ROLLED OR WHOLE CORN FOR FEEDLOT STEERS BEING LIMIT- OR AD LIBITUM-FED

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Story in Brief

Effects of processing of dry corn (rolled to two different particle sizes or fed whole) on performance of growing steers fed either ad libitum or restricted to 83% of ad libitum intake for the first half of the finishing period was investigated. Fall-born steer calves (n=144, 540 lb initially) stratified by weight were started on feed in either July, September or November. The high concentrate (92%) diets contained either finely rolled (1,550 μm), coarsely rolled (3,100 μm) or whole (5,700 μm) corn and was provided for ad libitum consumption or supply was limited to 83% of that consumed by ad libitum-fed steers for the first half of the finishing period. For cattle fed ad libitum, feed intake tended to be highest with coarsely rolled corn during the first half of the feeding and over the total trial with no difference during the second half of the trial. Although coarsely rolled corn produced the fastest rate of gain, feed efficiency tended to improve with larger particle size, being best for whole corn. Though limit-fed steers had trends that were similar to ad libitum fed steers, particle size of the corn did not significantly alter their intake or rate or efficiency of gain. Steers fed coarser diets had heavier carcasses and more internal fat than steers fed fine or whole corn; other carcass characteristics were not altered. Carcass traits of limit fed cattle were not altered by particle size of the grain. Although fecal starch, an index of incomplete digestion of the grain, was greater for corn with larger particle sizes, when averaged over the total trial, more starch was passed in feces for steers fed the coarsely rolled grain. Rate and efficiency of gain were best for corn fed whole, especially for cattle given ad libitum access to feed. Limiting intake reduced the impact of particle size on feedlot performance.

(Key Words: Cattle, Whole Corn, Particle Size, Limit Feeding.)

Introduction

Processing corn grain to alter the diameter of grain particles can alter both the site and extent of digestion and thereby alter performance of feedlot steers (Hale, 1973; Turgeon et al., 1983; Secrist et al., 1995). Generally, smaller

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particle sizes lead to more extensive digestion of starch both in the rumen and total tract (Waldo, 1973). However, starch digested by mammalian enzymes in the small intestine may be utilized more efficiently than starch fermented in the rumen (Owens et al., 1986). Flow of starch to the intestine usually is greater from whole and coarsely processed than finely ground, flaked, or high moisture corn (Galyean et al., 1979). Compared with rolled or ground corn, whole corn often produces superior rates and efficiencies of gain by feedlot cattle (Owens et al., 1995). This experiment was designed to investigate the relative importance of corn processing (rolled to two different particle diameters or fed whole) for growing steers fed by two different methods (limit- or ad libitum- feeding).

Materials and Methods

Predominately black, Brangus x English crossbred, fall-born steers (n=144) were received in either July, September or November of 1994 at the feedlot research facilities at Stillwater, OK. All calves came from the same calf crop from the same ranch in northeastern Oklahoma. At weaning (June 1994) the calves were stratified by weight and assigned randomly as blocks to: 1) be placed in the feedlot immediately, 2) graze native range until being placed in the feedlot in September, or 3) graze native range until being placed in the feedlot in November. Upon arrival at the feedlot, steers in each of these three blocks (n=48) were weighed, vaccinated with a modified live virus 4-way respiratory and 7-way clostridial vaccine. After weighing, steers were stratified by weight and allotted randomly to treatment and pen ensuring an equal weight distribution for each pen within each block. The treatments were arranged in a 3 x 2 factorial with date entering the feedlot serving as the block. Three corn processing treatments (finely rolled, coarsely rolled or whole corn) were fed either ad libitum or 83% of that consumed by ad libitum-fed steers.

The steers were housed (8 steers/pen) in 18 partially covered pens (6 pens/block and 3 pens/treatment combination) with slated floors and cement fenceline feedbunks. Table 1 contains relevant information about days fed and implants. All calves were implanted twice (Synovex-S® followed by Revalor- S®) with the second implant at least 70 d before slaughter. The cattle were dewormed with a feed-borne antihelmintic (Safeguard®) after feed intakes had stabilized.

Isocaloric and isonitrogenous dry corn based diets (Table 2) were fed once each afternoon. The basal ingredients (corn, cottonseed hulls and protein supplement) were analyzed for dry matter, crude protein and starch. The diets differed only in the extent to which the dry corn was processed within a few days prior to feeding.

