South Dakota State University

Department of Animal Science

FINAL REPORT

Evaluation of high-moisture ear corn as a roughage source in finishing diets fed to beef steers

Submitted to: Iowa Beef Industry Council

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NON-TECHNICAL SUMMARY

The experiment titled “Evaluation of high-moisture ear corn as a roughage source in finishing diets fed to beef steers” was conducted at the South Dakota State University Ruminant Nutrition Center located in Brookings, SD. The study was led by Zachary Smith, Ph.D., an Associate Professor in the Department of Animal Science at South Dakota State University (Email: Zachary.Smith@sdstate.edu; Office #: 605-688-5165). The purpose of this experiment was to determine the roughage value of high-moisture ear corn (HMEC), often referred to as earlage, in diets fed to finishing beef steers. This experiment used 192 steers housed in twenty-four pens (6 pens/treatment) with 8 steers per pen. Steers were fed (dry matter basis): 1) a control diet based upon high-moisture corn (HMC) grain (65%), modified distillers grains plus solubles (20%), grass hay (10%) and a suspended supplement (5%), HAY10; 2) a diet based upon HMEC (75%), modified distillers grains plus solubles (20%), and a suspended supplement (5%), EAR14; 3) a diet based upon HMEC (55%), modified distillers grains plus solubles (20%), HMC (20%) and a suspended supplement (5%), EAR10; or 4) a diet based upon HMEC (35%), modified distillers grains plus solubles (20%), HMC (40%) and a suspended supplement (5%), EAR6. Bunks were managed according to a slick-bunk management system and steers were fed monensin (30 g/ton) and administered a steroidal implant (200 mg trenbolone acetate and 20 mg estradiol) on d 28. No beta adrenergic agonist was fed during this experiment. Feeding a lower roughage equivalent from earlage results in decreased DMI with no appreciable change in ADG, resulting in improved gain efficiency.

TECHNICAL REPORT

Impacts

Based upon feed cost of production, yield, and harvest window length, cattle feeders can feed earlage as the sole roughage source with roughage equivalent ranging from 6% to 14% on a DM basis, without detriment to carcass quality, yield grade or altering liver abscess prevalence or severity. Feeding a lower roughage equivalent from earlage results in decreased DMI with no appreciable change in ADG, resulting in improved gain efficiency.

List of quantitative impacts:

- Feeding earlage compared to other roughage sources allows for all roughage to be obtained in a short time frame and earlage can be offered at a laid-in price with no further processing charges and minimal shrink if ensiled appropriately.
- Feeding greater levels of earlage reduces reliance on off-farm feedstuffs
- Earlage can be offered on a roughage equivalent as low as 6% and as high as 14% (DM basis) without harming carcass quality grade.

Introduction

Earlage is a prevalent feed ingredient used by beef producers in the Midwest region of the United States. Earlage is a source of energy (corn) and fiber (corn cob, husk and shank) for cattle producers and can be used to market home-raised feedstuffs through cattle. Earlage is commonly referenced as a processed grain source with “built-in” roughage. A good rule of thumb is that on average earlage is approximately 80% grain and 20% roughage. Many integrated crop-livestock systems may desire to increase the use of earlage for a variety of reasons such as undesirable weather conditions and workload demands at harvest and local demand for field corn depending upon geographical location and proximity to corn markets. Increased use of earlage in finishing diets may be economically beneficial because of ease of inventory and diet management, reduced need for further grain or roughage processing, reductions in off-farm feed purchases. However, knowledge gaps exist related to the true roughage value of earlage when used as the sole roughage source in feedlot finishing diets.

The experimental objective was to determine the roughage value of high-moisture ear corn (HMEC), often referred to as earlage, and impacts on growth performance and carcass traits when included in diets fed to finishing beef steers.

Methods and Results

Materials and Methods

All procedures involving the use of animals in this experiment were approved by the South Dakota State University Institutional Animal Care and Use Committee (Approval #2404-046E).

