EFFECTS OF PROGRAMMED FEED INTAKE ON PERFORMANCE AND CARCASS CHARACTERISTICS OF FEEDLOT STEERS

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Story in Brief

Ninety three predominantly small-framed Hereford yearling steers (645 lb) were used to determine the effect of two different methods of limit feeding on feedlot performance. Steers were fed a high corn diet either ad libitum, 80% of ad libitum for first 56 days and ad libitum for remainder of trial or were fed to obtain constant daily weight gains (3.29 or 2.96 lb). Daily feed intakes over the 138 day trial were 20.28, 18.43, 18.87 and 17.54 lb/day for ad libitum, 80%, high programmed and low programmed steers, respectively. Carcass adjusted daily gains were reduced by 6.2% with limit feeding (3.37 vs 3.16 lb), whereas feed efficiency was increased by 4% (6.03 vs 5.79 lb feed/lb gain). The most efficient steers were those programmed to obtain specific weight gains (6.03 vs 5.73). The estimated metabolizable energy value of the diet was increased by 2.9% with limit feeding (2.89 vs 2.97 mcal/kg). The percentage of steers grading choice was reduced from 95.8% to 72% with limit feeding. Animal behavior, passage rate and diet digestibility were not altered by limit feeding. Improvements in feed efficiency in programmed fed steers possibly could be attributed to reduced day-to-day fluctuations in feed intake by individual steers and reduced animal-to-animal variation in gains.

(Key Words: Feedlot Steers, Limit Feeding, Programmed Feeding)

Introduction

Several recent studies have reported that feed efficiency of feedlot cattle can be improved by controlling or limiting feed intake. Most of these studies have controlled intake by feeding certain pens of cattle a specific percentage of the feed consumed by pens of cattle with ad libitum access to feed. This approach to controlled feeding has been shown to increase feed efficiency by around 5% (Lofgreen, 1969; Plegge et al., 1985, 1986; Hicks et al., 1987) in several trials, whereas in other trials efficiency was not altered or was decreased by approximately 1% (Davis et al., 1973; Lofgreen et al., 1983). The optimum level of restriction appears to be in the range of 90 to 95% of ad libitum. Another approach to controlled feeding was recently tested by Lofgreen et al. (1987) in which three groups of steers were fed either ad libitum or 90% or 80% of ad libitum until the steers reached a weight of 700 pounds at which time all steers were fed ad libitum untill slaughter. Over the 193 day feeding trial, there was a trend towards increased feedlot performance with restricted feeding. Feed efficiency was improved by 5.4% and 4.7% with 90% and 80% of ad libitum feeding during the first portion of the trial. The final approach to limit feeding (Zinn, 1986) is to limit the amount of feed provided so that

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cattle will achieve a prescribed daily weight gain. Zinn observed that feed efficiency was improved 4.3% by programming feed intake.

Reducing feed intake should not improve efficiency according to the net energy equations. These equations precisely predict feedlot results of cattle with ad libitum access to feed. However, the above studies indicate that controlled feeding improves efficiency so that prediction should be inaccurate. Suggested reasons for improved feed efficiency with controlled feeding include reduced feed wastage, increased diet digestibility, reduced animal activity, and reduced gut and liver size which in turn reduce the maintenance requirement. The objectives of this study were to evaluate the effects of programming feed intake to obtain specific weight gains and of limiting intake only during the first half of a feeding period on the performance of feedlot steers. We also measured the effect of controlled feeding on diet digestibility, passage rate, animal activity, feed waste and liver weight.

Materials and Methods

Ninety-six crossbred (primarily British crosses) yearling steers which had been wintered on wheat pasture near Dalhart, Texas were trucked to Goodwell, Oklahoma on June 3, 1987. On arrival, all cattle were individually weighed, ear tagged, implanted with Synovex-S, and injected with ivermectin and a BRSV vaccine. These steers were predominantly Herefords (78 head) of small frame size. The steers were divided into twelve pens of eight head each and four treatments were randomly assigned to the pens. The treatments were: 1) controls - fed ad libitum, 2) fed at 80% of ad libitum for first 56 days and ad libitum for remainder of trial, 3) programmed to gain 3.29 lb/day and 4) programmed to gain 2.96 lb/day.

