EFFECTS OF LEVELS AND SOURCES OF PROTEIN ON PERFORMANCE AND CARCASS CHARACTERISTICS OF STEERS FED ALL-CONCENTRATE RATIONS

by

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INTRODUCTION

The development of large-scale commercial cattle feeding has been accompanied by a distinct trend toward the use of high-energy rations. A number of factors have been responsible for this trend. First, the increased demand for cattle finished at lighter weights has made it advantageous to use high-energy rations. Second, most commercial feedlots have attempted to mechanize their feed processing and handling facilities. Although roughage handling can be mechanized, it is often expensive to do so. The third and most important factor is the relative cost of nutrients in roughage and concentrates.

All-concentrate rations based upon various cereal grains have been successfully fed to cattle during the past few years. In general, the removal of roughage from these rations results in reduced feed intake with similar weight gains and an improvement in feed efficiency. The percentage of protein present in the ration may also be increased by removing roughages of low protein content. The level of protein necessary to meet the requirements of steers finished on all-concentrate rations has not been extensively studied. Suitability of various sources of protein in this type of ration also needs further investigation. In instances where the protein content of the concentrate is relatively high, supplemental protein may not be necessary to meet the requirements of steers fed all-concentrate rations.

This research was conducted to determine the effects of levels and sources of protein on performance and carcass characteristics of steers finished on all-concentrate rations. The experimental rations were: milo alone, milo plus 1% urea, or milo plus soybean meal isonitrogenous to 1% urea.

REVIEW OF LITERATURE

All-Concentrate Rations

Meade and Regan (1931) successfully reared dairy calves on rations devoid of roughage by the addition of codliver oil and alfalfa ash. They were among the first workers to conclude that calves could be reared to 19 months of age and that normal growth could be secured on a ration containing no roughage, provided codliver oil and alfalfa ash were supplied. They considered a lack of vitamin A, alone or in conjunction with an inadequate supply of certain minerals, to be the limiting factor in earlier research in this area.

Much of the early research with all-concentrate rations has dealt with the supplementation of barley, primarily because the seed coat is highly fibrous. More recently, success with grains other than barley have been reported.

Pope et al. (1963) observed that cattle fattened on all-concentrate rations based on steam-rolled milo gained as rapidly as those fed conventional rations with 25% cottonseed hulls. Cattle fattened on the all-concentrate diet were the most efficient and had a higher dressing percentage.

Brethour and Duitsman (1964) compared a conventional milo-silage ration with an all-milo ration supplemented with minerals and vitamins. The cattle receiving the all-concentrate ration gained slightly faster, consumed less feed and were the most efficient.

Ellis (1965) summarized the results of 27 trials involving approximately 3,330 cattle. Average daily gain, average daily feed intake and feed efficiency respectively for the all-concentrate rations were 1.20 kg, 8.67 kg, and 7.24 kg compared to 1.15 kg, 10.16 kg, and 8.82 kg for the

part roughage rations.

Montgomery and Baumgardt (1965) fed pelleted rations to Holstein heifers and crossbred lambs consisting of the following alfalfa meal: ground shelled corn ratios--100:0, 80:20, 60:40, and 40:60. Dry matter and gross energy digestibility increased as the percent corn was increased in the diet. Dry matter consumption decreased as the corn increased, and daily energy consumption was similar for all rations. No significant differences existed in average daily gains or carcass characteristics. Similar results have been reported by Brent et al. (1961) with pelleted sorghum grain and alfalfa hay rations. Results of these trials support the hypothesis that ruminants will adjust voluntary food intake in relation to physiological demand for energy if fill or rumen load does not limit their consumption.

An excellent review by Wise et al. (1968) comparing performance of cattle fed all-concentrate diets with those fed conventional low roughage diets indicated that rate of gain was essentially equal, feed consumption was markedly lower on the all-concentrate rations, and less feed per unit of gain was required when roughage was excluded. Carcass characteristics were similar for both types of rations. Liver abscesses were more prevalent on all-concentrate rations; however, when aureomycin was fed at the rate of 75 to 85 mg per day the number of liver abscesses was reduced to a level comparable to conventional rations.

Digestibility of Milo

Brethour and Duitsman (1964) compared all-barley and all-corn rations with all-milo rations. Feed required per pound of grain for the barley and corn rations was reduced 9 and 11%, respectively, when compared to the

milo ration. Pelleting the all-milo ration reduced feed intake, rate of gain and feed efficiency.

Saba et al. (1964) observed that digestibility of dry matter, protein, gross energy and nitrogen free extract was significantly greater for all-barley rations than for all-milo rations. Gains on the two rations were comparable but feed required per pound of gain was significantly less on the barley ration. Feed intake was greater on the milo ration indicating that the lower performance was not due to palatability.

Keating et al. (1965) fed all-concentrate milo and barley rations to sheep. The lambs on the milo ration produced higher daily gains with improved feed efficiency. The digestion of ether extract, crude fiber, starch, nitrogen free extract and gross energy was significantly greater for the lambs receiving the milo ration. The superiority of milo over barley for lambs is in contrast to the findings for cattle and suggests that the digestibility values for lambs and cattle are not interchangeable for high grain rations.