Limit-fed pens received an average of 83% of the amount of feed consumed the previous week by ad libitum-fed pens within particle size and block. After the limit-fed steers had gained approximately 300 lb live weight, they were given ad libitum access to feed for the remainder of the trial. This was equivalent in time to approximately half of the total feeding period for each block.

Corn was rolled with a stacked roller system (2 pairs of rollers) generously loaned by Automatic Feed Mfg. Co., Pender, NE. Corn samples were taken weekly and geometric mean diameter was determined at a commercial laboratory using the method of Ensor et al. (1970). Geometric mean particle sizes were 1,550 μm (fine), 3,100 μm (coarse) and 5,700 μm (whole). Fecal samples were collected from each pen at weighing (monthly) and analyzed for starch, protein nucleic acid nitrogen (purine) content.

Steers were weighed following transport to the feedlot (5 h) and at 28 d intervals thereafter. The carcass-adjusted final weight was calculated by dividing hot carcass weight by 63.5%. A 4% pencil-shrink was applied to all live weights (except d 0) prior to calculating gains. All animals were slaughtered by Excel Corporation, Dodge City, KS. Carcass data were collected following a 48 h chill.

Results and Discussion

Effects of particle size on feedlot performance are summarized for ad libitum- and limit-fed steers in Tables 3 and 4, respectively. Though no significant ($P<.10$) particle size by intake restriction interactions were detected, it was of interest to examine effects within each feeding method to determine if responses to processing were similar for both feed intake levels. Feed intake by ad libitum-fed steers (Table 3) during the first half of the feeding period (Period 1) tended ($P=.07$) to show a quadratic response with the coarsely rolled corn having the highest intake. A similar quadratic trend ($P=.10$) was observed overall. Because limit-fed steers were fed in proportion to intake by steers with ad libitum access to feed, feed intake for limit-fed steers exhibited a similar response numerically to particle size treatment, though differences did not approach significance ($P<.10$).

Gain differences among ad libitum-fed steers reflected differences in feed intake. Responses tended to be quadratic for Period 1 ($P=.13$), Period 2 ($P=.14$), and for the total trial on both a live and a carcass-weight adjusted basis ($P<.05$). Similarly, both live and carcass adjusted finished weights exhibited a significant quadratic effect with steers fed coarsely rolled corn being heaviest. Limit-fed steers cattle responded similarly in Period 1; however, during Period 2, gains only tended ($P=.20$) to increase with increasing particle size. Overall, the effect of particle size on gain by limit-fed steers was not significant. For steers fed ad libitum, feed efficiency tended to respond linearly in Period 1 ($P=.11$) and overall ($P=.09$). However, no effect of particle size on feed efficiency was detected in Period 2. Feed efficiency calculated for limit-fed steers mirrored that of ad libitum-fed steers although differences were not significant.

Carcass data also are summarized in Tables 3 and 4. Carcasses showed no effect of particle size for ad libitum-fed steers, except for heavier carcass weights and higher kidney, heart and pelvic fat of steers fed coarsely rolled corn. This may reflect increased fat which also was evident in numerically higher backfat thicknesses and marbling scores. Such differences were not evident for limit fed cattle. Previous work suggested that marbling score was greatest for cattle fed a medium (1.54 um) particle size corn (Secrist et al., 1995).

Fecal starch should reflect incompletely digested starch when diets contain the same starch concentration (Zinn, 1992). In Period 1, fecal starch of ad libitum-fed steers increased linearly with increasing particle size. However, fecal starch content tended to respond quadratically both in Period 2 and overall (P=.18 and P=.08) with concentrations in feces of steers fed coarsely rolled corn. During Period 1, fecal starch values indicate that finely rolled corn was digested more extensively with little difference between coarsely rolled and whole corn. Presumably, whole corn was reduced in particle size similar to that of rolled corn in Period 1 and perhaps more than rolled corn in Period 2. Chewing has been reported to have limited effect on particle size reduction of previously processed corn. Yet with whole corn, the mean particle size reaching (or leaving) the rumen of steers actually may have been smaller or of more optimum size distribution than that reaching the rumen of steers fed coarsely rolled diets. For limit-fed steers, fecal starch concentration increased linearly with particle size in Period 1(P=.07), Period 2 (P=.09), and overall (P<.03) as particle size increased. When only a limited amount of diet is provided, steers eat more rapidly which may reduce the amount of chewing. This eating pattern may have continued throughout the entire finishing period and could be responsible for the higher fecal starch contents of limit-fed steers consuming whole corn. An alternative explanation for greater benefit from whole corn with ad libitum is that feeding corn whole may have reduced the incidence of subclinical acidosis; this might be expected from the slower ruminal fermentation of whole corn and increased saliva flow due to greater chewing during a meal and more rumination between meals.