Charolais × Red Angus cross bred beef steers (n = 192 steers; initial BW 989 ± 52.6 lbs) were used in a 146-d finishing study that was conducted at the Ruminant Nutrition Center (RNC) in Brookings, SD. There were 8 steers assigned to each of the 24 pens used in this experiment. The steers used in this experiment were procured in the fall of 2023 and were used in an unrelated receiving and backgrounding phase experiment. All steers had been previously vaccinated for respiratory pathogens and *clostridial* species. The steers were selected for uniformity of BW and temperament from a pool of 260 steers. All 260 steers were weighed on d 1 and this BW was used for allotment purposes. The final pool of 192 steers were stratified by weight and a random number integer was used to assign cattle to block replicate. Once assigned to block replicate, steers were again stratified by BW and assigned by random number sequence that corresponded to dietary treatment; the combination of block replicate and dietary treatment corresponded to the pen in which the steer would be fed. This method of allocation allows for a similar mean BW and standard deviation for all pens of cattle.

The BW measures collected on d 1 and at the culmination of the experiment on d 146 were shrunk 4% to account for digestive tract fill. Steers were weighed approximately every 28 d during the experiment. Steers received a steroidal implant (200 mg TBA and 20 mg estradiol) and were vaccinated against *clostridial* species on d 28. Implant retention was evaluated on d 56 by a single trained evaluator, abnormal implant rate was 1.6%: abnormalities included partial implant missing (1 steer) and soft inflammation (2 steers). Severe abnormalities including abscessed and abscessed out rate was 0.0%.

A 24-h observation of steers occurred on d 46 and 123, after all steers had been acclimated to people in their vicinity. Behaviors (active, resting, drinking, eating, and ruminating) were noted at the pen level by accounting for the behavior of each steer every 10 minutes during a 24-h period. Behavior evaluation began at 0700h and concluded at 0650h the following day. Chewing time was determined by summing time spent eating and ruminating.

All diets, along with the grass hay and HMEC were subjected to particle separation using the Penn State Particle Separator apparatus. A total of 18 samples were collected for each feed ingredient and diet sample shaken. All samples were shaken by a single technician to minimize measurement error, all methods were conducted according to the procedures outlined in the product manual.

Test diets were fed beginning on study d 1 (Table 1) and fed at 2% of BW (DM basis). Intake was by prescription for the transition to greater concentrate inclusion and *ad libitum* feeding, which required approximately 21 d. All steers were fed diets twice daily in equal portions. Feed deliveries were managed so that there was minimal day-to-day variation in the quantity of feed delivered, and such that only a small portion of feed remained in the bunks each morning. Feed ingredients were sampled weekly for determination of DM. Targeted inclusion of both grass hay and HMEC in the test diets was achieved; composition of the test diets (Table 1) was reconstructed from actual feed batching records and assayed DM content, tabular ingredient composition along with tabular energy values (Preston, 2016) were used; intake records were compiled at 7 d intervals. Steers that were removed from the study or that died during the study were assumed to have consumed feed equal to the pen mean DMI up to the point of removal or death. A single steer was removed during the study because of health reasons unrelated to treatment (Ear10). All pen mean BW data were recalculated after this individual was deleted from the data set.

Individual steer BW was recorded for each animal at d 1, 28, 56, 84, 119, and on d 146 in the morning prior to feeding for the calculation of live growth performance. Body weights were measured prior to the morning feeding; a 4% pencil shrink was applied to initial and final BW.

Observed dietary NE was calculated using live shrunk-basis growth performance, and from daily energy gain (EG; Mcal/d): EG = ADG $^{1.097}$ $0.0557W^{0.75}$, where W is the mean equivalent shrunk BW [kg; (NRC, 1996)]. Using final BW at 28% empty body fat (EBF) as mature final BW (NRC, 1996; Guiroy et al., 2001). Maintenance energy (EM) was calculated by the equation: EM = 0.077(median feeding BW $^{0.75}$). Dry matter intake is related to energy requirements and dietary NEm according to the following equation: DMI = EG/(0.877NEm − 0.41), and can be resolved for estimation of dietary NEm by means of the quadratic formula x =(−b − √b2− 4ac)/2c, where a = −0.41EM, b = 0.877EM + 0.41DMI + EG, and c = −0.877DMI (Zinn and Shen, 1998). Dietary NEg was derived from NEm by the following equation: NEg = 0.877NEm − 0.41 (Zinn, 1987).