Oltjen et al. (1967) conducted metabolism and plasma amino acid studies with steers fed corn, wheat, barley and milo all-concentrate rations. Digestibility of dry matter, crude protein, urinary nitrogen loss and nitrogen retention were all significantly lower when steers were fed the milo ration. Blood plasma urea levels were directly related to the crude protein content of the rations. Milo which had the lowest crude protein also had the lowest plasma urea level. Dietary amino acid intake could not be related to plasma amino acid concentrations indicating that the resulting plasma amino acid pattern 16 hours after feeding were probably a reflection of the hydrolyzed microbial protein.

Level of Protein

Jones and Hogue (1960) studied the responses of lambs fed different levels of protein and energy. The net energy and protein levels were set at 90 and 120% of the minimal recommendations. Lambs on the high energy-low protein rations consumed 78.6% of the expected amount of net energy, gained slower and were the least efficient. Feed consumption was highest for the low energy-high protein rations. As the energy level was increased, it was also necessary to increase the protein level to maintain feed consumption and growth rate of lambs. These findings are similar to those reported by Rea and Ross (1960).

Goodrich et al. (1961) fed conventional cattle fattening rations composed of 20% brome grass hay and 80% rolled shelled corn with soybean meal added to bring the protein levels to 9.5, 10.6, 12.0 and 12.7%. Average daily gain and pounds of feed per 100 pounds of gain for the respective protein levels were: 2.42, 925; 2.55, 878; 2.46, 885, and 2.39, 903. The 10.6% crude protein ration produced the fastest rate of gain and best feed efficiency. Similar findings on the same type of rations were reported by Weichenthal et al. (1963).

Bond et al. (1962) fed high energy beef cattle rations containing two protein levels. Animals on higher protein or protein equivalent rations (13%) gained faster, more efficiently, and consumed more feed than when on a low protein diet (5%). Consumption of rations intended to be high-energy and low protein was very low indicating an effect of protein level on voluntary feed intake.

Hale et al. (1963) observed that as the protein level in high milo rations was increased from 11% to 14% by the addition of cottonseed meal,

feed efficiency was improved (888 lb vs. 869 lb) but rate of gain was essentially the same.

Saba et al. (1964) compared 11 and 14% crude protein high milo fattening rations supplemented with milo gluten meal. The protein level had no significant effect on any of the measures of performance; however, the higher level apparently reduced feed intake.

Mc Ginty et al. (1966) compared a 9.8% crude protein all-milo ration containing no supplemental protein with all-milo rations supplemented with cottonseed, cottonseed meal or urea to increase the crude protein content to 11.9%. Animals receiving the ration supplemented with cottonseed made significantly greater gains than did animals fed the other three rations. This increase in response could be due to the increased energy provided by the cottonseed. Feed intake and rate of gain were slightly lower on the 9.8% protein ration but did not differ significantly from 11.9% protein urea and cottonseed meal supplemented rations. Animals on the lower protein level tended to be higher in dressing percent, marbling score and carcass grade.

Research conducted by Haskins et al. (1967) indicates that a level higher than 11% is necessary for maximum gains in steers fed all-concentrate rations. In comparing 11% and 14% crude protein corn rations supplemented with urea or soybean meal, a significant increase in average daily gain was observed for those steers receiving the higher protein level. The level or source of supplemental nitrogen did not appear to be associated with rumen parakeratosis or liver abscesses.

Oltjen et al. (1967) reported that the addition of 1% urea to an all-corn ration resulted in a marked increase in digestibility of dry matter and crude protein. Nitrogen retention was doubled. The addition of 1%

urea to an all-milo ration had little effect on digestibility of dry matter, caused a marked increase in urinary nitrogen loss and no improvement in nitrogen retention. The addition of urea resulted in a significant increase in blood urea concentrations. It would appear that the corn protein (zein) is slowly degraded in the rumen (Mc Donald, 1954) and that a readily available nitrogen source such as urea is beneficial in rations of this type.

Putnam et al. (1969) removed the supplemental protein from all-concentrate corn rations during the last half of the finishing period. They concluded that finishing rations containing 8 to 9% crude protein are adequate from 360 kg to slaughter weight.

Urea and Soybean Meal as Sources of Supplemental Protein in All-Concentrate Rations

There is a definite relationship between the utlization of urea by ruminants and the amount of readily available energy in the ration. It has been shown by Oltjen et al. (1962) that ruminants perform well while obtaining 100% of their dietary nitrogen from urea, when readily available carbohydrates made up 90% of the ration.

Results of Oltjen et al. (1965) indicate similar performance of steers fed all-concentrate rations when either soybean meal or urea supplied approximately 30% of the total nitrogen in the ration. The same study by Oltjen and Davis (1965) reported in a subsequent paper indicated cattle receiving the soybean meal ration had significantly greater molar percentage of acetate and a wider acetate to propionate ratio than steers receiving the urea containing rations. The ruminal epithelium was darker and there was more clumping of the papillae in the rumen of steers fed the soybean meal ration.

Durham et al. (1966) found that 9 mg of aureomycin per kg of feed fed in conjunction with urea in all-milo rations had a depressing effect on average daily gain and feed efficiency. This trend suggests the microorganisms which incorporate urea into protein have their activity impaired by the antibiotic. Similar results were obtained by Bolsen et al. (1968) when aureomycin was supplied at the rate of 44 mg per kg of diet.

