wheat | $s_{\bar{x}}$[a] | F[b] |
|---|---|---|---|---|---|
| | ----conventional | steam-rolled---- | | | |
| Empty body wt. gain/kg. feed, kg. | 0.152 | 0.143 | 0.144 | 0.0056 | 0.68 |
| Energy gain/kg. feed, megcal. | 0.403 | 0.375 | 0.337 | 0.0347 | 0.92 |

[a]Standard errors of treatment means.

[b]Calculated F values from analysis of variance, both non-significant ($P<.05$).

shown in Table XXXIII. No significant ($P<.05$) differences were obtained by either comparison, and ranking of means was similar for both methods.

An average value of 2487.2 kcal./kg. of empty body weight was used to estimate the initial caloric content of the 36 experimental steers, calculated from slaughter group data shown in Table XLVII (appendix). Prediction equations used to estimate initial empty body weight and composition of the experimental steers are shown in Table L. Table LII contains the corresponding correlations.

The $NE_m$ of the basal ration was calculated to be 1404.5 kcal./kg., as shown in Table LIV. Terminal carcass composition and components of gain of the 27 steers fed milo and wheat are shown in Table LVI. No significant ($P<.05$) differences were obtained.

The procedure for calculating $NE_{m+p}$ of the milo, wheat and milo-wheat combination is shown in Table LXI, using Table LIX as a key. The two methods of calculating $NE_p$ are shown in Table LXV.

## Trial III

### Feedlot Performance

Feedlot performance of the steers fed the six types of processed milo is shown in Table XXXIV. Significant ($P<.05$) F values were obtained for average daily intake and feed/kg. gain. Comparison of treatment means indicated that consumption of the reconstituted-rolled milo was significantly less

TABLE XXXIV

TRIAL III: FEEDLOT PERFORMANCE

| Item | Coarsely Ground | Finely Ground | Dry Rolled | Recon.-Rolled | Recon.-Ground | Steam-Process-Flaked | $s_{\bar{x}}$[b] | F[d] |
|---|---|---|---|---|---|---|---|---|
| No. steers completing trial | 12 | 12 | 11 | 11 | 10 | 11 | | |
| No. days on feed, av. | 160 | 160 | 160 | 160 | 160 | 160 | | |
| Initial live shrunk wt., kg. | 241.5 | 241.5 | 241.6 | 238.6 | 241.8 | 248.0 | -- | -- |
| Final live shrunk wt., kg. | 409.1 | 415.8 | 411.1 | 408.7 | 413.9 | 435.5 | -- | -- |
| Av. daily gain, kg. | 1.14 | 1.18 | 1.14 | 1.14 | 1.14 | 1.28 | 0.058[c] | 1.05 |
| Av. daily intake, kg.[a] | 7.70[1] | 7.63[1] | 7.38[1] | 6.62[2] | 7.33[1] | 7.45[1] | 0.201 | 3.70[e] |
| Feed/kg. gain, kg.[a] | 6.77[1] | 6.47[1,2] | 6.43[1,2] | 5.82[2] | 6.44[1,2] | 5.90[2] | 0.091 | 3.49[e] |
| Initial empty body wt., kg. | 226.7 | 226.7 | 226.8 | 224.0 | 227.0 | 232.8 | -- | -- |
| Final empty body wt., kg. | 395.2 | 403.0 | 394.9 | 394.6 | 397.1 | 418.7 | -- | -- |
| Av. daily EBW gain, kg. | 1.05 | 1.10 | 1.05 | 1.06 | 1.06 | 1.16 | 0.001 | 0.99 |
| Feed/kg. EBW gain, kg.[a] | 7.59[1] | 7.10[1,2] | 7.13[1,2] | 6.43[2] | 7.12[1,2] | 6.51[2] | 0.242 | 3.05[e] |

[a]Any 2 means without a common number differ significantly ($P<.05$).
[b]Standard error of treatment means.
[c]Standard error with 10 observations. Other standard errors for this variable may be obtained by (0.058) ($\sqrt{10 \div n}$), where n equals the number of observations.
[d]Calculated F value from analysis of variance.
[e]Significant ($P<.05$).

than for the other five grains, and feed efficiency was significantly higher for the reconstituted-rolled milo than for coarsely ground. Steam-process-flaked milo also produced significantly more efficient gains than coarsely ground milo.

Although differences in rate of gain were not significant ($P<.05$), finely ground and steam-process-flaked milo produced average daily gains 3.17 and 11.88% higher than coarsely ground milo, as shown in Table XXXV. Rates of gain were very similar for the other grains. All five processing methods produced reductions in average daily intake and improvements in feed efficiency, compared to coarse grinding. Reconstituting-rolling resulted in the greatest decrease in consumption (14.09%), with only a slight reduction in rate of gain (0.11%) and a corresponding increase in feed efficiency of 14.03%. Steam-process-flaking produced a small reduction in intake (3.27%), coupled with an 11.88% increase in rate of gain, resulting in a 12.88% improvement in efficiency. Improvements in feed efficiency were very similar for fine grinding (4.39%), dry rolling (5.02%) and reconstituting-grinding (4.90%).

Analysis of feed/kg. gain on an empty body weight basis (Table XXXIV) produced the same results as the comparison previously discussed on a shrunk weight basis.

Carcass Merit

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

TABLE XXXV

TRIAL III: FEEDLOT PERFORMANCE USING COARSELY GROUND MILO AS A BASIS FOR COMPARISON[a]

| Item | Coarsely Ground | Finely Ground | Dry Rolled | Recon.-Rolled | Recon.-Ground | Steam-Process-Flaked |
|---|---|---|---|---|---|---|
| | % | -------% change compared to coarsely ground milo | | | | -------- |
| Av. daily gain | 1.15 | 3.17 | -0.75 | -0.11 | -0.34 | 11.88 |
| Av. daily intake | 7.70 | -0.97 | -4.16 | -14.09[b] | -4.83 | -3.27 |
| Feed/kg. gain | 6.77 | -4.39 | -5.02 | -14.03[b] | -4.90 | -12.88[b] |

[a]Data taken from Table XXXIV. Gain is on shrunk weight basis.
[b]Significantly ($P<.05$) different than value for coarsely ground milo.

Net Energy

Calculated net energy values of the six types of processed milo are shown in Table XXVII. Significant ($P<.01$) F values were obtained for $NE_{m+p}$ of the total ration and $NE_{m+p}$ and $NE_p$ of the milo. Comparison of treatment means indicated that reconstituted-rolled milo was significantly higher than all others except steam-process-flaked, and steam-process-flaked and dry rolled were significantly higher than coarsely ground milo for all three net energy values.

Coarse grinding milo produced an estimated $NE_p$ value of 114.3 megcal./100 kg. Comparison of the other five processing methods with coarse grinding indicated increases in $NE_p$ as follows: fine grinding, 8.8%; reconstituting-grinding, 8.8%; dry rolling, 16.8%; steam-process-flaking, 20.7% and reconstituting-rolling, 33.4%.

Significant F values were obtained for empty body weight gain/kg. feed ($P<.01$) and energy gain/kg. feed ($P<.10$), in

TABLE XXXVI

TRIAL III: CARCASS MERIT

| Item | Coarsely Ground | Finely Ground | Dry Rolled | Recon.-Rolled | Recon.-Ground | Steam-Process-Flaked | $s_{\bar{x}}$[a] | F[b] |
|---|---|---|---|---|---|---|---|---|
| No. steers completing trial | 12 | 12 | 11 | 11 | 10 | 11 | | |
| Dressing, %[c] | 62.16 | 61.92 | 61.893 | 61.81 | 61.80 | 61.67 | 0.468 | 0.14 |
| Carcass grade[d] | 9.67 | 9.00 | 9.35 | 8.99 | 9.47 | 9.72 | 0.486 | 0.49 |
| Ribeye area, sq. in.[e] | 10.47 | 10.78 | 10.43 | 10.83 | 10.91 | 11.01 | 0.276 | 0.81 |
| Fat thickness, in.[f] | 0.65 | 0.67 | 0.63 | 0.60 | 0.52 | 0.72 | 0.061 | 1.22 |
| Marbling[g] | 12.92 | 12.83 | 13.78 | 11.89 | 12.89 | 14.80 | 0.965 | 1.17 |
| Cutability, %[h] | 49.20 | 49.20 | 49.07 | 49.82 | 50.05 | 48.65 | 0.467 | 1.26 |

[a] Standard error of treatment means for 10 observations. Other standard errors may be obtained by (X) ($\sqrt{10 \div n}$), where X = $s_{\bar{x}}$ reported and n = no. of observations.

[b] Calculated F value from analysis of variance. None were significant ($P<.05$).

[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 measurement 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). 11=slight, 12=slight plus, 13=small minus, 14=small, 15=small plus.

[h] Boneless trimmed retail cuts from the major wholesale cuts, as % of carcass = 51.34 (fat thickness) -0.462 (% kidney fat) +0.740 (ribeye area) -0.0093 (chilled carcass wt.).