The comparative NEm and NEg values HMEC was estimated using the substitution technique. Ingredient NEg values for HMEC was determined for Ear14, Ear10, and Ear6, respectively, and determined as follows: NE HMEC fed at 75% inclusion = (NE Ear14 diet – 0.2435Hay10 diet)/ 0.7565, where 0.2435 and 0.7565 are the proportions of Hay10 diet and Ear14 diet, respectively. NE HMEC fed ay 55% inclusion = (NE Ear10 diet – 0.4400Hay10 diet)/ 0.5600, where 0.4400 and 0.5600 are the proportions of Hay10 diet and Ear10 diet, respectively. NE HMEC fed ay 35% inclusion = (NE Ear6 diet – 0.6401Hay10 diet)/ 0.3599, where 0.6401 and 0.3599 are the proportions of Hay10 diet and Ear6 diet, respectively.

Cattle were shipped when they were visually appraised to have approximately 0.60 in of rib fat (RF). Cattle were shipped in late August of 2024 and harvested the following day at Cargill in Schuyler, NE. Steers were co-mingled at the time of shipping and remained as such until 0700h the morning following shipping. A pen mix-up at the beef plant resulted in loss of carcass data on 47 total steers as they were harvested the night prior to our anticipated harvest time. Individual steer identity was tracked through the harvest facility for the remaining 144 steers that were available the morning of their scheduled harvest. Livers were evaluated for the prevalence and severity of abscessed livers. Hot carcass weight was recorded at the hot scale during the tag transfer procedure. Carcass traits including rib eye area (REA), RF, and USDA marbling scores were obtained from camera data at the packing plant. Dressing percentage (DP) was calculated as: HCW/(Final BW × 0.96). Yield grade was determined using the USDA regression equation (USDA, 1997). Estimated empty body fat percentage was calculated from carcass measurements and BW at 28% EBF was estimated using equations described previously (Guiroy et al., 2001; Guiroy et al., 2002). Estimated proportion of closely trimmed boneless retail cuts from carcass round, loin, rib, and chuck (Retail Yield) was also calculated from carcass traits (Murphey et al., 1960).

Growth performance was calculated on a deads and removals-excluded basis. Growth performance, carcass traits, and particle size analysis of the diet were analyzed as a randomized complete block design using the GLIMMIX procedure of SAS 9.4 (SAS Inst. Inc., Cary, NC) with pen as the experimental unit. Categorical data (i.e. USDA Quality grade and Yield grade) were analyzed as multinomial proportions using the GLIMMIX procedure of SAS 9.4 (SAS Inst. Inc.). For all analyses, the model included the fixed effects of treatment; block was considered a random effect. Least squares means were generated using the LSMEANS statement of SAS. Data means were separated and denoted to be different using the pairwise comparisons PDIFF and LINES option of SAS when a significant preliminary F-test was detected and also by use of orthogonal polynomials (Steel and Torrie, 1960). An α of 0.05 determined significance and tendencies are discussed from 0.05 to 0.10.

Results

Particle size

The distribution of particle size based upon the Penn State Particle Separator apparatus are shown for ingredients and diets in Tables 2 and 3, respectively. There was a linear decrease ($P = 0.01$) in particles greater than 0.75 in. as HMEC concentration in the diet decreased. Diets containing HMEC had a greater amount of diet material retained on the 0.31 in. sieve compared to the Hay diet ($P = 0.01$). There was a linear increase ($P = 0.01$) in particles retained on the 0.16 in. sieve as HMEC concentration in the diet decreased. Finally, diets containing HMEC had a lesser amount of diet material captured below the 0.16 in. sieve compared to the Hay diet ($P = 0.01$) and as HMEC decreased, the proportion of diet material captured below the 0.16 in. sieve linearly ($P = 0.01$) increased.