Oltjen and Putnam (1966) fed steers purified diets with urea and isolated soy protein. Nitrogen retention was lowest on the urea diet, being only 64% of that obtained with isolated soy protein. The longer the steers remained on the urea diets, the greater the nitrogen retention and the less the urinary excretion, indicating an adaptation period. Plasma amino acid concentration was similar for both nitrogen sources but the amounts of the individual amino acids were widely different. Using the value of 100 for each amino acid in the plasma when steers were fed soy protein, the relative values on urea were: serine 130, glycine 142, valine 71, isoleucine 82, leucine 70, and phenylalanine 76. They suggest insufficient quantities of branched chain volatile fatty acids were synthesized in the rumen causing low blood plasma concentrations of valine, isoleucine, leucine and phenylalanine. This depressed nitrogen retention and tissue growth on the urea diets.

Haskins et al. (1967) fed steers ground shelled corn rations supplemented with 1% urea or soybean meal at an isonitrogenous level. Gains made by steers consuming different sources of protein were not significantly different, but there was a tendency for steers consuming rations containing soybean meal to gain slightly faster than those fed urea. Feed consumption was slightly lower on the urea supplemented ration but favorable feed

conversion rates were obtained from both sources. Similar results on the same type of ration have been reported by Wise et al. (1965) but feed efficiency favored the urea supplemented ration.

Mc Cartor and Tillman (1967) compared 12% crude protein iso-nitrogenous all-milo rations supplemented with urea or cottonseed meal. Differences in feed consumption, daily gain and feed efficiency were not significant. Neither diet was improved by the addition of dehydrated alfalfa meal indicating that urea can serve as the only source of supplemental nitrogen in all-milo rations if the diet is properly supplemented with minerals and vitamins. Aureomycin supplied at the rate of 7.7 mg per kg of feed did not have any apparent depressing effect on the utilization of urea.

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EFFECTS OF LEVELS AND SOURCES OF PROTEIN ON PERFORMANCE AND CARCASS CHARACTERISTICS OF STEERS FED ALL-CONCENTRATE RATIONS

All-concentrate rations based upon various cereal grains have been successfully fed to cattle. Removal of roughage results in similar weight gains with reduced feed intake and improved feed efficiency. Ration protein may also be increased by removing low protein roughages. The protein requirements of steers finished on all-concentrate rations has not been extensively studied. Goodrich, Gastler and Whetzal (1961) and Weichenthal et al. (1963) have shown that cattle fattened on conventional rations require no more than 11% protein. However, Haskins et al. (1967) found that more than 11% crude protein is necessary for maximum gains on all-concentrate rations. Putnam, Oltjen and Bond (1969) concluded that all-concentrate rations containing 8 to 9% crude protein are adequate from 360 kg to slaughter weight.

Suitability of various sources of protein in this type of ration also needs further investigation. Results of Oltjen, Davis and Hiner (1965) and Haskins et al. (1967) indicate similar performance of steers fed all-concentrate rations containing supplemental protein from either urea or soybean meal. Durham, Ellis and Albin (1966) and Bolsen et al. (1967) have indicated that chlorotetracycline fed with urea depressed average daily gain and feed efficiency.

The research reported here was designed to determine the effects of levels and sources of protein on performance and carcass characteristics of steers fed all-concentrate milo rations.

Experimental Procedure

Trial 1. Twelve Hereford steer calves averaging 266 kg were fed ad libitum a pre-experimental ration composed of 60% dehydrated alfalfa crumbles and 40% ground milo with limited amounts of prairie hay fed seperately. Over a 3 week period the alfalfa crumbles and prairie hay were eliminated. After the 3 week transition period, the animals were randomly divided into two groups of similar weight. Two animals from each group were randomly selected to receive one of the three diets shown in table 1. The animals were individually fed ad libitum. Orts were weighed back and fresh feed was added to the containers daily. Water was available at all times. Steers were individually weighed and beginning and ending weights were the means of weights on 2 consecutive days. They were individually weighed at 28 day intervals during the test.

During the 155 day feeding trial, each animal was subjected to a digestion and nitrogen balance study of the ration he consumed. Two studies were conducted and one heavy steer and one light steer from each treatment was subjected to each. The first study consisted of a 3-day adjustment period followed by a 5-day collection period. At the end of the first study, the two remaining steers from each treatment were transfered to the metabolism stalls for a 3-day adjustment period followed by an 8-day collection period. Feed intake was limited to 80% of the steer's normal consumption in the first study and 1½% of their body weight in the second study. Excreta were collected once per day. Five percent aliquots of feces and urine were obtained for chemical analysis. Fifteen ml of 50% sulfuric acid and 15 ml of tolulene were added to each urine collection container daily to prevent ammonia loss. Fecal aliquots were frozen prior

