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Effects of Feed Intake Restriction on Performance and Carcass Characteristics of Finishing Beef Steers[1,2]

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Abstract

*Crossbred steers (n = 264, 311 ± 1.6 kg initial BW) were blocked by BW, randomly assigned to one of four treatments (28 pens, 7 pens per treatment), and fed a common 90% concentrate diet to determine the effects of the severity of caloric restriction on animal performance and carcass characteristics. Treatments were 1) ad libitum access to feed for 151 d (**AL100**); 2) 75% of DMI by AL100 for 65 d, 95% of DMI by AL100 for 65 d, and ad libitum access to feed for 21 d (**AL85**); 3) 80% of DMI by AL100 for 65 d, 100% of DMI by AL100 for 65 d, and ad libitum access to feed for 21 d (**AL90**); and 4) 85% of DMI by AL100 for 65 d, 105% of DMI by AL100 for 65 d, and ad libitum access to feed for 21 d (**AL95**). Feed was offered for AL85, AL90, and AL95 based on DMI by AL100 the previous week. All steers were fed a similar quantity of DM for 4 d prior to initial, interim, and final BW determinations to minimize gastrointestinal fill differences. Overall DMI was greater (P<0.01) for AL100 than for the average of the remaining treatments and decreased linearly (P<0.01) among AL95, AL90, and AL85. Overall ADG (carcass-adjusted) was less (P<0.01) for AL85, AL90, and AL95 than for AL100, whereas overall ADG:DMI (carcass-adjusted) did not differ (P>0.10) between AL100 and the average of the remaining treatments. Overall ADG and ADG:DMI (carcass-adjusted) responded quadratically (P<0.05) with increasing DMI restriction. Hot carcass weight, longissimus area, and kidney, pelvic, and heart fat percentage were greater (P<0.05) for AL100 than for the remaining treatments and responded quadratically (P<0.10) among AL85, AL90, and AL95. Marbling score was greater (P<0.10) for AL100 than for the average of the remaining treatments, and the number of carcasses grading Prime + Choice tended to be higher (P<0.15) for AL100 and AL95. Restricting feed intake of finishing yearling steers to an average of 85 to 95% of ad libitum for 130 d of a 151-d feeding period generally resulted in slower ADG, lesser marbling scores, and carcasses that were lighter and leaner compared with yearling steers allowed ad libitum to feed and harvested after an equal number of days on feed.*

(Key Words: Caloric Restriction, Restricted Feeding, Limit Feeding.)

Introduction

Evidence suggests that maximum feed intake by feedlot cattle may not support maximum gain efficiency (Meissner et al., 1995; Ferrell and Jenkins, 1998). Numerous methods of offering feedlot cattle less feed than could be consumed by offering ad libitum access have been developed (Galyean, 1999) as strategies to increase animal performance, simplify bunk management, or both. Execution of these methods generally imposes either continuous DMI restriction to a constant degree throughout the feeding period, DMI restriction to a constant degree for a fraction of the feeding period followed by a pe-

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riod of ad libitum access to feed, or DMI restriction to various degrees for various durations during the feeding period followed by a final period of ad libitum access to feed.

Previous data indicate that using the latter approach of programming intake by steers to support an increasing rate of gain can increase gain efficiency 8 to 9% without altering ADG, days on feed, or carcass quality (Knoblich et al. 1997; Loerch and Fluharty, 1998). In the work by Knoblich et al. (1997) and Loerch and Fluharty (1998), dietary CP was increased as DMI restriction increased to provide a similar quantity of CP daily. Rossi et al. (2000; Exp. 1) reported that animal performance did not differ between steers fed either 14 or 12% CP diets at an average of 84% of ad libitum for 150 d of a 184-d feeding period compared with steers allowed ad libitum access to a 12% CP diet for 170 d. Further data describing the effects of incremental DMI increases on performance by finishing steers fed a common diet for an equal number of total days on feed are not available. In addition, Wilson and Osbourn (1960) suggested that the duration of the period of restriction and the pattern of re-alimentation are important determinants of the extent of growth compensation. The objective of the present study was to evaluate the effects of the severity of caloric restriction, independent of duration, on performance and carcass characteristics of steers.