TABLE XXXVII

TRIAL III: NET ENERGY VALUES OF PROCESSED MILO

| Net Energy Value | Coarsely Ground | Finely Ground | Dry Rolled | Recon.-Rolled | Recon.-Ground | Steam-Process-Flaked | $s_{\bar{x}}$[f] | F[g] |
|---|---|---|---|---|---|---|---|---|
| | ----- | ----- | ----- | Megcal./100 kg. | ----- | ----- | | |
| $NE_{m+p}$ of total ration[a,e] | 138.5[1] | 114.7[1,2] | 150.3[2] | 160.8[3] | 145.5[1,2] | 152.7[2,3] | 2.34 | 10.30[h] |
| $NE_{m+p}$ of milo[b,e] | 150.2[1] | 157.6[1,2] | 164.5[2] | 177.1[3] | 158.7[1,2] | 167.3[2,3] | 2.82 | 10.29[h] |
| $NE_m$ of milo[c] | 172.6 | 187.7 | 201.6 | 230.3 | 187.7 | 208.2 | -- | -- |
| $NE_p$ of milo[d,e] | 114.3[1] | 124.3[1,2] | 133.5[2] | 152.5[3] | 124.3[1,2] | 137.9[2,3] | 4.18 | 9.54[h] |

[a]Energy for gain and maintenance ÷ intake of total ration.
[b](Energy for gain and maintenance - energy attributed to basal) ÷ intake of milo.
[c]$NE_p$ X 1.51, (1.51 = ratio of $NE_m$ to $NE_p$ on basis of av. crude fiber content).
[d]Determined by dividing maintenance requirement and energy gained between milo and premix on basis of ratio in ration (83.4% milo, 16.6% premix).
[e]Any two values without a common number differ significantly (P<.01).
[f]Standard error of treatment means.
[g]Calculated F value from analysis of variance.
[h]Significant (P<.01).

a comparison of the two efficiency expressions, shown in Table XXXVIII. Empty body weight gain/kg. feed was significantly higher for reconstituted-rolled milo than for all others except steam-process-flaked milo; steam-process-flaked milo was significantly higher than coarsely ground milo. Comparison of treatment means for caloric gain/kg. feed was conducted at the 5% protection level. The reconstituted-rolled, steam-process-flaked and dry rolled grains were significantly higher than coarsely ground milo.

An average value of 2486.1 kcal./kg. of empty body weight was used to estimate the initial caloric content of the 67 experimental steers, calculated from slaughter group data shown in Table XLVIII (appendix). Prediction equations used to estimate initial empty body weight and composition of the experimental steers were those developed from the Trial II slaughter group, shown in Table L. Terminal carcass composition and components of gain are shown in Table LVII. No significant ($P<.05$) differences were obtained.

The procedure for calculating $NE_{m+p}$ of the milo is shown in Table LXII, using Table LIX as a key. Calculation of $NE_p$ is shown in Table LXVI.

## Trial IV

### Feedlot Performance

Feedlot performance of the steers fed the four types of processed milo is shown in Table XXXIX. A significant ($P<.01$) F value was obtained for average daily intake of

TABLE XXXVIII

TRIAL III: EFFICIENCY OF WEIGHT AND ENERGY GAIN

| Term | Coarsely Ground | Finely Ground | Dry Rolled | Recon.- Rolled | Recon.- Ground | Steam-Process-Flaked | $s_{\bar{x}}$[c] | F[d] |
|---|---|---|---|---|---|---|---|---|
| Empty body wt. gain/kg. feed, kg.[a] | 0.136[1] | 0.144[1] | 0.143[1] | 0.160[2] | 0.144[1] | 0.155[2] | 0.0035 | 6.16[e] |
| Energy gain/kg. feed, megcal.[b] | 0.621[1] | 0.670[1,2] | 0.698[2] | 0.724[2] | 0.652[1,2] | 0.710[2] | 0.0236 | 2.57[f] |

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

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

[c]Standard error of treatment mean.

[d]Calculated F values from analysis of variance.

[e]Significant (P<.01).

[f]Significant (P<.10).

TABLE XXXIX

TRIAL IV: FEEDLOT PERFORMANCE

| Item | Coarsely Ground | Finely Ground | Recon.-Rolled | Steam-Process-Flaked | $s_{\bar{x}}$[c] | F[d] |
|---|---|---|---|---|---|---|
| No. steers completing trial | 8 | 9 | 8 | 10 | | |
| No. days on feed | 166 | 166 | 166 | 166 | | |
| Initial live shrunk wt., kg. | 235.3 | 237.1 | 236.4 | 233.8 | -- | -- |
| Final live shrunk wt., kg. | 393.2 | 373.3 | 380.4 | 378.1 | -- | -- |
| Av. daily gain, kg. | 0.94 | 0.81 | 0.87 | 0.87 | 0.044 | 1.67 |
| Av. daily intake (total ration), kg. | 6.63 | 6.28 | 6.10 | 6.56 | 0.153 | 2.73 |
| Av. daily intake (grain), kg.[a] | 3.06[1] | 2.81[1,2] | 2.59[2] | 3.10[1] | 0.092 | 7.08[e] |
| Feed/kg. gain (total ration), kg. | 7.12 | 7.96 | 7.12 | 7.67 | 0.157 | 1.57 |
| Feed/kg. gain (grain), kg. | 3.29 | 3.56 | 3.01 | 3.63 | 0.081 | 2.77 |
| Initial empty body wt., kg. | 220.9 | 222.6 | 222.0 | 219.6 | -- | -- |
| Final empty body wt., kg. | 376.0 | 358.9 | 362.7 | 360.6 | -- | -- |
| Av. daily EBW gain, kg. | 0.93 | 0.82 | 0.84 | 0.84 | 0.029 | 2.61 |
| Feed/kg. EBW gain (total ration), kg. | 7.11 | 7.80 | 7.29 | 7.81 | 0.285 | 1.52 |
| Feed/kg. EBW gain (grain), kg.[b] | 3.29[1,2] | 3.50[1,2] | 3.07[2] | 3.70[1] | 0.151 | 3.22[f] |

[a] Any 2 means without a common number differ significantly ($P<.01$).
[b] Any 2 means without a common number differ significantly ($P<.05$).
[c] Standard error of treatment means, with 8 observations. Other standard errors may be obtained by (X) ($\sqrt{8 \div n}$), where X = $s_{\bar{x}}$ reported and n = no. of observations.
[d] Calculated F value from analysis of variance.
[e] Significant ($P<.01$).
[f] Significant ($P<.05$).

milo. Comparison of treatment means indicated that the steers fed reconstituted-rolled milo consumed significantly less grain than those fed either coarsely ground or steam-process-flaked milo. Differences in average daily intake of the total ration, average daily gain and feed/kg. of gain were non-significant ($P<.05$).

A summary of feedlot performance using coarsely ground milo as a basis for comparison is shown in Table XL. Although reconstituting-rolling resulted in a 7.33% reduction in average daily gain, milo/kg. gain was 8.52% less than for coarse grinding. Steers fed steam-process-flaked and finely ground milo performed poorly, with a lower rate of gain and higher feed/kg. gain than for coarsely ground milo. Differences were non-significant ($P<.05$).

When milo/kg. gain was placed on an empty body weight basis (Table XXXIX), a significant ($P<.05$) F value was obtained. Milo/kg. empty body weight gain was significantly less for reconstituted-rolled than for steam-process-flaked milo.

Carcass Merit

A significant ($P<.01$) F value was obtained for dressing percentage. Comparison of the means of the four processing methods indicated that the steers fed the reconstituted-rolled milo dressed significantly higher than those fed coarsely ground and steam-process-flaked milo.

No significant ($P<.05$) differences were obtained in carcass grade, ribeye area, fat thickness, marbling and cutabil-

TABLE XL

TRIAL IV: FEEDLOT PERFORMANCE USING COARSELY GROUND MILO AS A BASIS FOR COMPARISON[a]

| Item | Coarsely Ground | Finely Ground | Recon.-Rolled | Steam-Process-Flaked |
|---|---|---|---|---|
| | kg. | ---% change compared to---- coarsely ground milo | | |
| Av. daily gain | 0.94 | -14.12 | -7.33 | -7.66 |
| Av. daily intake (total ration) | 6.63 | -5.36 | -8.01 | -1.07 |
| Av. daily intake (milo) | 3.06 | -8.11 | -15.24[b] | 1.27 |
| Feed/kg. gain (total ration) | 7.12 | 11.81 | 0.00 | 7.74 |
| Feed/kg. gain (milo) | 3.29 | 8.37 | -8.52 | 10.53 |

[a]Data taken from Table XXXIX. Gain is on shrunk weight basis.
[b]Significantly ($P<.01$) different than value for coarsely ground milo.

ity, shown in Table XLI.

Net Energy

Calculated net energy values of the four types of processed milo are shown in Table XLII. A significant ($P<.05$) F value was obtained for $NE_{m+p}$ of the milo. Comparison of treatment means indicated that reconstituted-rolled milo was significantly higher in $NE_{m+p}$ than finely ground and steam-process-flaked milo. Differences in $NE_{m+p}$ of the total ration and $NE_p$ of the processed grains were non-significant ($P<.05$).

Coarse grinding milo produced estimated $NE_{m+p}$ and $NE_p$ values of 153.6 and 114.3 megcal./100 kg., respectively. Reconstituting-rolling increased $NE_{m+p}$ and $NE_p$ of the milo 9.1 and 7.3%, compared to coarse grinding.

Two efficiency terms, empty body gain/kg. total ration

TABLE XLI

TRIAL IV: CARCASS MERIT

| Item | Coarsely Ground | Finely Ground | Recon.-Rolled | Steam-Process-Flaked | $s_{\bar{x}}$[a] | F[b] |
|---|---|---|---|---|---|---|
| No. steers completing trial | 8 | 9 | 8 | 10 | | |
| Dressing, %[d,e] | 57.02[1] | 58.33[1,2] | 60.18[2] | 57.43[1] | 0.632 | 5.02[c] |
| Carcass grade[f] | 7.28 | 7.14 | 6.56 | 7.40 | 0.385 | 0.97 |
| Ribeye area, sq. in.[g] | 10.50 | 10.51 | 10.56 | 10.96 | 0.276 | 0.77 |
| Fat thickness, in.[h] | 0.20 | 0.21 | 0.22 | 0.23 | 0.036 | 0.14 |
| Marbling[i] | 8.81 | 8.53 | 8.30 | 8.80 | 0.640 | 0.15 |
| Cutability, %[j] | 52.67 | 53.09 | 52.68 | 53.21 | 0.366 | 0.66 |

[a]Standard error of treatment means, with 8 observations. Other standard errors may be obtained by (X) ($\sqrt{8 \div n}$), where X = $s_{\bar{x}}$ reported and n = no. of observations.
[b]Calculated F value from analysis of variance.
[c]Significant (P<.01).
[d]Any two means without a common number differ significantly (P<.01).
[e]Calculated on basis of final live shrunk weight and chilled carcass weight.
[f]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.
[g]Determined by measurement of ribeye tracings at the 12th rib.
[h]Average of three measurements on ribeye tracings.
[i]Marbling scores, 1=devoid minus to 30=abundant plus, with 3 scores per classification (minus, average, plus). 11=slight, 12=slight plus, 13=small minus, 14=small, 15=small plus.
[j]Boneless trimmed retail cuts from the major wholesale cuts, as % of carcass = 51.34 (fat thickness) -0.462 (% kidney fat) +0.740 (ribeye area) -0.0093 (chilled carcass wt.).