Growth performance and carcass data

Growth performance and carcass data are presented in Table 4. No difference was noted for ADG when HMEC was compared to hay ($P = 0.31$). However, HMEC inclusion tended to quadratically influence ($P = 0.08$) ADG being maximal for Ear10. Overall, dietary treatment influenced DMI and G:F ($P \leq 0.02$). Lesser inclusion of HMEC quadratically influenced DMI (P =

0.01) being maximal for Ear10 and linearly increased (*P* = 0.02) feed efficiency (i.e. G:F). Steers from Ear6 had greater performance-determined NEm and NEg compared to all other dietary treatments (*P* ≤ 0.02) with lesser total HMEC linearly increasing performance determined NEm and NEg (*P* ≤ 0.01). The ratio of observed-to-expected (O:E) dietary NEm (*P* = 0.01) was greater for HMEC diets compared to Hay10 and O:E dietary NEg (*P* = 0.07) was greatest for Ear14 compared to Hay10, with Ear10 and Ear6 being intermediate, not differing from others (*P* ≥ 0.10). The substitution NEg (Mcal/cwt) value for earlage was estimated to be 65.42, 66.97, and 73.74 (Mcal/cwt), for earlage when included at approximately 75%, 55%, or 35% inclusion on a DM basis. At the highest level of inclusion, these estimates are in good agreement with current feed standards of 61.0 Mcal/cwt NEg (personal communication with industry consultants) and 63.5 Mcal/cwt NEg according to (NASEM, 2016).

Hot carcass weight (HCW) and rib fat (RF) tended to be quadratically (*P* ≤ 0.09) influenced by altering HMEC inclusion, being maximal at Ear10 for HCW and Ear14 for RF, respectively. As HMEC inclusion decreased estimated empty body fatness linearly (*P* = 0.04) decreased and AFBW increased quadratically (*P* = 0.05). Categorical outcomes for liver abscess prevalence and severity, USDA Yield Grade, nor USDA Quality Grade were not influenced by dietary treatment or earlage inclusion level (*P* ≥ 0.26).

Feeding behavior

Feeding behavior outcomes are shown in Table 5. On d 46, steers from Hay10 had greater DMI compared to Ear10 and Ear6 (*P* = 0.01) and as earlage inclusion decreased, DMI linearly decreased (*P* = 0.01). On d 46, time spent active, drinking, or eating was not influenced by dietary treatment ($P \geq 0.28$). However, time spent resting, ruminating and chewing was altered by dietary treatment ($P \leq 0.04$). As roughage equivalent from earlage decreased, DMI as well as time spent ruminating and chewing decreased, but time spent resting increased ($P \leq 0.03$). Finally, as roughage equivalent from earlage decreased, time spent ruminating per pound of DMI linearly decreased ($P = 0.05$). On d 123, steers from Ear6 were consuming less DMI than all other treatments ($P = 0.03$). Steers from Hay10 spent more time eating compared to Ear10 and Ear6 ($P = 0.04$), with Ear14 being intermediate, and not differing from Hay10, Ear10 or Ear6 ($P \geq 0.10$). Steers from Hay10 spent a greater amount of time on d 123 ruminating and chewing compared to all other treatments ($P \leq 0.01$). As roughage equivalent from earlage decreased, DMI was quadratically influenced, being maximal at Ear10 and least for Ear6 ($P = 0.03$) on d 123. Finally, time spent chewing tended to linearly decrease as the roughage equivalent from earlage decreased ($P = 0.07$). Time spent eating, ruminating and chewing per pound of DMI was altered by dietary treatment on d 123 ($P \leq 0.05$). As the earlage level in the diet decreased, time spent eating per pound of feed tended to be altered (quadratic; $P = 0.07$).

Conclusions

Ear10 resulted in the best blend of gain and efficiency compared to all other treatments. As the roughage equivalent from earlage decreased, feed conversion is improved. Based upon feed cost of production, yield, and harvest window length, cattle feeders can feed earlage as the sole roughage source with roughage equivalent ranging from 6% to 14% on a DM basis. Furthermore, earlage inclusion did not alter carcass quality, yield grade or liver abscess prevalence or severity. Feeding a lower roughage equivalent results in decreased DMI with no, resulting in improved gain efficiency.

Unexpected Problems or Outcomes

The earlage material was harvested in an unusually dry and warm fall season, hence the earlage material was a drier than preferred. However, steers used in this experiment exhibited performance typical of cattle originating from the Northern Plains region. Also, observed growth performance was in good agreement with current estimates for maintenance and gain as well as tabular ingredient energy values. We did not observe any issues with feed or management that might compromise the integrity of the data collected. Because of an un-planned cattle mixing event that occurred at the beef plant, a portion of the steers were harvested the night prior to our arrival to the beef plant to conduct the tag transfer process. Hence, carcass data were not available for 47 of the 192 total steers used in this experiment.