Materials and Methods

Animals and Diets. Two hundred seventy-six crossbred steers were received from Oklahoma and Kansas at the West Texas A&M Research Feedlot over 8 d in June 2000. All procedures used were reviewed and approved by the Amarillo-Area Cooperative Research, Education, and Extension Triangle Animal Care and Use Committee (protocol number 2000 – 09). Animals were processed on the morning following arrival. Processing included individual identification with a numbered ear tag in the left ear (Allflex®; Brussels Agri Services, Brussel, Ontario, Canada), individual BW determination, vaccination against viral antigens (IBR, PI_3, BRSV, BVD; Reliant 4®; Merial Animal Health, Iselin, NJ) and clostridial organisms (Vision 7®; Bayer Animal Health, Shawnee Mission, KS), treatment for internal and external parasites (Dectomax®; Pfizer Animal Health, Exton, PA), and excision of previous implant(s). All BW measurements taken during the experiment were acquired using a single animal scale. Scale accuracy was verified before BW determination using twenty 22.67-kg certified weights; the scale was calibrated as needed. Twelve steers were determined to be ineligible for the study because of health problems or lack of conformity with BW of the remaining steers.

Cattle were fed a common 65% concentrate diet (Table 1) at 1.5% of BW for 4 d to minimize fill differences before beginning the study. Two hundred sixty-four steers were individually weighed, implanted (36 mg of zeranol; Ralgro®; Schering-Plough, Union, NJ), blocked by BW, and randomly assigned to one of four treatments (7 pens per treatment) on June 19, 2000. Study pens (6.1 m × 27.4 m) were soil-surfaced, contained an individual water tank, allowed 16.7 to 18.5 m^2 of pen space per animal, and allowed 31 to 34 cm of bunk space per animal. Cattle were re-implanted with Revalor-S® (28 mg of estradiol + 120 mg of trenbolone acetate; Hoechst Roussel Vet, Warren, NJ) on d 56.

Treatments. Based on previous data (Knoblich et al., 1997), the experiment was designed to include a final period of ad libitum access to feed for 28 d (Period 3). The remainder of the projected feeding period was divided into two DMI restriction periods of equal length (Periods 1 and 2), and the magnitude of increased DMI from Periods 1 to 2 was similar across treatments. In addition, a review of six feedlot studies (unpublished observations) employing at least one interval of DMI restriction followed by a final period of ad libitum access to feed suggested that an expected compensatory DMI increase following a period of restriction may be approximately 2 to 10% greater than DMI by cattle allowed ad libitum access. The final period in the present study was abbreviated to 21 d because DMI and ADG were greater than initially projected. Therefore, treatments were as follows 1) ad libitum access to feed for 151 d (AL100); 2) 75% of DMI by AL100 for 65 d, 95% of DMI by AL100 for 65 d, and ad libitum access to feed for 21 d (AL85); 3) 80% of DMI by AL100 for 65 d, 100% of DMI by AL100 for 65 d, and ad libitum access to feed for 21 d (AL90); and 4) 85% of DMI by AL100 for 65 d, 105% of DMI by AL100 for 65 d, and ad libitum access to feed during Period 3 (AL95).

All steers were adapted to a common 90% concentrate diet by feeding 65, 75, and 82.5% concentrate diets (Table 1) for 6 d each, including a 3-d transition period between diets. Diet transitions were made by offering equal NE_g on d 1 of the new diet. During the adaptation period, DMI by AL85, AL90, and AL95 treatments was increased at a rate similar to AL100 steers until AL100 steers refused feed or until assigned pens reached 75% (AL85), 80% (AL90), or 85% (AL95) of predicted overall feed intake. Thereafter, DMI by AL85, AL90, and AL95 was adjusted weekly based on DMI the previous week by AL100. Feed was offered at approximately 110% of ad libitum for steers on AL100, and orts were weighed weekly and DM determined. Increases in feed offered between periods were accomplished by offering an additional 0.2 kg of DM/d until the desired DMI was achieved. Potential

TABLE 1. Dietary ingredient and chemical composition (% of DM).