## TABLE XLII

### TRIAL IV: NET ENERGY VALUES OF PROCESSED MILO

| Net Energy Value | Coarsely Ground | Finely Ground | Recon.-Rolled | Steam-Process-Flaked | $s_{\bar{x}}$[g] | F[h] |
|---|---|---|---|---|---|---|
| | ----------Megcal./100 kg.---------- | | | | | |
| $NE_{m+p}$ of total ration[a] | 131.6 | 127.7 | 136.1 | 124.6 | 3.20 | 2.46 |
| $NE_{m+p}$ of milo[b,f] | 153.6[1,2] | 146.1[2] | 167.5[1] | 137.9[2] | 6.92 | 3.36[i] |
| $NE_m$ of milo[c] | 172.6 | 154.5 | 185.1 | 147.5 | -- | -- |
| $NE_p$ of milo[d] | 118.2 | 107.9 | 126.0 | 102.4 | 6.32 | 2.60 |
| $NE_p$ of milo[e] | 114.3 | 102.3 | 122.6 | 97.7 | 7.85 | 2.12 |

[a]Energy for gain and maintenance ÷ intake of total ration.
[b](Energy for gain and maintenance - energy attributed to basal) ÷ intake of milo.
[c]$NE_p$[e] X 1.51, (1.51 = ratio of $NE_m$ to $NE_p$ on basis of av. crude fiber content).
[d](Energy gained - av. loss in energy of basal steers) ÷ intake of milo.
[e]Energy gained ÷ (Milo intake - milo used to meet maintenance requirement not met by basal).
[f]Any two values without a common number differ significantly ($P<.05$).
[g]Standard error of treatment means.
[h]Calculated F value from analysis of variance.
[i]Significant ($P<.05$).

and energy gain/kg. total ration, are shown in Table XLIII. Differences were non-significant ($P<.05$).

An average value of 2486.1 kcal./kg. of empty body weight was used to estimate the initial caloric content of the 35 experimental steers, calculated from slaughter group data shown in Table XLVIII (appendix). Prediction equations used to estimate initial empty body weight and composition of the experimental steers were those developed from the Trial II slaughter group, shown in Table L. Terminal carcass composition and components of gain are shown in Table LVIII. No significant ($P<.05$) differences were obtained.

Calculation of the $NE_{m+p}$ of the milo is shown in Table LXIII, using Table LIX as a key. The two methods of calculating $NE_p$ are shown in Table LXVII. Again, as in Trials I and II the second method produced slightly lower values in all cases although the relationship between treatments was essentially the same.

TABLE XLIII

TRIAL IV: EFFICIENCY OF WEIGHT AND ENERGY GAIN

| Term | Coarsely Ground | Finely Ground | Recon.-Rolled | Steam-Process-Flaked | $s_{\bar{x}}$[a] | F[b] |
|---|---|---|---|---|---|---|
| Empty body wt. gain/kg. feed, kg. | 0.141 | 0.131 | 0.139 | 0.130 | 0.0049 | 1.33 |
| Energy gain/kg. feed, megcal. | 0.447 | 0.382 | 0.429 | 0.386 | 0.0860 | 1.20 |

[a]Standard error of treatment means.

[b]Calculated F values from analysis of variance; both were non-significant ($P<.05$).

# DISCUSSION

Air-dry milo, both rolled and ground, averaged approximately 12.6% moisture (100% - % dry matter), for Trials I, III and IV while the steam-process-flaking, reconstituting and reconstituting-steam-process-flaking procedures increased moisture levels to averages of 17.2, 23.6 and 30.0%, respectively. The average moisture level of the steam-process-flaked milo was very similar to the 18 - 20% range reported as desirable by Hale et al. (1965). The average moisture content of the reconstituted grain was in the lower end of the 23 - 32% range obtained by McGinty and Riggs (1967). Actually, the moisture content obtained in Trial III was considerably lower (19.6%) than in Trials I (26.4%) and IV (28.8%).

All processing methods decreased the density of milo as compared to whole milo. Steam-process-flaking, reconstituting-rolling and reconstituting-steam-process-flaking resulted in the greatest decreases in density, averaging 59, 52 and 55% less than whole milo, respectively. These three processing methods also produced particle sizes strikingly different from the ground or rolled air-dry products. However, steam-process-flaking, compared to the other two procedures, produced more large particles (flakes) and much less fine material. The fine particles in the reconstituted-steam-process-flaked and the reconstituted rolled and ground products were very fluffy in nature. It should be noted that "coarse" grinding through a 4.76 mm. screen produced 35% less "fines" (material passing through the 0.36 mm. screen) than "fine" grinding through a 3.18 mm. screen.

Results of Trials I and III, comparing processing methods of milo in group feeding experiments, were similar. A summary of feedlot performance, for those processing methods which were included in both trials, is shown in Table XLIV. Coarsely ground milo was used as the standard of comparison. Trial IV results were not included because the steers were individually fed; whereas, in Trials I and III they were group fed _ad libitum_. Note the average results. Fine grinding resulted in a slight increase in gain on a lower feed intake and a consequent average improvement in efficiency of 6.0%. Reconstituting-rolling affected gain very little, but lowered feed intake markedly and improved feed efficiency 9.7%. On the other hand, steam-process-flaking increased gain considerably with very little additional feed, resulting in a feed efficiency improvement of 8.2%.

Both steam-process-flaking and reconstituting-rolling produced greater improvements in feed efficiency in Trial III than in Trial I (3.5 and 5.4% in Trial I and 12.9 and 14.0% in Trial III for steam-process-flaking and reconstituting-rolling, respectively). The greater improvements in efficiency in Trial III may have been due to the higher concentrate ration which was fed and the higher level of milo

TABLE XLIV

SUMMARY OF EFFECT OF MILO PROCESSING ON FEEDLOT PERFORMANCE IN TRIALS I AND III[a]

| | Daily Gain[b] | | | Daily Intake[c] | | | Feed/kg. Gain[c] | | |
|---|---|---|---|---|---|---|---|---|---|
| | Trial I | Trial III | Av. | Trial I | Trial III | Av. | Trial I | Trial III | Av. |
| Finely Ground | 3.3 | 3.2 | 3.2 | -4.7 | -1.0 | -2.9 | -7.6 | -4.4 | -6.0 |
| Recon.-Rolled | 0.8 | -0.1 | 0.7 | -5.0 | -14.1 | -9.6 | -5.4 | -14.0 | -9.7 |
| Steam-Process-Flaked | 8.2 | 11.9 | 10.0 | 4.3 | -3.3 | 1.0 | -3.5 | -12.9 | -8.2 |

[a]Data taken from Tables XXVI and XXXV (shrunk wt. basis).

[b]Live shrunk wt. basis.

[c]Intake and feed conversion are for total ration, on 90% dry matter basis.

in the ration (Trial III - 83.4%, Trial I - 54%). Increased improvement in feed efficiency of reconstituted milo as the level of milo in the ration increased was also observed by Franke *et al*. (1960) and Parrett and Riggs (1966). Also, a larger, heavier roller mill was used in Trial III; perhaps the greater roller pressure which was exerted was of some value in improving utilization of the milo.

Fine grinding, dry rolling and reconstituting-grinding produced very similar results in all respects in Trial III. Fine grinding had a definite advantage over coarse grinding, but little apparent advantage over rolling. This is consistent with results obtained by Smith *et al*. (1949) and Richardson *et al*. (1961).

It is interesting to note that in Trials I and III the percent increases in feed efficiency paralled the percent decreases in intake for the dry rolled, reconstituted-rolled and reconstituted-ground grains, while for finely ground and steam-process-flaked milo the increases in feed efficiency were of greater magnitude than the decreases in intake. For the first three, energy intake appeared to be the governing factor; that is, as utilization of a grain increased, less was required to provide the same amount of energy. However, for the other two grains, particularly the steam-process-flaked, the improvement in feed efficiency seemed to be principally the result of faster gain, with only a slight increase (Trial I) or decrease (Trial III) in intake, with the feed required for maintenance thus spread over a greater gain. Even if this were true, it is obvious that advantages in rate of gain and apparent feed efficiency are important economically. Furthermore, the faster gaining steers on the steam-process-flaked milo could be marketed earlier, resulting in a real improvement in feed efficiency not demonstrated in Trials I and III in which steers were fed a constant time rather than to a constant weight.

Improvements in feed efficiency for fine grinding of milo, compared to coarse grinding, are probably due to increased surface area. The biochemical process of fermentation brought about by reconstitution and oxygen-free storage appears to increase starch availability, when followed by either grinding or rolling. Steaming and flaking the reconstituted whole milo further increased milo utilization, indicating that fermentation alone did not result in maximum carbohydrate availability. Steam-processing partially cooks the milo and increases the moisture level, which may enhance utilization; however, it appears that maximum improvement by steam-process-flaking depends on the production of a flat flake by slow rolling with much roller pressure (Hale and Taylor, 1966). The mechanical process of rolling apparently improves the efficiency of utilization of milo grain. Dry rolling was superior to coarse grinding, and reconstituting-rolling outperformed reconstituting-grinding (Trial III). Conventional steam-rolling of milo (Trial II) produced better feed conversions than coarse grinding (Trials I, III and IV). These results indicate that the rolling process exerts a beneficial influence over and above the apparent reduction in particle size it accomplishes, in dry as well as steam-cooked or reconstituted milo. The superiority of rolling over grinding was also observed in high moisture corn (Matsushima and Stenquist, 1967). It appears that significant improvements in the utilization of milo can be obtained by combining proper rolling with either the reconstitution process or partial cooking with steam.

The results of Trials I, III and IV indicate that milo processing method has little to no effect on carcass merit. It is possible that, with larger numbers, a real difference in fat thickness and carcass grade might be detected to correspond with the faster rates of gain observed for steers fed steam-process-flaked milo.