Completed and Planned Publications, Presentations, and Outreach Media (no citations for this work are currently available as of 12/4/2024; however, upon publication the citations and a copy of the published results in final form will be shared with the IBIC)

-Refereed Journal Publication: Plan to submit the results from this experiment to The Translational Animal Science (TAS) Journal by May of 2025.

-Reviewed Abstracts: An abstract was submitted to the Midwest ASAS meeting for the 2025 meeting to be held in Omaha, NE. We intend to submit an abstract of this work to the Plains Nutrition Council Conference to be held April 2026 in San Antonio, TX.

-Extension Publications: The results from this experiment will be prepared for submission to the South Dakota State University Animal Science Research Report for 2025 release that will occur around April of 2025. The results from this experiment will also be highlighted by the South Dakota State University Feedlot Extension Specialist in a future popular press release. The short summaries of research that are authored by Warren Rusche, Ph.D. are commonly featured in Drovers, BEEF, and FEEDLOT magazine.

Personnel Support

Weston Peschel and Riley Leeson (M.S. students) and both *graduate research assistants* were partially supported by this grant which covered a full year graduate research assistant stipend, fringe benefits, and tuition. Upon completion of their M.S. degrees each student hopes to pursue a position in beef cattle nutrition and management.

Budget (through November 30, 2024)[1]

Item	Requested, $	Expenses, $	Available, $	Remaining, %
GRA Salaries	19,960.00	17,030.93	1,278.81	6%
Benefits	200.00	53.81	146.19	73%
Travel	0.00	630.77	0.00	0%
Contractual	65,610.00	65,698.89	0.00	0%
Supplies	0.00	930.60	0.00	0%
Tuition	7,661.00	7,661.00	0.00	0%
Total Funds	93,431.00	92,006.00	1,425.00	2%

[1] Reports are generated at the end of each month.

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Table 1. Actual diet formulation and tabular nutrient values.[1]

	Dietary Treatment			
d 1 to 7	Hay10	Ear14	Ear10	Ear6
HMEC, %	0.00	24.85	24.85	24.85
HMC, %	40.06	13.15	13.15	13.15
Corn Silage, %	23.63	34.73	34.73	34.73
MDGS, %	19.07	21.24	21.24	21.24
Hay, %	11.81	0.00	0.00	0.00
Susp. Supp., %	5.41	6.03	6.03	6.03
d 8 to 14				
HMEC, %	0.00	37.66	37.66	37.66
HMC, %	52.45	19.56	19.56	19.56
Corn Silage, %	12.88	16.11	16.11	16.11
MDGS, %	19.33	21.00	21.00	21.00
Hay, %	10.11	0.00	0.00	0.00
Susp. Supp., %	5.23	5.67	5.67	5.67
d 15 to 21				
HMEC, %	0.00	79.30	59.66	59.66
HMC, %	66.89	0.00	19.11	19.11
MDGS, %	17.34	15.70	16.10	16.10
Hay, %	10.25	0.00	0.00	0.00
Susp. Supp., %	5.52	5.00	5.13	5.13
d 22 to 146				
HMEC, %	0.00	75.65	56.00	35.99
HMC, %	64.81	0.00	19.44	39.24
MDGS, %	19.82	19.18	19.34	19.51
Hay, %	10.03	0.00	0.00	0.00
Susp. Supp., %	5.34	5.17	5.22	5.26
Nutrient composition (d 22 to 146)				
Dry matter, %	65.74	62.25	62.82	63.41
NEm, Mcal/cwt	94.22	89.77	92.49	95.26
NEg, Mcal/cwt	63.93	60.92	63.05	65.23
CP, %	15.53	14.78	15.00	15.23
NDF, %	18.89	23.58	20.90	18.18

[1] All values except dry matter are presented on a dry matter basis.

[2] Provided monensin at 30 g/ton and 2.8% NPN to diet DM.

Table 2. Particle size distribution of ingredients according to the Penn State Particle Separator apparatus.