	Diet (% concentrate)			
Item	65	75	82.5	90
Ingredient composition				
Corn, whole	50.4	60.25	67.15	75.49
Cottonseed hulls	15.0	10.0	7.5	5.0
Alfalfa hay, ground	20.0	15.0	10.0	5.0
Cottonseed meal	5.6	5.25	5.35	4.01
Molasses, cane	4.0	4.0	4.0	4.0
Choice white grease	2.0	2.5	3.0	3.0
Supplement	3.0[a]	3.0[a]	3.0[a]	3.5[b]
Chemical composition[c]				
CP, %	14.01	13.75	13.52	13.51
Ca, %	0.60	0.53	0.46	0.60
P, %	0.35	0.36	0.37	0.32
K, %	1.03	0.95	0.88	0.81
NE_m, Mcal/kg	1.76	1.92	2.01	2.09
NE_g, Mcal/kg	1.15	1.26	1.34	1.43

[a]Starter supplement contained (DM basis): 16.67% urea, 8.33% $(NH_4)_2SO_4$, 7.51% Ca, 1.88% P, 3.51% K, 2.35% S, 9 mg of Co/kg, 406 mg of Cu/kg, 1586 mg of Fe/kg, 19 mg of I/kg, 1745 mg of Mn/kg, 0.3 mg of Se/kg, 1226 mg of Zn/kg, 26.5 g of monensin/kg, and 8.8 g of tylosin/kg.

[b]Finishing supplement contained (DM basis): 22.856% urea, 7.14% $(NH_4)_2SO_4$, 12.49% Ca, 0.14% P, 3.39% K, 2.74% Mg, 2.06% S, 7 mg of Co/kg, 306 mg of Cu/kg, 1053 mg of Fe/kg, 15 mg of I/kg, 1271 mg of Mn/kg, 0.9 mg of Se/kg, 1659 mg of Zn/kg, 30.9 g of monensin/T, and 8.8 g of tylosin/kg.

[c]Protein and K were determined analytically (Technicon, 1977); the remaining values were derived from tabular data (NRC, 1996).

differences in gastrointestinal fill prior to determining ending BW of Periods 1, 2, and 3 were minimized by feeding all steers 75, 90, and 90%, respectively, of DMI the previous week by AL100 steers for 4 d.

Carcass Evaluation. Steers were shipped to a commercial slaughter facility (IBP, Amarillo, TX) to be harvested after an average of 151 d of feeding. Hot carcass weight was determined immediately after slaughter, and carcasses were evaluated after chilling for approximately 48 h for longissimus area; fat thickness over the 12th rib; percentage kidney, pelvic, and heart fat; yield grade; marbling score; and quality grade (USDA, 1997) by the Beef Carcass Research Center personnel of West Texas A&M University.

Laboratory Procedures. Weekly diet samples were composited gravimetrically within 4-wk intervals and were ground in a Wiley mill to pass a 1-mm screen. These samples and samples of orts were analyzed for DM (100°C for 24 h). Following digestion of diet samples in a block digester, digested samples were analyzed for N and P using automated procedures (Technicon, 1977).

Statistical Analyses. Carcass-adjusted final BW of all steers was calculated as hot carcass weight divided by overall mean dressing percentage. Overall performance on a live basis is not presented because hides contained a noticeable amount of mud at the end of Period 3. Data were analyzed as a randomized complete block design. The distribution of the number of carcasses grading Choice, Prime + Choice, Select, and Select + Standard were analyzed by Chi-square using CATMOD procedures of SAS® (SAS Inst., Inc., Cary, NC). Liver abscess score and number of carcasses grading Prime and Standard were not analyzed because of a limited number of observations.

Remaining data were analyzed using the MIXED procedures of SAS® (SAS Inst., Inc.) with pen as the experimental unit. Performance data were not analyzed as repeated measures because all periods were not of equal length. The fixed effect of treatment and the random effect of block were included in the model. Actual overall DMI during the restriction periods were 92.9, 89.9, and 86.4% of DMI by steers allowed ad libitum access for AL95, AL90, and AL85, respectively. Therefore, contrast coefficients for these unequally spaced treatments were determined using IML procedures of SAS((SAS Inst., Inc.). Orthogonal contrasts were used to separate means and were as follows: 1) AL100 *vs* the average of AL85, AL90, and AL95; 2) linear effects among AL85, AL90, and AL95; and 3) quadratic effects among AL85, AL90, and AL95. The significance level for all analyses was set at 0.10.