The results of Trial II indicate that milo and wheat, or an equal mixture of the two, are similar in feeding value for fattening cattle. The tendency toward a lower rate of gain when wheat was included in the ration was also observed by Brethour and Duitsman (1959) at the Ft. Hays, Kansas station. However, feed intake decreased more than rate of gain in the Ft. Hays work, so that feed conversion was 14% better for wheat than milo.

Feeding twice daily in individual stalls (Trial IV) failed to give results similar to those obtained by *ad libitum* feeding with three steers to a pen (Trials I and III), in comparing milo processing methods. Feed intake was lower, causing lower rates of gain. The greatest discrepancy was in total ration/kg. of gain, with coarsely ground milo producing a value identical to reconstituted-rolled milo and superior to finely ground and steam-process-flaked milo. Differences in efficiency were narrowed when only milo required per kg. of gain was considered. In this case reconstituting-rolling showed an 8.5% improvement over coarse grinding. This technique is valid since a basal ration was fed to meet maintenance requirements, with milo fed for production above maintenance -- that is, body gain. A higher total ration requirement per kg. of gain is to be expected under the conditions of Trial IV because milo intake was low and the crude fiber content of the basal was high (16.70%). Certainly, high concentrate rations produce more efficient gains than those containing moderate to large amounts of roughage. When only milo/kg. gain is considered, there are two opposing factors. As intake of milo increases, improvements in efficiency due to processing should become more apparent. On the other hand, with increasing intake, digestibility declines (Reid et al., 1966) and the heat increment may go up (Forbes et al., 1930; Blaxter, 1956; Lofgreen and Otagaki, 1960; Lofgreen and Garrett, 1967). At any rate, improvements in feed efficiency observed in Trials I and III for fine grinding and steam-process-flaking were not apparent under the feeding regime of Trial IV.

Principal factors influencing the performance of the steers in Trial IV appeared to be the limited time for consumption of feed, the length of time between feedings and variation in adaptability of the steers to the stalls. Church and Ralston (1963) indicated that limited time for consumption of feed increased variation in feed intake compared to *ad libitum* feeding. This would tend to decrease the precision of an experiment, although these workers did observe similar results in feed efficiency for the two methods of feeding. They also observed lowered feed intake, rate of gain and fat deposition for twice daily individual feeding compared to *ad libitum* feeding.

Bloat was much more of a problem in individually fed steers (Trial IV) than in *ad libitum* fed steers (Trial I and III). The length of time between feedings plus the stress of placing the steers in the stalls, where no water was available, appeared to be factors increasing the incidence of bloat. With individual stalls such as those used in Trials II and IV, better results could probably be obtained by feeding at more frequent intervals and by providing water in the stalls. Individual feeding has evidently given reliable results at the California station; however, cattle were maintained in separate pens and fed *ad libitum* (Garrett and Lofgreen, 1967).

Estimation of initial empty body weight was done on the basis of live shrunk weight instead of hot carcass weight as suggested by Lofgreen *et al*. (1962). Correlations between empty body weight and live shrunk weight were extremely high in both the Trial I and II slaughter groups (0.9911 and 0.9935, respectively). Additional correlations were calculated on the 67 Trial III experimental steers, comparing the two methods. The correlation between empty body weight and live shrunk weight was higher (0.9953) than the correlation between empty body weight and hot carcass weight (0.9806), although they were not significantly ($P<.05$) different. Regression equations are shown in Table XLV. Under the conditions of these trials, with standard shrinking procedures and rather uniform cattle, the use of live shrunk weight for predicting empty body weight was just as accurate as hot carcass weight.

Analysis of rate of gain and feed efficiency on a live shrunk weight basis and on an empty body weight basis gave very similar results in these four trials. Variable fill was not a problem. Only in Trial IV, in which a significant

TABLE XLV

PREDICTION OF EMPTY BODY WEIGHT FROM LIVE SHRUNK WEIGHT AND HOT CARCASS WEIGHT[a]

| | |
|---|---|
| $Y = 9.03 + 0.942 X \pm 3.630$<br>Y = Empty body wt., kg.<br>X = Live shrunk wt., kg. | $r_{xy} = 0.9953$[b] |
| $Y = 19.25 + 1.458 X \pm 7.319$<br>Y = Empty body wt., kg.<br>X = Hot carcass wt., kg. | $r_{xy} = 0.9806$[b] |

[a]Linear regression equations constructed from Trial III experimental group data (67 steers).

[b]Correlations significantly ($P<.01$) different from zero. The two correlations did not differ significantly ($P<.05$) from each other.

(P<.01) difference in dressing percentage was also observed, did subtracting rumen contents change the results, and the only effect in this case appeared to be in reducing animal to animal variation making it possible to obtain a significant (P<.05) F value for milo/kg. empty body weight gain. Differences in milo/kg. shrunk weight gain were not significant (P<.05). The ranking of treatment means was not changed.

Comparison of efficiency on the basis of empty body weight gain/kg. feed vs. energy gain/kg. feed gave somewhat similar results, although treatment rankings were sometimes different. The greatest difference between the two expressions of efficiency occurred in Trial I. Finely ground milo produced the highest empty weight gain/kg. feed and was next to the lowest in energy gain/kg. feed. Steam-process-flaking produced the next to the lowest empty body weight gain/kg. feed and the second highest caloric gain/kg. feed. In Trial III, dry rolled milo produced a relatively higher energy gain than empty body weight gain/kg. feed.

These results indicate that analysis of feedlot performance on the basis of live shrunk weight only should give meaningful results if: (1) a uniform group of cattle is used, (2) an allotment procedure, such as blocking or stratification, is accurately used to balance the treatments according to weight and condition and (3) cattle are adequately shrunk before weighing.

The major difference in results obtained by different methods of measuring feed efficiency in these trials was between weight gain and energy gain. This is understandable since the calves were scored for condition by visual appraisal at the beginning of the feeding trials as a basis of allotment, and prediction equations were used to estimate initial caloric content. These are sources of error. However, it seems logical to assume that if cattle are of similar weight and condition initially, caloric gain should parallel weight gain per unit feed. The necessity for incorporating energy gain and adjustments for rumen fill, as Meyer et al. (1960) propose, is surely greater when cattle of widely varying weight and condition are used without any allotment procedure or covariance analysis to balance the treatments, and if cattle are not shrunk before weighing.

The increased net energy for production of the reconstituted-rolled and steam-process-flaked milo grains observed in Trials I and III, and also in Trial IV for reconstituted-rolled milo, compared to coarsely ground milo, is probably at least partially explained by increased digestibility of the energy of milo, which was observed by Hale et al. (1966), Husted et al. (1966), Mehen et al. (1966), Buchanan-Smith et al. (1968) and McGinty and Riggs (1967). The same would appear to be true for the reconstituted-steam-process-flaked milo, although no digestion trials have been reported. Increased digestible energy has also been reported for reconstituted-ground milo (McGinty et al., 1966; 1967). Feed efficiency and $NE_p$ of milo were improved by reconstituting-grinding in Trial III (4.9 and 8.8%,respectively, compared to coarse grinding),but not to the degree realized by rolling the reconstituted whole grain. Fine grinding (Trials I and III) and dry rolling (Trial III) also increased feed efficiency and $NE_p$, compared to coarse grinding. Digestion trials by Mehen et al. (1966) and Buchanan-Smith et al. (1968) failed to pick up significant improvements in digestible energy for dry rolling and fine grinding, respectively, while Smith et al. (1949) did observe an increase in digestible energy due to fine grinding.

The use of the comparative slaughter technique to derive net energy values appeared to be reliable in these four trials. $NE_p$ values obtained for coarsely ground (Trial I - 95.5, Trial III - 114.3, Trial IV - 114.3 megcal./100 kg.) and conventional steam-rolled milo (Trial II - 101.8 megcal./100 kg.) were very similar to those reported for milo by Lofgreen and Garrett (1967a) who listed separate $NE_p$ values for Sacramento Valley milo grain and milo from the Southwest (116.8 and 97.0 megcal./100 kg., respectively) and subsequently revised them to 127.9 and 108.0 megcal./100 kg. (Garrett and Lofgreen, 1967b). $NE_p$ values reported by these workers for wheat were 136.7 and 130.1 megcal./100 kg., which are considerably higher than that obtained in Trial II (99.7 megcal./100 kg.).

Increases in feed efficiency of milo due to processing method were also reflected in $NE_p$ values obtained. It should be pointed out that the values obtained for net energy for production by this technique are dependent on performance of the cattle. As Tillman (1967) pointed out, net energy values can be affected by many factors independent of the ration, such as weather, insect annoyance, bloat or stress of any kind. The comparative slaughter technique involves several assumptions, from the taking of measurements through the calculation and interpretation of results. Carcass specific gravity was shown by Whiteman *et al*. (1953) to be subject to considerable error. From this measure body composition is obtained, by equations, and converted to caloric equivalents. The original equations for estimation of body water, protein and fat were developed by Kraybill *et al*. (1952) from a sample of animals ranging in percent separable body fat from 13.6 to 39.5, in a test specifically designed to bring about a wide variation in body composition. The indiscriminate use of these equations for one group of relatively homogeneous cattle in the expectation they will yield results applicable to a different group under varying conditions appears dangerous (Hall, 1966).

Acknowledging the shortcomings of this technique, it may still be as preferable for determining net energy as the use of a respiration chamber, if sufficient numbers are used and accuracy of measurements is stressed. Although the techniques involved in the use of a respiration chamber are more precise, it necessitates artificial conditions and small numbers of animals.

The fact that feed efficiency and net energy for production were closely related in these four trials ($r_{xy}$ = 0.6872 for 174 steers; refer to Table LXVIII, appendix, for specific correlations for each trial) enhances the reliability of energy values determined by the slaughter method. The similarity of carcass fatness, as estimated by fat thickness, marbling and percent fat, among treatments within a trial indicate that energy values of the milo should parallel feed efficiency. The net energy values obtained in these trials should be meaningful when used for fattening cattle under feedlot conditions.