TABLE 1. PERCENTAGE COMPOSITION AND CRUDE PROTEIN ANALYSIS OF EXPERIMENTAL RATIONS

Item	Ration		
	All-Milo	Milo+Urea	Milo+SBM
Ingredient, %			
Ground milo	97.25	96.25	90.50
Urea	....	1.00	....
Soybean meal	....	....	6.75
Salt	0.25	0.25	0.25
Premix			
ground limestone	1.00	1.00	1.00
trace mineral premix[a]	0.05	0.05	0.05
stilbesterol premix[b]	0.05	0.05	0.05
vitamin A premix[c]	0.02	0.02	0.02
chlorotetracycline premix[d]	0.04	0.04	0.04
fine ground milo	1.34	1.34	1.34
Percent protein (88% DM basis)			
Trial 1	9.55	11.77	11.91
Trial 2	8.40	10.70	10.91
Trial 3	10.42	13.02	12.94

[a] Percentage of indicated elements in trace miner premix: manganese, 4.4; iron, 6.6; copper, 1.32; cobalt, 0.23; iodine, 0.30; zinc, 5; magnesium, 20; sulfur, 2.70.
[b] Contains 2.2 g stilbestrol per kg.
[c] Contains 10,000 IU per g.
[d] Contains 22 g chlorotetracycline per kg.

to analysis. Feces were dried to a constant weight at 60 deg C. Feed and feces were ground in a Wiley mill and subjected to proximate analysis (A.O.A.C., 1960) and oxygen bomb calorimetry. Urine nitrogen was determined by the Kjeldahl method (A.O.A.C., 1960).

At the termination of the feeding trial, the steers were weighed and transported 109 km to a slaughter plant where carcass grades and hot carcass weights were determined. The left side of each carcass was seperated between the 12th and 13th rib and rib-eye area and fat thickness were measured without adjustment as proposed by U.S.D.A. (1965). A representative of the U.S.D.A.

Meat Grading Service graded the carcasses, assigned marbling scores, and estimated the percent kidney knob.

Feedlot, metabolism, and carcass data were subjected to analysis of variance (Snedecor, 1956), and the means were tested for significance by Duncan's multiple range test (Kramer, 1956).

Trial 2. Thirty-five Hereford steers averaging 305 kg were removed from bluestem pasture and fed ad libitum a pre-experimental ration composed of 60% dehydrated alfalfa crumbles and 40% ground milo. The alfalfa crumbles were gradually eliminated until, at the end of a 3 week period, the steers were consuming an all-milo ration. The steers were divided into three groups by weight, each group to receive one of the rations shown in table 1. Four steers from each group were picked at random to be individually fed; the remaining steers were group fed. All animals received feed and water ad libitum. Rations in trial 1 differ from trial 2 in that the premix of the latter was pelleted and then crumbled to obtain a better mix with the ground milo. Weighing procedures for this 100 day finishing trial were the same as in trial 1. At the termination of the trial, the steers were transported 109 km to a slaughter plant and carcass data were collected.

Feedlot and carcass data were subjected to analysis of variance for statistical evaluation (Snedecor, 1956).

Trial 3. Six Hereford yearling steers averaging 295 kg were selected on a weight basis for further digestion and nitrogen balance studies on the rations shown in table 1. Twenty-one days were required to change the cattle to an all-concentrate diet, the same procedure being used as in trial 2. During the transition period, the steers were transferred to metabolism stalls for a 7-day preliminary adjustment period. Animals and diets were arranged in a replicated 3 X 3 Latin square (Cochran and Cox, 1957). The steers were

fed their respective rations for a 14-day preliminary period followed by a 7-day collection period. Feed intake was limited to 2% of the steer's bodyweight and remained the same for each animal during each period. The same collection and analysis procedures were used as in trial 1.

Data were subjected to analysis of variance for Latin square design (Snedecor, 1956), and means were tested for significance by Duncan's multiple range test (Kramer, 1956).

Results

Trial 1. Means of performance and carcass data are presented in table 2. Steers consuming the 9.55% crude protein all-milo ration gained 0.18 kg less per day than steers consuming the 11.80% protein rations supplemented with urea or soybean meal ($P<.05$). Feed conversion was most efficient on the soybean meal supplemented ration and least efficient on the all-milo ration ($P<.10$). Steers tended to consume more of the higher protein rations. Carcass characteristics were significantly influenced by protein levels. Differences due to protein sources were not apparent. Steers fed the all-milo ration graded lower and had smaller rib-eye areas than steers fed the urea supplemented ration ($P<.10$). Marbling scores were greatest in steers fed the urea supplemented ration and lowest in those fed the all-milo ration ($P<.05$).

Results of the digestion and nitrogen balance study are presented in table 3. Nitrogen free extract digestibility was lower ($P<.05$) for the all-milo ration as was total digestible nutrient, dry matter, and energy digestibility ($P<.10$). Lower crude fiber digestion was observed for the urea supplemented ration ($P<.10$). Differences in nitrogen balance and nitrogen retention were not significant, but certain trends were apparent. Urinary nitrogen excretion was lowest for the all-milo ration and highest for the

TABLE 2. MEANS AND STANDARD ERRORS OF PERFORMANCE AND CARCASS TRAITS OF STEERS FED ALL-CONCENTRATE RATIONS CONTAINING DIFFERENT LEVELS AND SOURCES OF PROTEIN (TRIAL 1)