Item	Grass Hay (mean)	Std. Dev.	HMEC (mean)	Std. Dev.
Samples, n	18	-	17	-
Retained, %				
0.75 in. sieve	42.0	6.67	6.9	3.64
0.31 in. sieve	22.2	2.03	34.5	2.05
0.16 in. sieve	14.8	1.41	36.7	2.44
Less than 0.16 in.	21.0	5.67	21.8	3.00

Table 3. Particle size distribution of diets according to the Penn State Particle Separator apparatus.

Item	Hay10	Ear14	Ear10	Ear6	SEM	Overall	Ear. Lin.	Ear. Quad.
Samples, n	18	18	18	18	-	-	-	-
Retained, %								
0.75 in. sieve	4.02[b]	5.73[a]	5.08[ab]	3.60[b]	0.654	0.01	0.01	0.49
0.31 in. sieve	20.32[b]	27.79[a]	25.41[a]	23.01[b]	1.234	0.01	0.51	0.99
0.16 in. sieve	24.81[b]	32.89[a]	32.91[a]	33.79[a]	1.242	0.01	0.01	0.99
Less than 0.16 in.	51.11[a]	33.56[b]	36.59[b]	39.60[b]	2.322	0.01	0.01	0.87

Table 4. Cumulative growth performance responses.[1]

	Treatment[2]					*P* – value		
Item	Hay10	Ear14	Ear10	Ear6	SEM	Overall	Ear Lin.	Ear Quad.
Pens, n	6	6	6	6	-	-	-	-
Steers, n	48	48	48	48	-	-	-	-
Initial BW, lbs	990	989	990	989	-	-	-	-
d 146 BW, lbs	1508	1513	1527	1502	13.2	0.30	0.35	0.07
Initial to d 146								
ADG, lbs	3.54	3.59	3.68	3.51	0.090	0.31	0.32	0.08
DMI, lbs	24.43[a]	24.59[a]	24.43[a]	22.98[b]	0.369	0.01	0.01	0.02
G:F	0.145[c]	0.146[bc]	0.151[ab]	0.153[a]	0.0025	0.02	0.02	0.61
F:G[3]	6.90	6.85	6.62	6.54	-	-	-	-
Gain Eff.[4]	3.49[c]	3.51[bc]	3.63[ab]	3.70[a]	0.0861	0.05	0.20	0.65
Dietary Net Energy (NE), Mcal/cwt								
Maintenance	96.11[b]	95.89[b]	96.89[b]	99.46[a]	1.085	0.02	0.01	0.43
Gain	65.69[b]	65.50[b]	66.38[b]	68.64[a]	0.951	0.02	0.01	0.43
Observed-to-expected NE								
Maintenance	1.03[b]	1.07[a]	1.05[a]	1.06[a]	0.012	0.01	0.27	0.42
Gain	1.04[b]	1.08[a]	1.06[ab]	1.06[ab]	0.014	0.07	0.33	0.29
Earlage Substitution NEg, Mcal/cwt	-	65.42	66.97	73.74	-	-	-	-
Carcass Data								
Pens, n	5	3	5	4	-	-	-	-
Steers, n	38	24	35	32	-	-	-	-

Final BW[1,5], lbs	1505	1516	1529	1505	14.6	0.44	0.52	0.16
HCW, lbs	939	955	966	946	12.4	0.28	0.40	0.09
DP, %	62.45	63.04	63.20	62.84	0.723	0.81	0.69	0.50
RF, in	0.60^{g}	0.62^{g}	0.54^{h}	0.56^{gh}	0.025	0.07	0.12	0.07
REA, in. sq.	14.66	14.73	14.87	14.99	0.252	0.69	0.43	0.98
Marbling	537	528	542	510	20.1	0.55	0.48	0.26
cYG	3.38	3.46	3.26	3.20	0.111	0.28	0.12	0.56
RY, %	49.29	49.13	49.53	49.67	0.231	0.31	0.13	0.61
EBF, %	32.01^{gh}	32.25^{g}	31.44^{gh}	31.22^{h}	0.341	0.10	0.04	0.40
AFBW, lbs	1326^{h}	1341^{gh}	1385^{g}	1363^{gh}	19.9	0.09	0.28	0.05
Categorical Data								
Head[6], n	40	33	36	35	-	-	-	-
Liver Abscess								
Normal, %	85.0	81.8	94.4	91.4	-	0.38	0.26	0.27
A-, %	2.5	6.1	2.8	2.9				
A, %	2.5	3.0	0.0	0.0				
A+ or greater, %	10.0	9.1	2.8	5.7				
Yield Grade								
1, %	0.0	0.0	0.0	5.7	-	0.53	0.27	0.46
2, %	27.5	33.3	33.3	28.6				
3, %	60.0	42.4	63.9	57.1				
4, %	7.5	24.3	2.8	8.6				
5, %	5.0	0.0	0.0	0.0				
Quality Grade								
Select, %	5.0	6.0	0.0	11.4	-	0.93	0.55	0.78
Choice, %	82.5	85.0	83.3	80.0				
Prime, %	12.5	9.0	16.7	8.6				