# SUMMARY

Three feeding trials (Trials I, III and IV) were conducted to investigate the effect of processing method on the utilization of milo by fattening steers. One feeding trial (Trial II) was conducted to compare the feeding value of milo, wheat and a combination of the two. Evaluation was on the basis of feedlot performance, carcass merit and net energy.

No significant differences in any of these three criteria were observed between milo, wheat or a combination of the two, although a slight reduction in rate of gain occurred when wheat was included in the ration. The grains were steam-rolled.

All processing methods studied improved milo utilization compared to coarse grinding. Reconstituting-rolling, reconstituting-steam-process-flaking and steam-process-flaking significantly increased feed efficiency and net energy for maintenance plus production ($NE_{m+p}$) and for production only ($NE_p$), in two trials in which steers were group fed <u>ad libitum</u>. Average increases in efficiency of weight gain (milo only, 90% dry matter basis) and $NE_p$ for these three processing methods, compared to coarse grinding were as follows: reconstituting-rolling, 10.9 and 25.1%; reconstituting-steam-process-flaking, 11.72 and 22.0%;and steam-process-

flaking, 7.1 and 15.8%. Fine grinding, dry rolling and reconstituting-grinding produced very similar results.

Carcass merit, as measured by dressing percent, fat thickness, marbling, carcass grade, ribeye area and cutability, was not significantly affected by processing method in the group feeding trials (Trials I and III). In Trial IV (individually fed steers), the steers fed reconstituted-rolled milo dressed significantly higher than those fed either coarsely ground or steam-process-flaked milo.

Feeding twice daily in individual stalls (Trial IV) failed to give results comparable to those obtained by group feeding *ad libitum* (Trials I and III).

Net energy was determined by the comparative slaughter technique. In Trials I, II and IV, a basal ration containing approximately 55% roughage was fed to meet maintenance requirements, with grain fed for production above maintenance. A high concentrate (90%) ration was fed in Trial III. Essentially, the comparative slaughter technique involved using carcass specific gravity to estimate body composition at the beginning and end of the feeding trials, from which caloric gain was calculated. Energy gain plus energy required for maintenance was compared to feed intake, on a daily metabolic weight basis, to derive $NE_{m+p}$ values. Energy gain due to an increase in feed intake above maintenance was the basis for obtaining $NE_p$ values.

Initial empty body weights were predicted from live shrunk weights by regression equations. Correlations on 67 steers (Trial III) indicated that live shrunk weight was just as accurate as hot carcass weight for estimating empty body weight.

Comparison of feed/kg. gain using shrunk weight gain vs. empty body weight gain yielded essentially the same results. Variable fill was not a problem under the conditions imposed in these trials, i.e., rather uniform cattle, blocking or stratification on the basis of initial weight and condition score, and shrinking 16 hr. prior to weighing.

Feed efficiency expressed as weight gain per unit feed vs. energy gain per unit feed produced similar, but not identical, treatment rankings. Total ration/kg. gain was significantly correlated with net energy for production ($NE_p$) in all four trials. Grain/kg. gain and $NE_p$ were significantly correlated in Trials I, III and IV, but not in Trial II.

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# APPENDIX

TABLE XLVI

TRIAL I: INITIAL SLAUGHTER GROUP DATA

| Item | Mean |
|---|---|
| No. steers | 9 |
| Live shrunk wt., kg. | 218.23 |
| Rumen contents, kg. | 17.29 |
| Empty body wt., kg. | 200.95 |
| Carcass specific gravity | 1.079 |
| Body water, % | 63.26 |
| Body fat, % | 12.86 |
| Body protein, % | 19.32 |
| Kcal. from fat | 241,156 |
| Kcal. from protein | 220,768 |
| Total kcal. | 461,924 |
| Kcal./kg. empty body wt. | 2,302.9 |

TABLE XLVII

TRIAL II: INITIAL SLAUGHTER GROUP DATA

| Item | Mean |
|---|---|
| No. steers | 9 |
| Live shrunk wt., kg. | 230.08 |
| Rumen content, kg. | 14.01 |
| Empty body wt., kg. | 216.07 |
| Carcass specific gravity | 1.073 |
| Body water, % | 61.37 |
| Body fat, % | 14.90 |
| Body protein, % | 19.20 |
| Kcal. from fat | 304,431 |
| Kcal. from protein | 235,691 |
| Total kcal. | 540,122 |
| Kcal./kg. empty body wt. | 2,487.2 |

TABLE XLVIII

TRIALS III AND IV: INITIAL SLAUGHTER GROUP DATA[a]

| Item | Mean |
|---|---|
| No. steers | 12 |
| Live shrunk wt., kg. | 245.31 |
| Rumen content, kg. | 15.70 |
| Empty body wt., kg. | 229.61 |
| Carcass specific gravity | 1.073 |
| Body water, % | 61.37 |
| Body fat, % | 14.88 |
| Body protein, % | 19.21 |
| Kcal. from fat | 320,017 |
| Kcal. from protein | 250,823 |
| Total kcal. | 570,840 |
| Kcal./kg. empty body wt. | 2,486.1 |

[a]The same slaughter group was used to estimate initial caloric content of Trials III and IV experimental steers.

TABLE XLIX

TRIAL I: EQUATIONS FOR ESTIMATING INITIAL EMPTY BODY WEIGHT AND COMPOSITION OF EXPERIMENTAL STEERS[a]

$$Y = -8.79 + 0.961\,X \pm 3.212$$
Y = empty body wt., kg.
X = live shrunk wt., kg.

$$Y = -6.85 + 0.667\,X \pm 1.962$$
Y = water in empty body, kg.
X = empty body wt., kg.

$$Y = 7.35 + 0.092\,X \pm 2.074$$
Y = fat in empty body, kg.
X = empty body wt., kg.

$$Y = -.405 + 0.195\,X \pm 0.092$$
Y = protein in empty body, kg.
X = empty body wt., kg.

[a]Linear regression equations developed from Trial I slaughter group data (see Table XLVI). Refer to Table LI for correlations.

TABLE L

TRIAL II: EQUATIONS FOR ESTIMATING INITIAL EMPTY BODY WEIGHT AND COMPOSITION OF EXPERIMENTAL STEERS[a]

$Y = 1.50 + 0.933\ X \pm 3.136$
Y = empty body wt., kg.
X = live shrunk wt., kg.

$Y = 23.25 + 0.505\ X \pm 1.819$
Y = water in empty body, kg.
X = empty body wt., kg.

$Y = -25.72 + 0.270\ X \pm 2.007$
Y = fat in empty body, kg.
X = empty body wt., kg.

$Y = 2.00 + 0.183\ X \pm 0.157$
Y = protein in empty body, kg.
X = empty body wt., kg.

[a]Linear regression equations developed from Trial II slaughter group data (see Table XLVII). Refer to TableLII for correlations.

TABLE LI

TRIAL I: SLAUGHTER GROUP CORRELATIONS

| Variables | $r_{xy}$ |
|---|---|
| Live shrunk wt. (kg.) and empty body wt. (kg.) | 0.9911[a] |
| Body water (kg.) and empty body wt. (kg.) | 0.9926[a] |
| Body fat (kg.) and empty body wt. (kg.) | 0.7289[b] |
| Body protein (kg.) and empty body wt. (kg.) | 0.9998[a] |
| Body protein (kg.) and body water (kg.) | 0.9948[a] |

[a]Significantly ($P<.01$) greater than zero.

[b]Significantly ($P<.05$) greater than zero.

TABLE LII

TRIAL II: SLAUGHTER GROUP CORRELATIONS

| Variables | $r_{xy}$[a] |
|---|---|
| Live shrunk wt. (kg.) and empty body wt. (kg.) | 0.9935 |
| Body water (kg.) and empty body wt. (kg.) | 0.9915 |
| Body fat (kg.) and empty body wt. (kg.) | 0.9651 |
| Body protein (kg.) and empty body wt. (kg.) | 0.9995 |
| Body protein (kg.) and body water (kg.) | 0.9950 |

[a]All correlations significantly (P<.01) greater than zero.

TABLE LIII

TRIAL I: CALCULATION OF $NE_m$ OF BASAL RATION

| Item | Mean |
|---|---|
| No. steers | 9 |
| Initial live shrunk wt., kg. | 221.51 |
| Initial empty body wt., kg. | 204.10 |
| Final live shrunk wt., kg. | 236.38 |
| Final empty body wt., kg. | 220.75 |
| Carcass specific gravity | 1.097 |
| Body water, % | 68.78 |
| Body fat, % | 7.33 |
| Body protein, % | 19.22 |
| Kcal. gained | -61,750.2 |
| Av. daily gain/kg. $W^{.75}$, kcal. | -7.30 |
| Gain + maintenance/kg. $W^{.75}$, kcal. | 69.70 |
| Av. daily basal intake/kg. $W^{.75}$, kg. | 0.052 |
| $NE_m$, kcal./kg. | 1,351.9 |

TABLE LIV

TRIAL II: CALCULATION OF $NE_m$ OF BASAL RATION

| Item | Mean |
|---|---|
| No. steers | 9 |
| Initial live shrunk wt., kg. | 230.07 |
| Initial empty body wt., kg. | 216.07 |
| Final live shrunk wt., kg. | 268.88 |
| Final empty body wt., kg. | 252.76 |
| Carcass specific gravity | 1.100 |
| Body water, % | 69.95 |
| Body fat, % | 6.22 |
| Body protein, % | 19.17 |
| Kcal. gained | -115,050 |
| Av. daily gain/kg. $W^{.75}$, kcal. | -10.03 |
| Gain + maintenance/kg. $W^{.75}$, kcal. | 66.97 |
| Av. daily basal intake/kg. $W^{.75}$, kg. | 0.048 |
| $NE_m$, kcal./kg. | 1,404.5 |

TABLE LV

TRIAL I: TERMINAL CARCASS COMPOSITION AND COMPONENTS OF GAIN

| Item | Coarsely Ground | Finely Ground | Recon.-Rolled | Recon.-Steam-Process-Flaked | Steam-Process-Flaked | $s_{\bar{x}}$[c] | F[d] |
|---|---|---|---|---|---|---|---|
| Water in empty body, % | 56.27 | 55.58 | 54.90 | 55.20 | 54.00 | -- | -- |
| Protein in empty body, % | 18.45 | 18.33 | 18.18 | 18.19 | 17.99 | -- | -- |
| Fat in empty body, % | 20.79 | 21.62 | 22.49 | 22.16 | 23.62 | -- | -- |
| Gain in water, kg. | 95.50 | 95.47 | 90.23 | 89.71 | 93.23 | 2.552 | 1.18 |
| Gain in protein, kg. | 34.44 | 34.76 | 33.35 | 32.88 | 34.87 | 0.926 | 0.93 |
| Gain in fat, kg. | 57.82 | 61.72 | 64.15 | 62.73 | 72.34 | 4.172 | 1.64 |
| Other gain, kg.[a] | 8.68 | 8.74 | 8.39 | 8.30 | 8.78 | -- | -- |
| Av. daily gain, kcal./kg. $W^{.75}$[b] | 56.88 | 60.20 | 61.79 | 60.31 | 66.65 | 2.754 | 1.66 |

[a]Other gain = Total gain - (gains in water, protein and fat).