Steers were fed a cracked corn high concentrate ration twice daily (0700 and 1600) for the 138 day trial (Table 1). Chopped alfalfa hay was used to dilute the ration to 60 percent concentrate to start the cattle on feed. Roughage content of the diet was decreased sequentially in three steps until the cattle were on their final ration by 28 days on

Table 1. Diet composition, dry matter basis.[a]

	Ration Sequence			
Ingredient	1	2	3	4[a]
Corn, cracked	52.70	62.28	71.87	80.02
Chopped alfalfa	38.36	28.78	19.19	11.04
Cane molasses	3.88	3.88	3.88	3.88
Pelleted supplement[b]	5.06	5.06	5.06	5.06

[a]To provide 12.25% protein, .53% calcium, .78% potassium, .33% phosphorus, 94.7 Mcal NEm/cwt, 61.1 Mcal NEg/cwt and 30 g lasalocid/ton of total feed.

[b]Consisted of, as a percentage of the diet: soybean meal, 2.04; wheat middlings, .64; meat meal, .60; calcium carbonate, .53; dicalcium phosphate, .07; urea, .49; salt, .50; potassium chloride, .04; bovatec (68 g/lb), .02; vitamin A (30000 IU/g), .01; vitamin E, .01; trace minerals, .01; mineral oil, .10.

feed. For those pens programmed to obtain specific daily weight gains, daily feed allotments (increased every two weeks) were determined in the manner described by Zinn (1986). Amounts of feed offered to cattle being restricted for the first 56 days of the trial were adjusted daily based on the previous day's intakes of pens with ad libitum access to feed.

On days 34 through 40 of the trial, chromic oxide was included in the diet at a level of 0.2% and on days 40, 42 and 44 fecal grab samples were obtained from 4 to 8 steers per pen. Fecal samples were analyzed for starch, ash, acid-insoluble ash and chromium content. Fecal measurements for day 40 were used to estimate digestibility of the ration and measurements for days 42 and 44 were used to estimate passage rate through the rumen. On days 40 and 41, the steers were observed every 30 minutes for 24 hours (2000 to 1950) to monitor the time spent eating, standing, laying, standing and ruminating, or laying and ruminating.

Cattle weights were off truck weights (shrunk) at the start of the trial but were taken on full-feed on days 28, 56, 84, 112 and 138. To calculate gain and efficiency, full weights were reduced by 4% to compensate for digestive tract fill. Steers were trucked to Holcomb, Kansas on day 139 of the trial (October 22, 1987) for slaughter, and carcass data were obtained. Three steers were removed from the trial for causes not related to the experimental treatments. This trial was analyzed as a completely randomized design using a general linear models procedure. Orthogonal comparisons included ad libitum vs the mean of the three limited intake treatments, 80% of ad libitum vs the mean of the high and low programmed steers, and high (3.29 lb gain/day) programmed vs low (2.96 lb/day) programmed.

Results and Discussion

The effects of limit feeding on steer performance are presented in Table 2. Carcass adjusted daily gains tended to be reduced ($P<.10$) with limit feeding (3.37 vs 3.16 lb/day) and liveweight gains were reduced ($P<.05$) by 7.3% (2.88 vs 2.67 lb/day). During the first 56 days of the feeding period gains were reduced ($P<.01$) by 18.7% with limit feeding (3.26 vs 2.65 lb/day), whereas, during the last 82 days there was no difference in gain between treatment groups. Those cattle which were fed at 80% of ad libitum during the first 56 days appeared to make compensatory gains during the second half of the trial (2.62 vs 2.78 lb/day for ad lib and 80% steers). Steers in the high programmed (3.29 lb/day) and low programmed treatment groups (2.96 lb/day) gained only 83.6 and 86.8% of their programmed gains. Over the 138 day trial, feed intakes were 90.9, 93.0 and 86.5% of ad libitum for 80%, high programmed and low programmed steers, respectively. Over the first 56 days, intake for the 80% steers actually was 84.2% of ad libitum.

During the first 56 days of the feeding period, feed efficiency was not effected ($P>.10$) by limit feeding. However, during the second half of the trial feed efficiency tended ($P<.10$) to be increased (7.2%) with limit feeding (7.96 vs 7.39 lb feed/lb gain). These results are quite similar to those of two earlier limit feeding trials conducted at Goodwell (Hicks et al., 1987). Over the entire trial feed efficiency on a carcass weight basis tended to be increased ($P<.10$) by 4% with limit feeding (6.03 vs 5.79). The most efficient steers were those programmed to obtain specific weight gains. Dietary net energy values for maintenance (NEm) and gain (NEg) and metabolizable energy values (ME)

Table 2. Effect of limit feeding on steer performance.