Item	Ration		
	All-Milo	Milo+Urea	Milo+SBM
	Feedlot data		
No. steers	4	4	4
Avg initial wt, kg	261 ±13.42	281 ±16.98	257 ±14.54
Avg final wt, kg	443 ±22.73	491 ±21.78	468 ±16.58
Avg daily gain, kg*	1.18 ± 0.06[a]	1.36 ± 0.04[b]	1.36 ± 0.05[b]
Avg daily feed intake, kg	8.11 ± 0.23	8.66 ± 0.14	8.42 ± 0.21
Avg kg feed/kg gain[c]	6.89 ± 0.23	6.37 ± 0.17	6.19 ± 0.15
	Carcass data		
Avg hot carcass wt, kg	254 ±15.47	293 ± 9.75	279 ±10.89
Avg rib-eye area, cm^2[c]	64.47 ± 3.69	75.53 ± 1.85	72.48 ± 3.69
Avg rib-eye area/100 kg hot carcass wt, cm^2	25.36 ± 1.45	25.66 ± 0.63	26.03 ± 1.32
Avg fat over rib-eye, mm	10.92 ± 0.31	14.20 ± 1.45	14.00 ± 1.87
Avg carcass grade[dc]	9.50 ± 0.50	12.00 ± 0.91	10.75 ± 0.25
Avg yield grade[e]	2.93 ± 0.14	3.05 ± 0.15	3.06 ± 0.23
Avg marbling score[f]*	13.75 ± 0.20[a]	22.00 ± 1.04[b]	17.25 ± 0.85

* F-ratio from analysis of variance indicated significance at $P<.05$.

a,b Any mean in same row with a different subscript is significantly different ($P<.05$).

c F-ratio from analysis of variance indicated significance at P .10.

d High good=9; low choice=10.

e Most desirable=1; least desirable=5.

f Slight=11; slightly abundant=22.

TABLE 3. MEANS AND STANDARD ERRORS OF APPARENT DIGESTIBILITY AND NITROGEN BALANCE OF STEERS FED ALL-CONCENTRATE RATIONS CONTAINING DIFFERENT LEVELS AND SOURCES OF PROTEIN (TRIAL 1)

Item	Ration		
	All-Milo	Milo+Urea	Milo+SBM
Digestibility[a]			
Dry matter	80.1[b] ±2.6	85.2 ±0.5	85.6 ±1.4
Ether extract	79.8 ±3.7	75.9 ±3.2	82.1 ±2.4
Crude fiber[c]	60.1 ±4.7	48.3 ±1.9	61.3 ±4.3
Protein	64.8 ±2.4	69.9 ±1.7	71.9 ±3.4
Nitrogen free extract*	83.3 ±2.5[d]	90.1 ±0.5[e]	89.6 ±1.0[e]
Total digestible nutrients[c]	80.6 ±2.5	86.0 ±0.5	86.4 ±1.3
Energy	76.9 ±2.9	82.5 ±0.6	82.8 ±1.6
Nitrogen balance[a]			
Fecal	35.2 ±2.4	29.3 ±1.4	28.2 ±3.7
Urinary	27.2 ±3.2	43.4 ±10.6	33.5 ±5.4
Retention	37.6 ±3.9	27.3 ±10.8	38.3 ±8.7
Nitrogen retained[f]	20.7 ±1.9	24.4 ±10.0	34.7 ±12.6

[a] Percent of intake.
[b] Each value is the mean of 4 observations.
[c] F-ratio from analysis of variance indicated significance at $P<.10$.
* F-ratio from analysis of variance indicated significance at $P<.05$.
[d,e] Any mean in same row with a different subscript is significantly different ($P<.05$).
[f] Grams per day.

urea supplemented ration. Daily nitrogen retention was similar for the all-milo and urea supplemented rations but higher for the soybean meal supplemented ration.

Trial 2. Performance and carcass data are presented in table 4. There were no significant differences among rations, however, several trends were apparent. Feed consumption was lowest on the soybean meal supplemented ration and highest on the all-milo ration. Feed conversion was most efficient on the soybean meal based ration and least efficient on the all-milo ration. Average daily gain was nearly equal for all treatments. Differences in carcass characteristics were not evident.

Trial 3. Nitrogen balance and digestion coefficients are presented in table 5. Protein digestibility was lowest for the all-milo ration ($P<.001$). Total digestible nutrients were lower ($P<.10$) and digestibility of dry matter, nitrogen free extract and energy tended to be lower on the all-milo ration. Percent consumed nitrogen that appeared in the feces was significantly greater for the all-milo ration ($P<.01$). Steers on the urea supplemented ration had the greatest urinary nitrogen excretion while those on the all-milo ration had the lowest ($P<.01$). Steers on the soybean meal supplemented ration tended to retain more nitrogen per day than steers on the urea supplemented or all-milo rations.

Discussion

According to the National Research Council requirements (Burroughs et al., 1963) a 327 kg fattening steer needs 0.91 to 1.00 kg of total protein per day. A total feed intake of 9.53 kg per day of the 9.55% crude protein all-milo ration in trial 1 was necessary to meet these requirements. The observed daily feed intake of 8.11 kg supplied the steers with 0.77 kg of total protein.