[b]$\frac{\text{(kcal. of protein gained + kcal. of fat gained)} \div \text{no. days on feed}}{\text{mean test weight, kg.}^{.75}}$

[c]Standard error of treatment means.

[d]Calculated F values from analysis of variance, all non-significant (P<.05).

TABLE LVI

TRIAL II: TERMINAL CARCASS COMPOSITION AND COMPONENTS OF GAIN

| Item | Milo | Wheat | ½milo ½wheat | $s_{\bar{x}}$[c] | F[d] |
|---|---|---|---|---|---|
| | (conventional steam-rolled) | | | | |
| Water in empty body, % | 60.48 | 60.53 | 61.81 | -- | -- |
| Protein in empty body, % | 18.98 | 18.95 | 19.09 | -- | -- |
| Fat in empty body, % | 15.91 | 15.90 | 14.45 | -- | -- |
| Gain in water, kg. | 109.85 | 100.53 | 104.49 | 6.047 | 0.60 |
| Gain in protein, kg. | 34.54 | 31.63 | 31.79 | 2.228 | 0.54 |
| Gain in fat, kg. | 31.43 | 29.85 | 23.67 | 4.757 | 0.74 |
| Other gain, kg.[a] | 8.97 | 8.26 | 8.30 | -- | -- |
| Av. daily gain, kcal./kg. $W^{.75}$[b] | 36.05 | 33.53 | 29.49 | 3.710 | 0.80 |

[a]Other gain = Total gain - (gains in water, protein and fat).

[b]$$\frac{\text{(kcal. of protein gained + kcal. of fat gained)} \div \text{no. days on feed}}{\text{mean test weight, kg.}^{.75}}$$

[c]Standard error of treatment means.

[d]Calculated F values from analysis of variance, all non-significant (P<.05).

TABLE LVII

TRIAL III: TERMINAL CARCASS COMPOSITION AND COMPONENTS OF GAIN

| Item | Coarsely Ground | Finely Ground | Dry Rolled | Recon.-Rolled | Recon.-Ground | Steam-Process-Flaked | $s_{\bar{x}}$[c] | F[d] |
|---|---|---|---|---|---|---|---|---|
| Water in empty body, % | 52.92 | 52.28 | 51.66 | 52.91 | 52.93 | 52.52 | -- | -- |
| Protein in empty body, % | 17.69 | 17.53 | 17.36 | 17.72 | 17.71 | 17.59 | -- | -- |
| Fat in empty body, % | 25.07 | 25.91 | 26.75 | 25.06 | 25.04 | 25.61 | -- | -- |
| Gain in water, kg. | 70.88 | 72.30 | 65.83 | 72.16 | 72.08 | 78.53 | 3.518 | 1.22 |
| Gain in protein, kg. | 26.31 | 27.03 | 24.96 | 26.87 | 26.72 | 28.90 | 1.153 | 1.12 |
| Gain in fat, kg. | 64.30 | 69.81 | 70.61 | 64.48 | 64.30 | 70.84 | 4.259 | 0.57 |
| Other gain, kg.[a] | 6.97 | 7.15 | 6.65 | 7.12 | 7.08 | 7.62 | -- | -- |
| Av. daily gain, kcal./kg. $W^{.75}$[b] | 62.33 | 66.20 | 66.40 | 62.78 | 62.43 | 66.50 | 3.176 | 0.41 |

[a]Other gain = Total gain - (gains in water, protein and fat).

[b]
$$\frac{\text{(kcal. of protein gained + kcal. of fat gained)} \div \text{no. days on feed}}{\text{mean test weight, kg.}^{.75}}$$

[c]Standard error of treatment means.

[d]Calculated F values from analysis of variance, all non-significant (P<.05).

TABLE LVIII

TRIAL IV: TERMINAL CARCASS COMPOSITION AND COMPONENTS OF GAIN

| Item | Coarsely Ground | Finely Ground | Recon.-Rolled | Steam-Process-Flaked | $s_{\bar{x}}$[c] | F[d] |
|---|---|---|---|---|---|---|
| Water in empty body, % | 58.49 | 59.62 | 58.97 | 59.49 | -- | -- |
| Protein in empty body, % | 18.79 | 18.88 | 18.83 | 18.85 | -- | -- |
| Fat in empty body, % | 18.15 | 16.90 | 17.61 | 17.06 | -- | -- |
| Gain in water, kg. | 84.97 | 77.86 | 78.35 | 80.11 | 3.817 | 0.66 |
| Gain in protein, kg. | 28.21 | 24.98 | 25.65 | 28.35 | 1.144 | 1.40 |
| Gain in fat, kg. | 34.45 | 26.81 | 29.85 | 25.79 | 3.343 | 0.91 |
| Other gain, kg.[a] | 7.43 | 6.65 | 6.81 | 6.84 | -- | -- |
| Av. daily gain, kcal./kg. $W^{.75}$[b] | 39.70 | 33.18 | 35.69 | 34.40 | 2.564 | 1.14 |

[a]Other gain = Total gain - (gains in water, protein and fat).

[b]$$\frac{\text{(kcal. of protein gained + kcal. of fat gained)} \div \text{no. days on feed}}{\text{mean test weight, kg.}^{.75}}$$

[c]Standard error of treatment means.

[d]Calculated F values from analysis of variance, all non-significant (P<.05).

TABLE LIX

KEY TO STEPS IN THE PROCEDURE FOR CALCULATION OF $NE_{m+p}$ VALUES[a]

(a) Initial empty body weight estimated by regression equation, with initial live shrunk wt. as independent variable (see Tables XLIX and L for specific equations).

(b) Initial energy = empty body wt. X av. kcal. energy/kg. empty body wt. of slaugher group (see Tables XLVI, XLVII, XLVIII).

(c) Final empty body wt. = final shrunk wt. - reticulo-rumen content.

(d) Carcass specific gravity = $\frac{\text{wt. in air}}{\text{wt. in air} - \text{wt. in water}}$

(e) Empty body specific gravity = (0.9955 X carcass specific gravity) - 0.0013.

(f) Percent water in empty body =

$$100\left(4.008 - \frac{3.620}{\text{empty body specific gravity}}\right)$$

(g) Percent fat in empty body =
337.88 + (0.2406 X % water) - (188.91 X log % water)

(h) Percent protein in empty body =

$$\frac{[80.80-0.00078\ (\text{age in days})][100-(\%\ \text{water} + \%\ \text{fat})]}{100}$$

(i) Kg. fat = $\frac{\%\ \text{fat X final empty body wt., kg.}}{100}$

(j) Kg. protein = $\frac{\%\ \text{protein X final empty body wt., kg.}}{100}$

(k) Fat energy = kg. fat X 9367 kcal. per kg.

(l) Protein energy = kg. protein X 5686 kcal. per kg.

(m) Mean test wt. = $\frac{\text{initial shrunk wt.} + \text{final shrunk wt.}}{2}$

(n) Maintenance requirement = 77 kcal./kg. $(\text{mean test wt.})^{.75}$

(o) Basal correction (energy supplied by basal) = kg. basal consumed X estimated $NE_{m+p}$ value of basal, kcal./kg. (Trial I, 1020; Trial II, 1145; Trial III, 816; Trial IV, 1130).

---

[a]For use with Tables LX through LXIII.

TABLE LX

TRIAL I: CALCULATION OF $NE_{m+p}$ OF PROCESSED MILO[a]

| Item[b] | Coarsely Ground | Finely Ground | Recon.-Rolled | Recon.-Steam-Process-Flaked | Steam-Process-Flaked |
|---|---|---|---|---|---|
| No. steers | 9 | 9 | 9 | 9 | 9 |
| Initial shrunk wt., kg. | 227.1 | 222.3 | 221.8 | 222.5 | 225.8 |
| Initial empty body wt., kg. | 209.5 | 204.9 | 204.4 | 205.1 | 208.2 |
| Initial energy in empty body, kcal. | 482,351 | 471,753 | 470,638 | 472,311 | 479,563 |
| Final shrunk wt., kg. | 415.7 | 416.6 | 411.4 | 410.1 | 429.8 |
| Reticulo-rumen content, kg. | 9.8 | 11.1 | 10.9 | 11.4 | 12.3 |
| Final empty body wt., kg. | 405.9 | 405.5 | 400.5 | 398.7 | 417.5 |
| Carcass specific gravity | 1.0568 | 1.0546 | 1.0525 | 1.0535 | 1.0499 |
| Empty body specific gravity | 1.0507 | 1.0486 | 1.0465 | 1.0475 | 1.0438 |
| Water in empty body, % | 56.27 | 55.58 | 54.90 | 55.20 | 54.00 |
| Fat in empty body, % | 20.79 | 21.62 | 22.49 | 22.16 | 23.62 |
| Protein in empty body, % | 18.45 | 18.33 | 18.18 | 18.19 | 17.99 |
| Fat in empty body, kg. | 84.43 | 87.91 | 90.29 | 88.95 | 98.84 |
| Protein in empty body, kg. | 74.88 | 74.30 | 72.80 | 72.47 | 75.07 |
| Fat energy, kcal. | 790,940 | 823,469 | 845,809 | 833,184 | 925,907 |
| Protein energy, kcal. | 425,793 | 422,505 | 413,954 | 412,085 | 426,881 |
| Final total energy, kcal. | 1,216,733 | 1,245,974 | 1,259,764 | 1,245,270 | 1,352,788 |
| Energy gain, kcal. | 734,381 | 774,221 | 789,126 | 772,959 | 873,225 |