	Ad Lib	80 %	High Prog	Low Prog	SEM	Contrasts[e]
No. of Pens	3	3	3	3		
No. of Head	22	24	23	24		
Weight, lbs						
Initial	644	645	646	645	1.1	
Day 138	1084[a]	1058[ab]	1067[ab]	1041[b]	8.1	AL*,HL*
Daily Gain, lbs						
0-56 days	3.26[a]	2.55[b]	2.86[b]	2.53[b]	.11	AL**,HL+
57-138 days	2.62	2.78	2.67	2.59	.11	
0-138 days	2.88[a]	2.69[ab]	2.75[ab]	2.57[b]	.06	AL*,HL+
0-139 days[d]	3.37	3.11	3.30	3.06	.09	AL+,HL+
DM Intake, lbs						
0-56 days	18.71[a]	15.75[b]	17.15[ab]	15.68[b]	.50	AL**,HL+
57-138 days	20.81[a]	20.27[a]	20.10[a]	18.81[b]	.37	AL*, HL*
0-138 days	20.28[a]	18.43[b]	18.87[b]	17.54[c]	.23	AL**,HL**
Feed/Gain						
0-56 days	5.75	6.20	6.02	6.21	.22	
57-138 days	7.96	7.35	7.54	7.27	.23	AL+
0-138 days	7.06	6.87	6.88	6.84	.09	AL+
0-139 days[d]	6.03	5.93	5.72	5.73	.11	AL+
Net Energy, Mcal/cwt						
Maintenance	84.2[b]	87.5[a]	87.1[a]	88.6[a]	.87	AL**
Gain	56.1[b]	58.4[a]	58.1[a]	59.0[a]	.57	AL**
Metabolizable energy, Mcal/kg	2.89[b]	2.97[a]	2.96[a]	2.99[a]	.02	AL**

[abc]Means in the same row with different superscripts differ (P<.05).
[d]Based on carcass weight divided by .62, an assumed dressing percent.
[e]AL=Ad lib vs limited, HL=High programmed vs low programmed; **(P<.01), *(P<.05), +(P<.10).

were calculated from performance by the method described by Hays et al. (1987). Estimated NEm, NEg and ME values were significantly increased (P<.01) by 4.2, 4.3 and 2.9%, respectively, with limit feeding. The estimated NEm and NEg values for the ad libitum fed steers were lower (84.2 and 56.1 Mcal/cwt) than those predicted from diet composition (94.7 and 61.1 Mcal/cwt).

Effects of limit feeding on carcass characteristics are presented in Table 3. Dressing percentage tended (P<.10) to be lower for steers fed 80% of ad libitum for the first 56 days than for programmed steers (65.8 vs 66.6%). The percent of steers grading choice tended to be reduced (P<.10) with limit feeding (96 vs 72%) as also was noted in previous trials (Hicks et al., 1987). Final liver weight was not altered by limit feeding in these cattle. Thus, if maintenance requirements are correlated to liver mass, reduced maintenance requirements most likely cannot explain the observed improvements in feed efficiency.

Limit feeding did not alter steer behavior in this group of cattle (Table 4). These steers spent 15.5, 6.6 and 54.4% of their time ruminating, eating and laying, respectively. Passage rate and diet digestibility also were not altered by limit feeding (Table 5). With these cattle reduced animal activity or increased diet digestibility

Table 3. Effect of limit feeding on carcass characteristics.

	Ad Lib	80 %	High Prog	Low Prog	SEM	Contrasts[e]
Carcass wt, lb	690[a]	668[ab]	685[ab]	664[b]	7.3	AL+, HL+
Dressing Percent	66.27	65.79	66.80	66.47	.34	80+
Rib eye area, sq in	12.25	12.25	12.23	12.79	.28	
KPH, %	2.02	1.96	1.94	2.08	.11	
Fat thickness, in	.54	.54	.57	.49	.05	
Marbling Score[d]	14.15[a]	12.71[b]	13.54[ab]	12.71[b]	.40	AL*
Percent Choice	95.8 [a]	62.5 [b]	78.6 [ab]	75.0 [ab]	9.3	AL+
USDA Yield Grade	2.95	2.85	2.99	2.57	.21	HL*
Percent YG 4	0.0[b]	0.0[b]	13.1[a]	0.0[b]	3.6	
Cutability, %	50.0	50.2	49.9	50.9	.5	
Liver Abscesses						
Severity[f]	2.5	2.1	2.0	2.0	.30	
Incidence, %	38.1	41.7	13.1	41.7	11.2	
Liver Wt, lb	12.77	13.25	13.54	13.03	.38	

[abc]Means in the same row with different superscripts differ (P<.05).
[d]12=slight plus, 13=small minus, 14=average small
[e]AL=Ad lib vs limited, 80=80% vs programmed, HL=High programmed vs low programmed; *(P<.05), +(P<.10).
[f]0=no abscess, 1=one or two small abscesses, 2=moderate abscesses, 3=severe abscesses.