Results and Discussion

Period 1. Four steers died during the study for reasons unrelated to treatment: one steer from treatment AL95, two steers from AL90, and one steer from AL85. Feed DM consumed by deceased steers was adjusted based on average pen DMI. An additional AL90 steer was removed after the study started because of marked BW loss unrelated to treatment (hardware). Only the DMI to meet NE_m (NRC, 1996) was deducted for this steer because estimates of NE_m derived from mobilized tissue for growing animals are lacking and gut fill was not quantified. Performance data (Table 2) are presented with deceased animals removed.

As designed, Period 1 DMI was greater (P<0.01) for AL100 than the

TABLE 2. Effect of severity of feed intake restriction on animal performance.

Item	Treatment[a]				SE[b]	Contrast[c]
	AL100	AL95	AL90	AL85		
Initial BW, kg	307.6	307.4	307.4	307.4	1.2	—
d 1 to 65						
BW at d 65, kg	428.4	412.5	413.2	401.4	3.3	—
DMI, kg/d	8.45	7.22	6.83	6.45	0.15	x, y
ADG, kg/d	1.85	1.60	1.61	1.44	0.04	x, z
ADG:DMI	0.220	0.221	0.235	0.223	0.008	—
d 66 to 130						
BW at d 130, kg	547.2	533.5	533.1	518.2	4.1	—
DMI, kg/d	10.57	10.47	10.27	9.99	0.15	x, y
ADG, kg/d	1.84	1.87	1.86	1.81	0.04	—
ADG:DMI	0.173	0.176	0.181	0.181	0.003	x
d 131 to 151						
BW at d 151, kg	569.0	556.2	559.4	543.9	10.4	—
DMI, kg/d	10.18	10.38	10.29	10.33	0.15	—
ADG, kg/d	1.07	1.12	1.24	1.27	0.07	x
ADG:DMI	0.103	0.106	0.118	0.121	0.006	x, y
Overall[d]						
DMI, kg/d	9.66	9.11	8.81	8.56	0.08	x, y
ADG, kg/d	1.75	1.65	1.69	1.56	0.03	x, z
ADG:DMI	0.181	0.181	0.192	0.183	0.003	z

[a]AL100 = Ad libitum access to feed for the entire study; AL85 = 75% of DMI by AL100 for 65 d, 95% of DMI by AL100 for 65 d, and ad libitum access to feed for 21 d; AL90 = 80% of DMI by AL100 for 65 d, 100% of DMI by AL100 for 65 d, and ad libitum access to feed for 21 d; AL95 = 85% of DMI by AL100 for 65 d, 105% of DMI by AL100 for 65 d, and ad libitum access to feed for 21 d.

[b]Standard error of the least squares mean, n = 7.

[c]x = AL100 *vs* average of AL95, AL90, and AL85 ($P<0.10$), y = linear effect among AL95, AL90, and AL85 ($P<0.10$), z = quadratic effect among AL95, AL90, and AL85 ($P<0.10$).

[d]Final BW measurement was carcass adjusted.

average of remaining treatments and decreased linearly ($P<0.05$) among AL95, AL90, and AL85. Steer ADG during Period 1 was approximately 19% greater ($P<0.01$) for AL100 than for remaining treatments. Period 1 ADG responded quadratically ($P<0.10$) among AL85, AL90, and AL95; ADG was greatest for AL90 and AL95 and least for AL85. Period 1 ADG:DMI did not differ ($P>0.54$) among treatments.

Steers in the present study were restricted to 75, 80, or 85% of ad libitum during Period 1. Previous data support our observations of less DMI resulting in reduced ADG (Rossi et al., 2000; Rossi and Loerch, 2001; Rossi et al., 2001) compared with allowing ad libitum access to feed. Steers in the present study were fed a common diet throughout finishing. With the exception of Rossi et al. (2000) and Rossi et al. (2001; Exp. 1), formulated dietary CP concentration in previous studies has generally been increased as feed intake restriction has increased. Thus, changes in BW gain efficiency from feed intake restriction in the majority of previous data include a small dietary NE dilution from replacement of grain with protein sources.