TABLE LX (CONTINUED)

| | | | | | |
|---|---|---|---|---|---|
| Mean test wt., kg. | 321.4 | 319.4 | 316.6 | 316.3 | 327.8 |
| (Mean test wt.)$^{.75}$, kg. | 75.84 | 75.52 | 75.01 | 74.96 | 76.98 |
| Days on feed | 170 | 170 | 170 | 170 | 170 |
| Energy gain/day/$W^{.75}$, kcal. | 56.88 | 60.20 | 61.79 | 60.31 | 66.65 |
| Energy for gain and maint., kcal. | 133.88 | 137.20 | 138.79 | 137.31 | 143.65 |
| Basal consumed/day/$W^{.75}$, kg. | 0.0524 | 0.0518 | 0.0518 | 0.0519 | 0.0523 |
| Basal correction, kcal. | 53.54 | 52.88 | 52.88 | 52.95 | 53.34 |
| Energy from grain/day/$W^{.75}$, kcal. | 80.34 | 84.32 | 85.91 | 84.36 | 90.30 |
| Grain consumed/day/$W^{.75}$, kg. | 0.0639 | 0.0593 | 0.0597 | 0.0567 | 0.0670 |
| $NE_{m+p}$, kcal./kg. | 1265.9 | 1426.2 | 1442.1 | 1499.3 | 1351.3 |

[a]The steps in the procedure are keyed in Table LIX.

[b]Values shown are treatment means.

TABLE LXI

TRIAL II: CALCULATION OF $NE_{m+p}$ OF MILO AND WHEAT[a]

| Item[b] | Milo | Wheat | ½ Milo ½ Wheat |
|---|---|---|---|
| | conventional steam-rolled | | |
| No. steers | 9 | 9 | 9 |
| Initial shrunk wt., kg. | 229.6 | 231.1 | 231.3 |
| Initial empty body wt., kg. | 215.6 | 217.0 | 217.2 |
| Initial energy in empty body, kcal. | 536,201 | 538,708 | 540,292 |
| Final shrunk wt., kg. | 414.3 | 402.9 | 400.2 |
| Reticulo-rumen content, kg. | 13.9 | 15.7 | 14.7 |
| Final empty body wt., kg. | 400.4 | 387.3 | 385.5 |
| Carcass specific gravity | 1.0698 | 1.0700 | 1.0740 |
| Empty body specific gravity | 1.0637 | 1.0639 | 1.0679 |
| Water in empty body, % | 60.48 | 60.53 | 61.81 |
| Fat in empty body, % | 15.91 | 15.90 | 14.45 |
| Protein in empty body, % | 18.98 | 18.95 | 19.09 |
| Fat in empty body, kg. | 63.92 | 62.72 | 56.60 |
| Protein in empty body, kg. | 76.00 | 73.34 | 73.54 |
| Fat energy, kcal. | 598,746 | 587,530 | 530,192 |
| Protein energy, kcal. | 432,132 | 417,012 | 418,192 |
| Final total energy, kcal. | 1,030,878 | 1,004,542 | 948,384 |
| Energy gain, kcal. | 494,677 | 464,834 | 408,092 |

TABLE LXI (CONTINUED)

| | | | |
|---|---|---|---|
| Mean test wt., kg. | 321.9 | 317.0 | 315.8 |
| (Mean test wt.)$^{.75}$, kg. | 75.97 | 75.05 | 74.83 |
| Days on feed | 180 | 181 | 181 |
| Energy gain/day/W$^{.75}$, kcal. | 36.05 | 33.53 | 29.49 |
| Energy for gain and maint., kcal. | 113.05 | 110.53 | 106.49 |
| Basal consumed/day/W$^{.75}$, kg. | 0.0485 | 0.0477 | 0.0473 |
| Basal correction, kcal. | 55.58 | 54.68 | 54.16 |
| Energy from grain/day/W$^{.75}$, kcal. | 57.47 | 55.85 | 52.33 |
| Grain consumed/day/W$^{.75}$, kg. | 0.0405 | 0.0385 | 0.0371 |
| $NE_{m+p}$, kcal./kg. | 1421.6 | 1478.3 | 1448.2 |

[a]The steps in the procedure are keyed in Table LIX.

[b]Values shown are treatment means.

TABLE LXII

TRIAL III: CALCULATION OF $NE_{m+p}$ OF PROCESSED MILO[a]

| Item[b] | Coarsely Ground | Finely Ground | Dry Rolled | Recon.-Rolled | Recon.-Ground | Steam-Process-Flaked |
|---|---|---|---|---|---|---|
| No. steers | 12 | 12 | 11 | 11 | 10 | 11 |
| Initial shrunk wt., kg. | 241.5 | 241.5 | 241.6 | 238.6 | 241.8 | 248.0 |
| Initial empty body wt., kg. | 226.7 | 226.7 | 226.8 | 224.0 | 227.0 | 232.8 |
| Initial energy in empty body, kcal. | 563,717 | 563,717 | 563,956 | 556,786 | 564,243 | 578,774 |
| Final shrunk wt., kg. | 409.1 | 415.8 | 411.1 | 408.7 | 413.9 | 435.5 |
| Reticulo-rumen content, kg. | 13.9 | 12.7 | 16.2 | 14.06 | 16.76 | 16.75 |
| Final empty body wt., kg. | 395.2 | 403.0 | 394.9 | 394.6 | 397.1 | 418.7 |
| Carcass specific gravity | 1.0466 | 1.0447 | 1.0428 | 1.0466 | 1.0466 | 1.0454 |
| Empty body specific gravity | 1.0406 | 1.0387 | 1.0368 | 1.0405 | 1.0406 | 1.0394 |
| Water in empty body, % | 52.92 | 52.28 | 51.66 | 52.91 | 52.93 | 52.52 |
| Fat in empty body, % | 25.07 | 25.91 | 26.75 | 25.06 | 25.04 | 25.61 |
| Protein in empty body, % | 17.69 | 17.53 | 17.36 | 17.72 | 17.71 | 17.59 |
| Fat in empty body, kg. | 99.80 | 105.32 | 106.14 | 99.24 | 99.86 | 107.98 |
| Protein in empty body, kg. | 69.80 | 70.52 | 68.47 | 69.85 | 70.26 | 73.50 |
| Fat energy, kcal. | 934,913 | 986,541 | 994,261 | 929,587 | 935,413 | 1,011,460 |
| Protein energy, kcal. | 396,907 | 401,033 | 389,349 | 397,208 | 399,506 | 417,972 |
| Final total energy, kcal | 1,331,820 | 1,387,574 | 1,383,609 | 1,326,795 | 1,334,919 | 1,429,432 |
| Energy gain, kcal. | 768,103 | 823,857 | 819,654 | 770,009 | 770,676 | 850,658 |

TABLE LXII (CONTINUED)

| | | | | | | |
|---|---|---|---|---|---|---|
| Mean test wt., kg. | 325.3 | 328.7 | 326.4 | 323.6 | 327.8 | 341.7 |
| (Mean test wt.)$^{.75}$, kg. | 76.54 | 77.14 | 76.73 | 76.24 | 77.02 | 79.42 |
| Days on feed | 160 | 160 | 160 | 160 | 160 | 160 |
| Energy gain/day/W$^{.75}$, kcal. | 62.33 | 66.20 | 66.40 | 62.78 | 62.43 | 66.50 |
| Energy for gain and maint., kcal. | 139.33 | 143.20 | 143.40 | 139.78 | 139.43 | 143.50 |
| Premix consumed/day/ W$^{.75}$, kg. | 0.0172 | 0.0169 | 0.0163 | 0.0148 | 0.0164 | 0.0161 |
| Premix correction, kcal. | 14.11 | 13.85 | 13.32 | 12.15 | 13.40 | 13.15 |
| Energy from grain/day/ W$^{.75}$, kcal. | 125.22 | 129.34 | 130.08 | 127.63 | 126.03 | 130.35 |
| Grain consumed/day/ W$^{.75}$, kg. | 0.0840 | 0.0824 | 0.0794 | 0.0724 | 0.0796 | 0.0783 |
| $NE_{m+p}$, kcal./kg. | 1502.3 | 1576.3 | 1644.7 | 1771.2 | 1586.7 | 1673.2 |

[a]The steps in the procedure are keyed in Table LIX.

[b]Values shown are treatment means.