Purine content of feces, an indication microbial activity in the large intestine (Zinn and Owens, 1986), should reflect extent of starch fermented in the large intestine. In contrast to expectation, fecal purine concentration was not altered by grain processing method during Period 1 for ad libitum-fed steers. Moreover, in Period 2, fecal purine concentration tended to be higher for steers fed finely rolled corn. Feces of limit-fed steers cattle matched the patterns observed with ad libitum-fed cattle. The mechanism for higher microbial growth in the large intestine with finely rolled corn is not apparent although perhaps the starch reaching the large intestine from finely rolled corn may have been more extensively digested than the larger particles from the less extensively processed corn (coarsely rolled and whole). This would lead to increased large intestinal digestion and the higher purine values for steers fed the finely rolled corn.

Implications

For rate and efficiency of gain, whole corn appeared superior to finely or coarsely rolled corn for finishing steers. However, the advantage for whole corn was not apparent when feed intakes were limited. Cost of processing also should be less when corn is fed whole. Animal age also may be involved, as younger cattle chew their feed more thoroughly and eat slower than older cattle. With less extensive chewing of whole corn, digestibility and energy utilization may be depressed as noted with cows, older yearlings, or when cattle consume feed very rapidly as with limit feeding. For best utilization of whole corn, fines should be removed prior to feeding and supplements should be pelleted to prevent separation of fine materials. Fines may lower ruminal pH and lead to acidosis, liver abscesses and laminitis which in turn hurt gain and feed efficiency. In this study, maximum starch digestibility did not produce the fastest, most efficient or economical gain by feedlot steers.

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Table 1. Implant and days on feed data for blocks.

Block	July	September	November
Date on feed	July 14, 1994	Sept. 15, 1994	Nov. 15, 1994
First implant day (Synovex)	42	0	0
Second implant day (Revalor)	131	93	82
Slaughter date	Feb. 7, 1995	March 7, 1995	May 9, 1995
Total days on feed	208	173	175
Days after last implant	77	80	93

Table 2. Diet and calculated nutrient composition (% of DM).

Ingredient	% of diet dry matter
Dry corn	82.05
Cottonseed hulls	8.00
Soybean meal	4.00
Cottonseed meal	4.00
Limestone	1.00
Urea	.60
Salt	.30
Manganous oxide	.004
Copper sulfate	.001
Zinc sulfate	.002
Vitamin A-30	.01
Rumensin-80	.017
Tylan-40	.013
Calculated[a] nutrient content, dry matter basis	
NEm, Mcal/cwt	95.0
NEg, Mcal/cwt	60.0
Crude protein, %[b]	13.4
Potassium, %[c]	.57
Calcium, %[c]	.44
Phosphorous, %[c]	..32
Magnesium, %	.16
Cobalt, ppm	.01
Copper, ppm	8.5
Iron, ppm	51.5
Manganese, ppm	44.0
Zinc, ppm	34.9

[a] NRC (1984).
[b] Based on Kjeldahl analysis of individual feeds.
[c] Analyzed by commercial laboratory.

Table 3. Feedlot performance and carcass traits for steers fed different corn particle sizes ad libitum: linear (L) or quadratic (Q) effects.