The lack of an effect of feed intake restriction on gain efficiency has been reported for steers restricted to 80 (Loerch and Fluharty, 1998; Exp. 2) or 81% of ad libitum (Rossi et al., 2001; Exp. 2) for approximately 60 to 70 d. In contrast, Rossi and Loerch (2001; Exp. 2) reported that gain efficiency was increased 5% for steers restricted to 76% of ad libitum for approximately 65 d. Gain efficiency has more commonly been decreased by feed restriction early in the overall feeding period; gain efficiency has been decreased (numerically or statistically) 4 to 8% when steers were restricted from 71 to 80% of ad libitum for approximately 30 to 95 d (Knoblich et al., 1997; Loerch and Fluharty, 1998; Rossi et al., 2000; Rossi et al., 2001). These data suggest that restricting steer DMI >20% of ad libitum may adversely affect gain efficiency. Sainz (1995) reviewed the literature and indicated that feed intake restriction >15% of ad libitum decreased gain efficiency. Present data suggest that gain efficiency is not adversely affected when steer DMI of an isoclaoric diet is restricted to 75% of ad libitum.

Period 2. The DMI in Period 2 by AL90 did not equal DMI by AL100 nor did DMI by AL95 exceed AL100 as expected, suggesting that the restriction in Period 1 might have been of insufficient severity, duration, or both to translate into a subsequent feed intake response. Thus, steers assigned to treatments AL95 and AL90 actually had ad libitum access to feed during Period 2. Steer DMI was approximately 3% greater (P<0.10) for AL100 than for the average of the remaining treatments and decreased linearly (P<0.10) among AL95, AL90, and AL85. However, steer ADG in Period 2 did not differ (P>0.30) among treatments, and ADG:DMI was 3.5% greater (P<0.10) for the average of AL85, AL90, and AL95 than for AL100.

The inability of AL90 and AL95 to consume the targeted quantities of DM was unexpected. Although gastrointestinal organ weight of sheep was reduced by DMI restriction (Burrin et al., 1990; McLeod and Baldwin, 2000), the data of Wright and Russel (1991) indicated that gastrointestinal organ weight of cattle restricted to 71% of ad libitum for approximately 200 d was comparable with that of unrestricted cattle after 35 d of refeeding. The improvement in gain efficiency in the second restriction period in the present study was considerably less than observed in previous studies in which duration of restriction (i.e., length of Periods 1 and 2) varied by approximately 5 to 25 d.

Rossi and Loerch (2001) increased steer DMI from 80 to 98% of ad libitum and reported that ADG was numerically 6% greater and ADG:DMI was 9% greater than steers allowed ad libitum access to feed. In a second study (Rossi and Loerch, 2001), ADG was similar, and ADG:DMI was 12% greater, when steer DMI was increased from 76 to 91% of ad libitum than when steers were allowed ad libitum access to feed. Rossi et al. (2001) indicated that ADG:DMI was 20, 20, and 26% greater as steer DMI was increased from 74 to 90, 76 to 91, and 81 to 95% of ad libitum, respectively. Knoblich et al. (1997; Exp. 1) increased steer DMI from 76 to 92% and 75 to 85% of ad libitum and observed that ADG:DMI was 28 to 30% greater than steers allowed ad libitum access, whereas increasing DMI from 74 to 80% of ad libitum resulted in 17% greater ADG:DMI. Rossi et al. (2000; Exp. 1) indicated that ADG:DMI was 16% greater when steer DMI was increased from 77 to 91% or from 78 to 90% of ad libitum. Perhaps the greater magnitude of increased DMI by AL85, AL90, and AL95 from Period 1 to Period 2 in the present study and(or) equal duration of restriction used across treatments compared with previous studies precluded a more marked increase in gain efficiency.

Period 3. Period 3 DMI did not differ (P>0.39) among treatments, whereas Period 3 ADG was less (P<0.10) for AL100 compared with restricted steers. Period 3 ADG:DMI was approximately 12% greater (P<0.10) for the average of AL85, AL90, and AL95 than for AL100, and ADG:DMI among AL95, AL90, and AL85 increased linearly (P<0.10).