Table 4. Effect of limit feeding on steer behavior.

	Ad Lib	80 %	High Prog	Low Prog	SEM
Time spent, %					
Ruminating	14.32	17.10	14.15	16.32	1.87
Eating	5.57	7.90	5.90	7.12	1.41
Laying	54.03	56.25	54.95	52.17	3.31

Table 5. Effect of limit feeding on diet digestibility.

	Ad Lib	80 %	High Prog	Low Prog	SEM
DM Intake, lb					
days 36-42	20.03	15.63	17.75	16.25	
Digestibility, %					
Total Diet	71.2	74.6	70.1	71.2	5.09
Starch	89.6	92.2	90.5	91.5	3.96
Passage rate, %/hr	3.23	2.95	3.32	3.14	.35
Fecal Starch, %					
day 40, 7/13/87	22.74	18.65	17.22	18.49	3.15
day 42, 7/15/87	17.34	15.61	19.54	18.20	2.84
day 44, 7/17/87	22.25	13.05	19.11	17.39	3.44
Mean	21.05	15.82	18.59	17.99	2.19

apparently cannot account for the improvement in feed efficiency noted with limit feeding. However, it must be noted that rather large variation in digestibility parameters here does not rule out this possibility.

Another potential reason for improvements observed in feed efficiency with limit feeding is reduced feed wastage. On day 43 of this trial concrete bunk pads were cleaned so that feed wastage over a 24 hour period could be monitored. No feed wastage was observed in these steers. Other potential reasons for improvement are reduced animal-to-animal variation and reduced day-to-day variation in feed intake within a pen with limit feeding (Zinn, 1986). Zinn notes that animals fed under ad libitum conditions tend to have very wide day-to-day (and within day) fluctuations in feed intake which may result in digestive disturbances and decreased feed utilization. During the 24 hour observation period aggressive eaters and timid eaters were noted in both ad libitum fed and limit fed pens. Animal-to-animal variation in time at the bunk was not reduced with limit feeding. However, day-to-day variation in pen intake was reduced with programming of feed intakes because steers were fed constant amounts of feed over two week intervals (Figure 1). In steers fed 80% of ad libitum for the first 56 days, day-to-day variation was not altered because feed allotments were adjusted daily based on intakes of pens with ad libitum access to feed (Figure 2).

Reduced animal-to-animal variation in daily gain with limit feeding is another potential cause of increased feed efficiency.

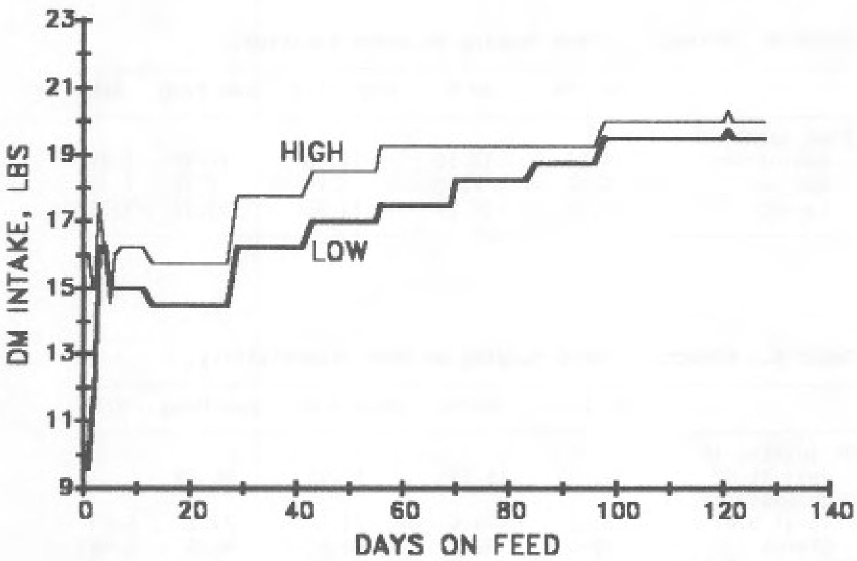

Figure 1. Feed dry matter intake versus time on feed for steers programmed to obtain specific weight gains. Feed allotments increased every two weeks.