TABLE 4. MEANS AND STANDARD ERRORS OF PERFORMANCE AND CARCASS TRAITS OF STEERS FED ALL-CONCENTRATE RATIONS CONTAINING DIFFERENT LEVELS AND SOURCES OF PROTEIN (TRIAL 2)

Item	Ration		
	All-Milo	Milo+Urea	Milo+SBM
	Feedlot data		
No. steers	11	12	12
Avg initial wt, kg	309 ± 8.05	302 ± 6.97	303 ± 7.41
Avg final wt, kg	470 ± 8.88	463 ±10.02	466 ±10.40
Avg daily gain, kg	1.61 ± 0.03	1.61 ± 0.07	1.63 ± 0.05
Avg daily feed intake, kg[a]	11.21 ± 0.22	10.80 ± 0.51	10.19 ± 0.74
Avg kg feed/kg gain[a]	6.96 ± 0.22	6.72 ± 0.39	6.27 ± 0.20
	Carcass data		
Avg hot carcass wt, kg	271 ± 4.98	270 ± 5.67	269 ± 6.24
Avg rib-eye area, cm^2	71.15 ± 2.18	73.13 ± 2.07	70.80 ± 1.93
Avg fat over rib-eye, mm	15.50 ± 1.43	14.60 ± 0.99	13.50 ± 1.37
Avg carcass grade[b]	9.54 ± 0.25	9.50 ± 0.15	9.50 ± 0.19
Avg yield grade[c]	2.81 ± 0.18	2.83 ± 0.11	2.84 ± 0.17
Avg marbling score[d]	13.54 ± 0.89	12.83 ± 0.44	12.83 ± 0.49

[a] Standard errors were calculated using the data from the 4 individually fed steers and the means of the group fed steers.
[b] High good=9; low choice=10.
[c] Most desirable=1; least desirable=5.
[d] Slight=11; small=14.

TABLE 5. MEANS AND STANDARD ERRORS OF APPARENT DIGESTIBILITY AND NITROGEN BALANCE OF STEERS FED ALL-CONCENTRATE RATIONS CONTAINING DIFFERENT LEVELS AND SOURCES OF PROTEIN (TRIAL 3)

Item	Ration		
	All-Milo	Milo+Urea	Milo+SBM
Digestibility[a]			
Dry matter	77.7[b] ±2.4	80.6 ±2.0	80.8 ±2.9
Ether extract	58.3 ±4.4	62.1 ±2.6	66.0 ±3.6
Crude fiber	47.8 ±2.6	50.2 ±4.2	47.4 ±4.2
Protein***	60.7 ±2.0[c]	69.7 ±1.7[d]	70.3 ±2.1[d]
Nitrogen free extract	82.7 ±2.7	85.3 ±2.2	85.4 ±3.1
Total digestible nutrients[f]	78.6 ±2.7	81.9 ±2.1	81.8 ±3.0
Energy	75.7 ±2.9	78.3 ±2.1	79.6 ±3.4
Nitrogen balance[a]			
Fecal**	39.3 ±2.1[c]	30.3 ±1.7[d]	29.7 ±2.1[d]
Urinary**	36.1 ±2.4[c]	50.6 ±2.3[d]	44.1 ±3.1[e]
Retention	24.6 ±3.3	19.1 ±2.1	26.2 ±3.3
Nitrogen retained[g]	22.2 ±3.4	19.3 ±2.4	28.5 ±3.1

[a] Percent of intake.
[b] Each value is the mean of 6 observations.
** F-ratio from analysis of variance indicated significance at P<.01.
*** F-ratio from analysis of variance indicated significance at P<.001.
[c,d,e] Any mean in same row with a different subscript is significantly different (P<.05).
[f] F-ratio from analysis of variance indicated significance at P<.10.
[g] Grams per day.

The higher protein content of the urea and soybean meal supplemented rations in conjunction with a slight increase in feed intake furnished the steers with 1.00 kg of total protein per day. Calculated expected daily gains from energy intake was 1.18 kg, 1.16 kg and 1.20 kg respectively for steers fed the all-milo, milo plus 1% urea and milo plus soybean meal rations (Lofgreen and Garrett, 1968). This would indicate that the the lower daily gain observed for steers on the all-milo ration was not due to energy consumption, however, it could have been due to a lower protein consumption. Decreased feed consumption of steers on the all-milo diet can partially be accounted for by the lower daily gain and smaller size of the steers throughout the finishing trial.

The protein content of the all-milo ration in trial 1 (9.55%) was higher in protein than the corresponding ration in trial 2 (8.40%). However, feed consumption in the second trial was considerably greater. The average feed intake of 11.21 kg of the 8.40% protein ration furnished the steers with 0.94 kg of protein per day which was adequate to meet minimum requirements. Rations supplemented with urea or soybean meal provided the steers with 1.13 kg of protein per day. Although differences in performance were not significant, efficiency of feed conversion tended to be lower on the lower protein ration. Hale et al. (1963) observed that as the protein level in high milo rations was increased from 11% to 14% by the addition of cottonseed meal, feed efficiency was improved but rate of gain remained the same.

The absence of a significant difference in performance between steers receiving the urea and soybean meal supplemented all-concentrate rations agrees with the findings of Wise et al. (1965), Oltjen et al. (1965) and Haskins et al. (1967). Efficiency of feed conversion tended to be lower on the urea supplemented ration. Durham et al. (1966) found that 9 mg of

chlorotetracycline per kg of feed fed in conjunction with urea in milo all-concentrate rations had a depressing effect on average daily gain and feed efficiency. Similar results were reported by Bolsen et al. (1968) when chlorotetracycline was supplied at the rate of 44 mg per kg of diet. This trend suggests that microorganisms which incorporate urea into protein may be sensitive to the antibiotic. In the present study, chlorotetracycline was supplied at the rate of 8.8 mg per kg of diet. This could account for the slightly lower efficiency of feed conversion for steers receiving the urea supplemented ration.