The DMI response of restricted steers in Period 3 was in contrast to that reported by Rossi and Loerch (2001; Exp.1), where steers consumed approximately 18% more during a period of ad libitum access to feed following a pattern of restriction similar to that in the present study (80 and 98% of ad libitum for approximately 70 and 80 d, respectively) than steers allowed ad libitum access. Loerch and Fluharty (1998; Exp. 2) fed steers 80 and 98% of ad libitum in consecutive periods (70 and 56 d, respectively) and indicated that DMI during a final period of ad libitum access to feed did not differ between previously restricted steers and steers allowed ad libitum access to feed. In the present study, AL85, AL90, and AL95 steers gained an average of 13% more BW/d when allowed ad libitum access to feed (Period 3) than control steers. Average daily gain for the previously restricted steers of Loerch and Fluharty (1998; Exp. 2) was numerically increased by approximately 9%, whereas Rossi and Loerch (2001) indicated that ADG by previously restricted steers was either increased (25%; Exp. 2) or numerically increased approximately 16% (Exp. 1).

Overall Performance. Overall DMI was greater (P<0.01) for AL100 than for the average of remaining treatments and decreased linearly (P<0.01) among AL95, AL90, and AL85. Overall carcass-adjusted ADG was greater (P<0.01) for AL100 than for the average of AL85, AL90, and AL95. Overall carcass-adjusted ADG responded quadratically (P<0.05) with increasing DMI restriction; ADG was greater for AL90 than for AL85 and AL95. Overall carcass-adjusted ADG:DMI did not differ (P>0.49) between AL100 and the average of remaining treatments. Overall ADG:DMI responded quadratically (P<0.05) with increasing DMI restriction; ADG:DMI was less for AL95 and AL85 than for AL90.

The increase in DMI by previously restricted cattle when allowed ad libitum access to feed agrees with previously reported data for steers that were prescribed to incremental increases in DMI and ADG (Knoblich et al.,1997; Rossi and Loerch, 2001; Rossi et al., 2001). Steers in several previous studies were fed to a common BW endpoint, allowing a longer duration in interim and final periods in which ADG for restricted steers was greatest. Gain efficiency has been

TABLE 3. Effect of severity of feed intake restriction on carcass characteristics.

Item	Treatment[a]					
	AL100	AL95	AL90	AL85	SE[b]	Contrast[c]
Hot carcass weight, kg	346.2	337.1	340.3	327.2	3.05	x, z
Marbling score	424	410	401	388	12	x
Quality grade distribution						
Prime, %	2.6	0.0	0.0	0.0	—	—
Choice, %	50.7	55.4	41.1	40.6	—	—
Select, %	42.9	38.2	56.3	52.6	—	—
Standard, %	3.9	6.5	2.6	6.8	—	—
Prime + Choice, %[d]	53.3	55.4	41.1	40.6	—	—
Select + Standard, %[d]	46.7	44.6	58.9	59.4	—	—
Fat thickness, cm	1.22	1.18	1.21	1.01	0.07	y
Longissimus area, cm^2	87.2	81.1	84.5	81.5	1.34	x, z
Kidney, pelvic, heart fat, %	2.11	1.95	2.05	1.86	0.06	x, z
Average yield grade	2.79	2.73	2.75	2.56	0.1	—
Yield grade distribution[e], %						
1	13.4	9.1	12.1	19.1	—	—
2	48.9	57.2	43.5	55.8	—	—
3	33.3	29.9	44.4	23.3	—	—
4	4.5	3.9	0.0	1.9	—	—
5	0.0	0.0	0.0	0.0	—	—

[a]AL100 = Ad libitum access to feed for the entire study; AL85 = 75% of DMI by AL100 for 65 d, 95% of DMI by AL100 for 65 d, and ad libitum access to feed for 21 d; AL90 = 80% of DMI by AL100 for 65 d, 100% of DMI by AL100 for 65 d, and ad libitum access to feed for 21 d; AL95 = 85% of DMI by AL100 for 65 d, 105% of DMI by AL100 for 65 d, and ad libitum access to feed for 21 d.

[b]Standard error of the least squares mean, n = 7.

[c]x = AL100 *vs* average of AL95, AL90, and AL85 (P<0.10), y = linear effect among AL95, AL90, and AL85 (P<0.10), z = quadratic effect among AL95, AL90, and AL85 (P<0.10).

[d]Chi-square statistic (P<0.15). Prime and Standard were not analyzed because of limited observations.