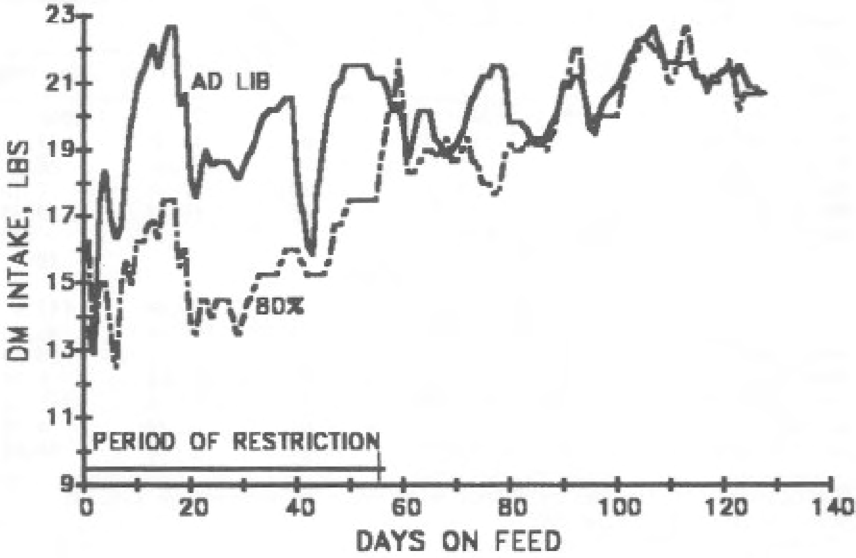

Figure 2. Feed dry matter intake versus time on feed for ad libitum fed steers and steers fed 80% of ad libitum for first 56 days of trial.

Coefficients of variation for carcass adjusted daily gains were 15.4, 16.7, 14.2 and 11.1% for ad libitum, 80%, high programmed and low programmed cattle, respectively. Animal-to-animal variation in daily gains was reduced with programming of feed intakes.

Economic analysis of this data is presented in Table 6. The number of additional days that limit fed steers would have to be fed to reach an adjusted final weight equal to that of the ad libitum fed steers was calculated assuming that gains observed during the last 28 days on feed were maintained. Additional feed cost were then calculated assuming that feed intake was the same as that observed in the last 28 day period. Total feed, yardage and interest cost per steer was $210.66, $217.61, $203.88 and $215.01 for ad libitum, 80%, high programmed and low programmed cattle, respectively. A potential savings of $6.78 per head was noted in the steers fed to gain 3.29 lb/day. This data indicates that restricting intake by more than 7% resulted in increased cost.

In summary, results of this trial suggest that limit feeding improves feed efficiency of feedlot steers but reduces rate of gain. Specific reasons for this improvement were not determined. Reduced liver size, reduced animal activity, reduced feed wastage or increased diet digestibility were not noted with this group of cattle and cannot explain improvements in feed efficiency. Reduced day-to-day fluctuations in feed intake and reduced animal-to-animal variation in gains in programmed steers possibly could account for some improvement in feed efficiency.

Table 6. Economics of limit feeding.

	Ad Lib	80 %	High Prog	Low Prog
Adjusted 138 day wt, lb[a]	1040	1007	1033	1001
DM Intake (0-138 days), lb	20.28	18.43	18.87	17.54
% of Ad lib intake		90.9	93.0	86.5
ADG (113-138 days), lb	2.16	2.33	2.15	2.18
DM Intake (113-138 days), lb	21.54	21.06	20.97	19.51
Additional days to reach adjusted final wt of ad lib cattle		14	3	18
Feed Cost (138 day)[b], $	165.12	150.06	153.64	142.81
Yard Cost (138 days)[c], $	45.54	45.54	45.54	45.54
Additional Feed Cost[b], $	0.00	17.40	3.71	20.72
Additional Yard Cost[c], $	0.00	4.62	0.99	5.94
Total Cost, $	210.66	217.61	203.88	215.01
Savings, $		-6.95	6.78	-4.35
Cost/lb gain, cents	53.20	55.09	51.75	54.43

[a]Carcass weight divided by actual mean dressing percentage (.6633)
[b]Feed cost of $5.90/cwt DM.
[c]Yardage plus interest cost of 33 cents/day.

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