Results of the metabolism studies show that increasing the protein level of the all-milo ration resulted in an increase in protein digestibility. It has been shown by Hale et al. (1963), Saba et al. (1964), Keating et al. (1965) and Oltjen et al. (1967) that milo protein is poorly digested by steers when compared to other cereal grains. The addition of urea which is readily hydrolyzed by rumen bacteria and the addition of soybean meal which has a higher digestible protein value than milo resulted in an increase in the percent of digestible protein present in the ration. The increase in nitrogen consumption resulted in an increase in urinary nitrogen excretion and no significant differences in nitrogen retention; however, there tended to be a slight increase in nitrogen retention for steers receiving the soybean meal supplemented ration. The increase in protein digestibility without an increase in nitrogen retention agrees with the findings of Oltjen et al. (1967) when 1% urea was added to an all-milo ration.

Steers on the all-milo ration in trial 1 did not have an adequate supply of protein. As a result of the low protein intake, the steers gained slower and were underfinished at the time of slaughter. The decrease in body weight and degree of finish resulted in smaller rib-eye areas and lower

carcass grades and marbling scores than were observed for steers receiving the urea and soybean meal supplemented rations. After adjustment for carcass weights, there were essentially no differences in rib-eye areas among treatments. There were no significant differences in carcass characteristics in trial 2 when all rations supplied the steers with enough protein to meet minimum requirements.

Summary

Two finishing trials and two metabolism studies were conducted to determine the effects of levels and sources of protein on performance and carcass characteristics of steers fed all-concentrate milo rations. Rations were: milo alone, milo plus 1% urea, and milo plus soybean meal isonitrogenous to 1% urea. The protein content of the milo was 9.55% in the first feeding trial and 8.40% in the second feeding trial. Low feed intake by steers consuming all rations was characteristic of the first finishing trial. Steers fed the all-milo ration in the first trial did not consume enough protein to meet minimum requirements. Protein consumption was adequate for supplemented rations. Steers fed the all-milo ration gained slower and were less efficient in feed conversion than steers receiving urea or soybean meal. Steers on the all-milo ration were underfinished at the termination of the 155 day finishing trial and had smaller rib-eye areas and lower carcass grades and marbling scores than were observed for steers receiving the urea supplemented ration. Feed consumption was considerably greater in the second finishing trial, and steers on all treatments consumed enough protein to meet minimum requirements. No significant differences were observed for performance or carcass characteristics.

Results of the metabolism studies show that protein digestibility was

increased when urea and soybean meal were added to the rations. The increase in protein digestibility resulted in an increase in nitrogen excretion with no significant differences in nitrogen retention.

No significant differences were observed between the urea and soybean meal supplemented rations, however, efficiency of feed conversion and nitrogen retention consistantly favored the soybean meal supplemented ration.

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APPENDIX

APPENDIX TABLE 1

FEEDLOT AND CARCASS DATA (TRIAL 1)

ANALYSIS OF VARIANCE

Item	Source of Variation	Degree of Freedom	Mean Squares	F	Level of Significance
Initial weight	Treatment	2	3064.5	0.70	N.S.
	Error	9	4404.9		
Final weight	Treatment	2	11032.5	1.34	N.S.
	Error	9	8203.0		
Average daily gain	Treatment	2	0.2133	4.47	P<.05
	Error	9	0.0477		
Daily feed intake	Treatment	2	1.4570	1.94	N.S.
	Error	9	0.7515		
Feed per kg gain	Treatment	2	0.5560	3.99	P<.10
	Error	9	0.1392		
Hot carcass weight	Treatment	2	7576.0	2.58	N.S.
	Error	9	2934.3		
Rib-eye area	Treatment	2	3.1378	3.20	P<.10
	Error	9	0.9820		
Fat over rib-eye	Treatment	2	0.0209	1.78	N.S.
	Error	9	0.0118		
Carcass grade	Treatment	2	6.2500	4.09	P<.10
	Error	9	1.5278		
Marbling score	Treatment	2	68.580	4.30	P<.05
	Error	9	15.950		

APPENDIX TABLE 2

DIGESTION AND NITROGEN BALANCE DATA (TRIAL 1)

ANALYSIS OF VARIANCE

Item	Source of Variation	Degree of Freedom	Mean Squares	F	Level of Significance
Digestibility					
Dry matter	Treatment	2	37.42	3.21	P<.10
	Error	9	11.67		
Ether extract	Treatment	2	39.58	0.99	N.S.
	Error	9	39.85		
Crude fiber	Treatment	2	207.75	3.51	P<.10
	Error	9	59.18		
Protein	Treatment	2	53.31	2.03	N.S.
	Error	9	26.33		
Nitrogen free extract	Treatment	2	58.08	4.35	P<.05
	Error	9	13.34		
Total digestible nutrients	Treatment	2	41.60	3.83	P<.10
	Error	9	10.86		
Energy	Treatment	2	46.41	3.15	P<.10
	Error	9	14.74		
Nitrogen balance					
Fecal	Treatment	2	56.52	2.03	N.S.
	Error	9	27.79		
Urinary	Treatment	2	266.13	1.31	N.S.
	Error	9	202.78		
Retention	Treatment	2	151.40	0.54	N.S.
	Error	9	276.55		
Nitrogen retained	Treatment	2	212.91	0.61	N.S.
	Error	9	347.95		