[e]Yield grade distributions presented for illustrative purposes.

increased 4 to 9% for restricted steers fed 0 to 2 d longer overall than unrestricted steers [Knoblich et al., 1997 (Exp. 1); Loerch and Fluharty, 1998 (Exp. 2); Rossi et al., 2001]. The 6% greater gain efficiency by AL90 than remaining treatments in the present study seems to agree with these data and suggests that gain efficiency of finishing steers may be improved by restricting DMI to 80% of ad libitum for 65 d of a 151-d feeding period. However, steer ADG under these conditions was numerically less.

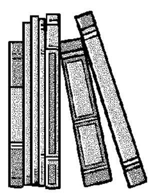
Carcass Characteristics. Hot carcass weight (Table 3) was heavier (P<0.01) for AL100 than for the average of remaining treatments and responded quadratically (P<0.10) among AL85, AL90, and AL95. Marbling score was greater (P<0.10) for AL100 than for the average of the remaining treatments, and the number of carcasses grading Prime + Choice or Select + Standard tended to differ (P<0.15) among treatments. Approximately 14% more carcasses graded low Choice or greater for AL100 and AL95 than for AL90 or AL85. Fat thickness did not differ (P>0.34) between AL100 and remaining treatments; however, fat thickness decreased linearly (P<0.10) for AL85, AL90, and AL95. Longissimus area was greater (P<0.01) for AL100 than for the average of the remaining treatments and responded quadratically (P<0.10) with increasing DMI restriction. Among AL85, AL90, and AL95, longissimus area was greater for AL90 and less for AL85 and AL95. Kidney, pelvic, and heart fat percentage was greater (P<0.10) for AL100, whereas a quadratic response (P<0.05) was evident among remaining treatments. Kidney, pelvic, and heart fat percentage was greatest for AL90, intermediate for AL95, and least for AL85. Average yield grade did not differ among treatments (P>0.34).

Earlier investigations into incremental increases in BW gain through previous feed restriction have reported little influence on carcass characteristics (Knoblich et al., 1997; Loerch and Fluharty, 1998) or decreased fat thickness and marbling score (Rossi et al., 2000) when cattle were fed to the same final BW. However, cattle in the present study were fed a similar number of days. The hot carcass weight response across treatments was approximately twice the magnitude of decreased hot weight computed from previous studies in which restricted and unrestricted cattle were fed a similar number of days [Knoblich et al., 1997 (Exp. 1); Loerch and Fluharty, 1998 (Exp. 2); Rossi et al., 2001]. Longissimus area seemed to mirror the response observed for hot carcas weight, which supports data regarding the relationship between longissimus area and BW (Price, 1977; Yambayamba et al., 1996).

According to Berg and Butterfield (1976), there is a tendency during re-alimentation for cattle to replenish intermuscular fat before rebuilding the subcutaneous depot. Measures of intermuscular fat mass were not obtained in the present study, whereas fat thickness was similar between the averages of AL95, AL90, and AL85 and AL100. Restricting DMI more than an average of 90% of ad libitum over 130 d of the 151-d feeding period was necessary to reduce fat thickness markedly, whereas measures of perirenal and intramuscular fat were generally reduced by all DMI restriction treatments. The combination of the tendency for lesser carcass quality when DMI was restricted and the numeric shifts in yield grade distribution would be expected to have practical economic implications to a feeder. Average carcass prices tabulated from actual quality and yield grade data (excluding carcasses that were dark, heavy, light, bloodshot, or >3.99 yield grade) were \$2.59, \$2.60, \$2.61, and \$2.57/kg for AL100, AL95, AL90, and AL85, respectively.

Implications

Gain efficiency by finishing yearling steers was neither improved nor adversely affected by restricting feed intake up to 75% of ad libitum for the initial 65 d of the feeding period, and steers fed 75 to 85% of ad libitum during this time were not able to subsequently consume more DM than steers allowed ad libitum access to feed. When duration of caloric restriction and length of the feeding period were controlled, programmed feeding to attain graded increases in feed intake by finishing yearling steers generally resulted in slower overall daily BW gain, lower marbling score, and carcasses that were lighter and leaner than yearling steers allowed ad libitum access to feed.



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