[1] All BW measures were pencil shrunk 4% to account for digestive tract fill.

[2] Treatments include a target DM inclusion of: Grass hay fed at 10% (DM basis) inclusion (Hay10), Earlage fed a 75% (DM basis) inclusion (Ear14), Earlage fed a 55% (DM basis) inclusion (Ear10), and Earlage fed a 35% (DM basis) inclusion (Ear6).

[3] Calculated as: 1/G:F.
[4] Calculated as: gain at the same level of DMI.
[5] Only including steers where carcass data was obtained and greater than 5 head remained per pen.
[6] All cattle with verified carcass identity.
[a,b] Means within a row lacking a common superscript differ ($P \leq 0.05$).
[g,h] Means within a row lacking a common superscript differ ($P \leq 0.10$).

Table 5. Behavior responses on d 46 and d 123 for RL2450.[1]

	Treatment[2]					*P* – value		
Item	Hay10	Ear14	Ear10	Ear6	SEM	Overall	Ear Lin.	Ear Quad.
Pens, n	6	6	6	6	-	-	-	-
Steers, n	48	48	48	48	-	-	-	-
Behavior (d 46), Min/d								
DMI, lbs	23.37[a]	22.94[ab]	22.10[bc]	21.36[c]	0.551	0.01	0.01	0.91
Active	494	515	518	500	24.7	0.73	0.55	0.61
Resting	457[b]	445[b]	461[b]	502[a]	18.5	0.04	0.01	0.48
Drinking	49	48	58	51	5.9	0.36	0.48	0.11
Eating	149	136	127	137	10.5	0.28	0.96	0.27
Ruminating	291[a]	296[a]	276[ab]	250[b]	14.6	0.03	0.01	0.79
Chewing	440[a]	433[a]	403[ab]	386[b]	19.2	0.04	0.03	0.71
Activity (d 46), Min/lbs of DMI								
Eating	6.4	5.9	5.8	6.4	0.45	0.43	0.26	0.26
Ruminating	12.4	12.9	12.5	11.7	0.59	0.26	0.05	0.73
Chewing	18.8	18.9	18.3	18.1	0.73	0.65	0.39	0.76
Behavior (d 123), Min/d								
DMI, lbs	23.06[a]	22.67[a]	23.45[a]	20.79[b]	0.843	0.03	0.03	0.03
Active	444	474	482	511	26.7	0.14	0.17	0.66
Resting	595	653	651	635	25.0	0.12	0.47	0.75
Drinking	19	18	19	19	3.8	0.99	0.74	1.00
Eating	99[a]	89[ab]	73[b]	78[b]	8.6	0.04	0.21	0.16
Ruminating	283[a]	206[b]	215[b]	196[b]	10.5	0.01	0.43	0.19
Chewing	382[a]	295[b]	288[b]	274[b]	10.4	0.01	0.07	0.73
Activity (d 123), Min/lbs of DMI								
Eating	4.3[a]	3.9[a]	3.1[b]	3.8[ab]	0.38	0.05	0.73	0.06
Ruminating	12.3[a]	9.1[b]	9.2[b]	9.6[b]	0.70	0.01	0.47	0.77
Chewing	16.5[a]	13.0[b]	12.3[b]	13.4[b]	0.73	0.01	0.61	0.16

[a,b] Means within a row lacking a common superscript differ ($P \leq 0.05$).