APPENDIX TABLE 3

FEEDLOT AND CARCASS DATA (TRIAL 2)

ANALYSIS OF VARIANCE

Item	Source of Variation	Degree of Freedom	Mean Squares	F	Level of Significance
Initial weight	Treatment	2	4322.3	1.04	N.S.
	Error	29	4154.0		
Final weight	Treatment	2	763.2	0.14	N.S.
	Error	29	5638.3		
Average daily gain	Treatment	2	0.0064	0.05	N.S.
	Error	29	0.1406		
Daily feed intake	Treatment	2	2.3400	0.71	N.S.
	Error	9	3.2960		
Feed per kg gain	Treatment	2	0.2456	0.48	N.S.
	Error	9	0.5095		
Rib-eye area	Treatment	2	0.4509	0.36	N.S.
	Error	29	1.2568		
Fat over rib-eye	Treatment	2	1.6586	0.55	N.S.
	Error	29	2.9988		
Marbling score	Treatment	2	1.4554	0.32	N.S.
	Error	29	4.6158		

APPENDIX TABLE 4

DIGESTION AND NITROGEN BALANCE DATA (TRIAL 3)

ANALYSIS OF VARIANCE

Item	Source of Variation	Degree of Freedom	Mean Squares	F	Level of Significance
Digestibility					
Dry matter	Treatment	2	18.22	1.27	N.S.
	Error	8	14.38		
Ether extract	Treatment	2	89.64	2.11	N.S.
	Error	8	42.40		
Crude fiber	Treatment	2	13.73	0.28	N.S.
	Error	8	49.64		
Protein	Treatment	2	174.10	20.43	P<.001
	Error	8	8.52		
Nitrogen free extract	Treatment	2	14.65	0.90	N.S.
	Error	8	16.30		
Total digestible nutrients	Treatment	2	29.00	3.84	P<.10
	Error	8	7.55		
Energy	Treatment	2	34.51	1.72	N.S.
	Error	8	20.12		
Nitrogen balance					
Fecal	Treatment	2	173.23	10.40	P<.01
	Error	8	16.66		
Urinary	Treatment	2	317.90	9.80	P<.01
	Error	8	32.44		
Retention	Treatment	2	83.60	1.87	N.S.
	Error	8	44.83		
Nitrogen retained	Treatment	2	657.58	2.36	N.S.
	Error	8	278.83		

EFFECTS OF LEVELS AND SOURCES OF PROTEIN ON PERFORMANCE AND CARCASS CHARACTERISTICS OF STEERS FED ALL-CONCENTRATE RATIONS

by

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Two finishing trials and two metabolism studies were conducted to determine the effects of levels and sources of protein on performance and carcass characteristics of steers fed all-concentrate rations. An all-milo ration and milo rations supplemented with 1% urea or soybean meal at an isonitrogenous level were compared. The protein content of the milo remained consistent within each feeding trial but varied between trials.

Twelve Hereford steers averaging 266 kg in body weight were randomly divided among three treatments and individually fed their respective rations. During the 155 day finishing trial, each steer was subjected to an 8 or 11-day digestibility study of the ration he consumed. Low feed intake was characteristic of steers receiving all rations. Steers on the 9.55% all-milo ration did not consume enough protein to meet minimum requirements. Protein consumption was adequate for steers receiving the urea or soybean meal supplemented rations. Steers fed the all-milo ration gained slower ($P<.05$) and were less efficient in feed conversion ($P<.10$) than steers receiving urea or soybean meal. Steers on the all-milo ration were underfinished at the time of slaughter and had smaller rib-eye areas ($P<.10$) and lower carcass grades ($P<.10$) and marbling scores ($P<.05$) than were observed for steers receiving the urea supplemented ration. Results of the metabolism study show that the all-milo ration was slightly but not significantly lower in protein digestibility and nitrogen retention.

In the second finishing trial, 35 Hereford steers averaging 305 kg in body weight were randomly divided among three treatments and fed their respective rations for 100 days. Four steers from each treatment were individually fed, and the remainder were group fed. Protein content of the milo in the second finishing trial (8.40%) was lower than that of the first (9.55%), but feed consumption was considerably greater in the second trial.

Steers on all treatments consumed enough protein to meet minimum requirements. No significant differences were observed for performance or carcass characteristics.

Six Hereford steers averaging 295 kg in body weight were used in the second metabolism study. Steers and diets were arranged in a replicated 3X3 Latin square. Results show that protein digestibility was increased when urea or soybean meal was added to the ration ($P<.001$). The increase in protein digestibility resulted in an increase in urinary nitrogen excretion ($P<.05$) with no significant differences in nitrogen retention.

No significant differences in performance or carcass characteristics were observed for the urea and soybean meal supplemented rations, however, efficiency of feed conversion and nitrogen retention consistantly favored the soybean meal supplemented rations.