TABLE LXIII

TRIAL IV: CALCULATION OF $NE_{m+p}$ OF PROCESSED MILO[a]

| Item[b] | Coarsely Ground | Finely Ground | Recon.-Rolled | Steam-Process-Flaked |
|---|---|---|---|---|
| No. steers | 8 | 9 | 8 | 10 |
| Initial shrunk wt., kg. | 235.3 | 237.1 | 236.4 | 233.8 |
| Initial empty body wt., kg. | 220.9 | 222.6 | 222.0 | 219.6 |
| Initial energy in empty body, kcal. | 549,257 | 553,493 | 551,886 | 545,839 |
| Final shrunk wt., kg. | 393.2 | 373.3 | 380.4 | 378.1 |
| Reticulo-rumen content, kg. | 17.16 | 14.40 | 17.71 | 17.42 |
| Final empty body wt., kg. | 376.0 | 358.9 | 362.7 | 360.6 |
| Carcass specific gravity | 1.0636 | 1.0672 | 1.0651 | 1.0668 |
| Empty body specific gravity | 1.0575 | 1.0611 | 1.0590 | 1.0607 |
| Water in empty body, % | 58.49 | 59.62 | 58.97 | 59.49 |
| Fat in empty body, % | 18.15 | 16.90 | 17.61 | 17.06 |
| Protein in empty body, % | 18.79 | 18.88 | 18.83 | 18.85 |
| Fat in empty body, kg. | 68.37 | 61.20 | 64.07 | 61.91 |
| Protein in empty body, kg. | 70.64 | 67.73 | 68.28 | 67.97 |
| Fat energy, kcal. | 640,525 | 573,307 | 600,158 | 579,976 |
| Protein energy, kcal. | 401,676 | 385,115 | 388,251 | 386,505 |
| Final total energy, kcal. | 1,042,201 | 958,422 | 988,409 | 966,480 |
| Energy gain, kcal. | 492,943 | 404,929 | 436,523 | 420,641 |

TABLE LXIII (CONTINUED)

| | | | | |
|---|---|---|---|---|
| Mean test wt., kg. | 314.2 | 305.2 | 308.4 | 306.0 |
| (Mean test wt.)$^{.75}$, kg. | 74.60 | 72.94 | 73.57 | 73.12 |
| Days on feed | 166 | 166 | 166 | 166 |
| Energy gain/day/$W^{.75}$, kcal. | 39.70 | 33.18 | 35.69 | 34.40 |
| Energy for gain and maint., kcal. | 116.70 | 110.18 | 112.69 | 111.40 |
| Basal consumed/day/$W^{.75}$, kg. | 0.0477 | 0.0476 | 0.0477 | 0.0472 |
| Basal correction, kcal. | 53.88 | 53.80 | 53.96 | 53.42 |
| Energy from grain/day/$W^{.75}$, kcal. | 62.82 | 56.38 | 58.73 | 57.99 |
| Grain consumed,/day,$W^{.75}$, kg. | 0.0411 | 0.0388 | 0.0350 | 0.0424 |
| $NE_{m+p}$, kcal./kg. | 1536.1 | 1461.1 | 1674.8 | 1378.8 |

[a]The steps in the procedure are keyed in Table LIX.

[b]Values shown are treatment means.

TABLE LXIV

TRIAL I: CALCULATION OF $NE_p$ OF PROCESSED MILO

| Item[a] | Coarsely Ground | Finely Ground | Recon.-Rolled | Recon.-Steam-Process-Flaked | Steam-Process-Flaked |
|---|---|---|---|---|---|
| Energy gain, kcal. | 56.88 | 60.20 | 61.79 | 60.31 | 66.65 |
| Energy gain attributed to grain[b] | 64.18 | 67.50 | 69.09 | 67.61 | 73.95 |
| Grain consumed, kg. | 0.0639 | 0.0593 | 0.0597 | 0.0567 | 0.0670 |
| $NE_p$ of grain, kcal./kg.[c] | 1009.1 | 1141.4 | 1159.0 | 1200.1 | 1105.6 |
| Energy from basal for maint., kcal.[d] | 70.96 | 70.08 | 70.09 | 70.18 | 70.70 |
| Grain used for maint., kg.[e] | 0.0035 | 0.0040 | 0.0040 | 0.0039 | 0.0036 |
| Grain available for gain, kg.[f] | 0.0604 | 0.0553 | 0.0557 | 0.0528 | 0.0634 |
| $NE_p$ of grain, kcal./kg.[g] | 954.8 | 1096.1 | 1114.8 | 1165.3 | 1058.0 |

[a]All intermediate values are on a per day per kg. $W^{.75}$ basis. All values shown are treatment means.

[b]Energy gain + (7.30 = av. energy loss of basal steers).

[c]$\frac{\text{Energy gain attributed to grain}}{\text{Grain consumed}}$

[d]Basal consumed X(1352 = estimated $NE_m$ of basal, kcal./kg.).

[e]$\frac{(77 = \text{maint. req.}) - \text{energy from basal}}{1720 = \text{estimated } NE_m \text{ of milo}}$

[f]Grain consumed - grain used for maint.

[g]$\frac{\text{Energy gain}}{\text{Grain available for gain}}$

TABLE LXV

TRIAL II: CALCULATION OF $NE_p$ OF MILO AND WHEAT

| Item[a] | Milo | Wheat | ½milo ½wheat |
|---|---|---|---|
| | conventional steam-rolled | | |
| Energy gain, kcal. | 36.05 | 33.53 | 29.49 |
| Energy gain attributed to grain[b] | 46.08 | 43.56 | 39.52 |
| Grain consumed, kg. | 0.0405 | 0.0385 | 0.0371 |
| $NE_p$ of grain, kcal./kg.[c] | 1136.8 | 1112.5 | 1057.3 |
| Energy from basal for maint., kcal.[d] | 68.18 | 67.08 | 66.44 |
| Grain used for maint., kg.[e] | 0.0051 | 0.0057 | 0.0061 |
| Grain available for gain, kg.[f] | 0.0354 | 0.0328 | 0.0310 |
| $NE_p$ of grain, kcal./kg.[g] | 1017.5 | 996.5 | 925.8 |

[a] All intermediate values are on a per day per kg. $W^{.75}$ basis. All values shown are treatment means.

[b] Energy gain + (10.03 = av. energy loss of basal steers).

[c] $\frac{\text{Energy gain attributed to grain}}{\text{Grain consumed}}$

[d] Basal consumed X (1404 = estimated $NE_m$ of basal, kcal./kg.).

[e] $\frac{(77 = \text{maint. req.}) - \text{energy from basal}}{1720 = \text{estimated } NE_m \text{ of milo}}$

[f] Grain consumed − grain used for maint.

[g] $\frac{\text{Energy gain}}{\text{Grain available for gain}}$

TABLE LXVI

TRIAL III: CALCULATION OF $NE_p$ OF PROCESSED MILO

| Item[a] | Coarsely Ground | Finely Ground | Dry Rolled | Recon.-Rolled | Recon.-Ground | Steam-Process-Flaked |
|---|---|---|---|---|---|---|
| Energy gain, kcal. | 62.33 | 66.20 | 66.40 | 62.78 | 62.43 | 66.50 |
| Energy gain attributed to grain, kcal.[b] | 51.98 | 55.20 | 55.37 | 52.35 | 52.06 | 55.46 |
| Grain consumed, kg. | 0.084 | 0.082 | 0.079 | 0.072 | 0.080 | 0.078 |
| Maint. req. met by grain, kcal.[c] | 64.22 | 64.22 | 64.22 | 64.22 | 64.22 | 64.22 |
| Grain used for maint., kg.[d] | 0.037 | 0.037 | 0.037 | 0.037 | 0.037 | 0.037 |
| Grain available for gain, kg.[e] | 0.046 | 0.045 | 0.042 | 0.035 | 0.042 | 0.041 |
| $NE_p$ of grain, kcal./kg.[f] | 1143.4 | 1243.4 | 1335.4 | 1525.1 | 1242.7 | 1379.2 |

[a]All intermediate values are on a per day per kg. $W^{.75}$ basis. All values shown are treatment means.

[b]Energy gain X (0.834 = % milo in ration).

[c](77=maint. req.) X (0.834 = % milo in ration).

[d]$\frac{\text{Maint. req. met by grain, kcal.}}{1720 = \text{estimated } NE_m \text{ of milo}}$

[e]Grain consumed - grain used for maint.

[f]$\frac{\text{Energy gain attributed to grain, kcal.}}{\text{Grain available for gain, kg.}}$

TABLE LXVII

TRIAL IV: CALCULATION OF $NE_p$ OF PROCESSED MILO

| Item[a] | Coarsely Ground | Finely Ground | Dry Rolled | Steam-Process-Flaked |
|---|---|---|---|---|
| Energy gain, kcal. | 39.70 | 33.18 | 35.69 | 34.40 |
| Energy gain attributed to grain[b] | 48.37 | 41.85 | 44.36 | 43.07 |
| Grain consumed, kg. | 0.0411 | 0.0388 | 0.0350 | 0.0424 |
| $NE_p$ of grain, kcal./kg.[c] | 1181.8 | 1078.5 | 1260.3 | 1024.0 |
| Energy from basal for maint., kcal.[d] | 66.42 | 66.32 | 66.52 | 65.85 |
| Grain used for maint., kg.[e] | 0.0061 | 0.0062 | 0.0061 | 0.0065 |
| Grain available for gain, kg.[f] | 0.0350 | 0.0326 | 0.0289 | 0.0360 |
| $NE_p$ of grain, kcal./kg.[g] | 1142.8 | 1022.5 | 1226.2 | 977.4 |

[a]All intermediate values are on a per day per kg. $W^{.75}$ basis. All values shown are treatment means.

[b]Energy gain +(8.67 = av. energy loss of basal steers).

[c]$\frac{\text{Energy gain attributed to grain}}{\text{Grain consumed}}$

[d]Basal consumed X(1393 = estimated $NE_m$ of basal, kcal./kg.).

[e]$\frac{\text{(77 = maint. req.) - energy from basal}}{\text{1720 = estimated } NE_m \text{ of milo}}$

[f]Grain consumed - grain used for maint.

[g]$\frac{\text{Energy gain}}{\text{Grain available for gain}}$

TABLE LXVIII

CORRELATIONS OF $NE_p$ AND FEED EFFICIENCY[a]

| $NE_p$ correlated with: | Trial I | Trial II | Trial III | Trial IV | Overall |
|---|---|---|---|---|---|
| No. steers | 45 | 27 | 67 | 35 | 174 |
| Total ration/kg. LSW gain[b] | -.68[d] | -.61[d] | -.83[d] | -.60[d] | -.69[d] |
| Grain/kg. LSW gain[b] | -.71[d] | -.01 | -.83[d] | -.63[d] | -.03 |
| Total/ration/kg. EBW gain[c] | -.68[d] | -.61[d] | -.85[d] | -.57[d] | -.70[d] |
| Grain/kg. EBW gain[c] | -.71[d] | -.01 | -.85[d] | -.59[d] | -.01 |

[a]Simple correlations

[b]Gain calculated on live shrunk wt. basis.

[c]Gain calculated on empty body wt. basis.

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

VITA

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