Item	Fine 1,550 µm	Coarse 3,100 µm	Whole 5,700 µm	SEM	P=
Liveweight, lb					
In-weight	537	548	542	3.59	L, .47
Finish live[a]	1101	1174	1140	15.85	Q, .01
Finish carcass[b]	1101	1176	1133	18.27	Q, .02
DM Intake, lb					
First half	16.6	18.2	15.9	.76	Q, .07
Second half	20.0	20.1	18.8	.86	Q, .21
Total	18.3	19.5	17.4	.70	Q, .10
Daily gain, lb					
First half	3.33	3.70	3.57	.14	Q, .13
Second half	2.70	3.05	2.70	.18	Q, .14
Total live	3.18	3.53	3.38	.10	Q, .05
Total carcass	3.02	3.37	3.18	.10	Q, .04
Feed:Gain					
First half	4.94	4.96	4.36	.25	L, .11
Second half	7.38	6.78	6.87	.41	Q, .44
Total live	5.91	5.68	5.27	.22	L, .07
Total carcass	5.93	5.68	5.32	.23	L, .09
Hot weight, lb	699	746	719	11.5	Q, .02
Dress, %	63.6	63.5	63.1	.65	L, .65
Quality grade, %					
Prime	4.2	8.3	0.0	3.5	Q, .21
Choice	45.8	33.3	50.0	6.1	Q, .09
Select	50.0	58.3	45.8	10.5	Q, .46
Standard	0.0	0.0	4.2	3.5	L, .39
Yield grade	3.2	3.2	3.1	.11	L, .60
Marbling score[c]	408	422	410	18.2	Q, .51
Backfat, inches	.59	.60	.57	.03	Q, .65
KPH, %	1.7	2.2	1.8	.09	Q, .01
Ribeye area, in^2	11.4	12.3	12.0	.32	Q, .14

[a]Live-weight with a 4% shrink.

[b]Calculated using carcass weight and average dressing percentage.

[c]Select = 300-399; Choice = 400-499.

Table 4. Feedlot performance and carcass traits for steers limit (83% of ad libitum) fed different corn particle sizes for the first half of the feeding period: linear (L) or quadratic (Q) effects.

Item	Fine 1,550 µm	Coarse 3,100 µm	Whole 5,700 µm	SEM	P=
Liveweight, lb					
In-weight	535	537	544	3.59	L, .10
Finish live[a]	1109	1131	1109	15.85	Q, .29
Finish carcass[b]	1099	1109	1101	18.27	Q, .69
DM Intake, lb					
First half	13.8	14.7	13.6	.76	Q, .32
Second half	20.0	20.1	19.4	.86	L, .61
Total	16.9	17.4	16.5	.70	Q, .50
Daily gain, lb					
First half	2.99	3.12	2.67	.14	L, .09
Second half	3.00	3.03	3.33	.18	L, .20
Total live	3.35	3.44	3.28	.10	Q, .36
Total carcass	3.05	3.08	3.01	.10	Q, .70
Feed:Gain					
First half	4.66	4.75	5.08	.25	L, .25
Second half	6.17	6.48	5.76	.41	Q, .38
Total live	5.38	5.31	5.29	.22	L, .79
Total carcass	5.48	5.52	5.37	.23	L, .79
Hot weight, lb.	697	704	699	11.5	Q, .66
Dress, %	62.9	62.3	63.0	.65	Q, .45
Quality grade, %					
Prime	0.0	0.0	0.0	3.5	1.00
Choice	43.5	45.8	58.3	6.1	L, .10
Select	48.2	54.2	41.7	10.5	Q, .53
Standard	8.3	0.0	0.0	3.5	L, .16
Yield grade	3.1	3.1	3.1	.11	L, .92
Marbling score[c]	414	430	416	18.2	Q, .51
Backfat, inches	.57	.59	.54	.03	Q, .54
KPH, %	1.7	1.8	1.8	.09	L, .36
Ribeye area, in^2	11.7	11.8	11.7	.32	L, .89

[a]Live-weight with a 4% shrink.
[b]Calculated using carcass weight and mean dressing percentage.
[c]Select = 300-399; Choice = 400-499.

Table 7. The effects of corn particle size on fecal characteristics of ad libitum fed steers: linear (L) or quadratic (Q) effects.

Item	Fine 1,550 µm	Coarse 3,100 µm	Whole 5,700 µm	SEM	P=
Starch, %					
First half	16.0	22.5	23.0	1.79	L, .03
Second half	17.5	24.2	17.8	3.71	Q, .18
Total	16.6	23.4	20.7	2.18	Q, .08
Protein, %					
First half	18.2	27.4	18.4	3.50	Q, .06
Second half	21.0	19.2	19.4	.55	L, .11
Total	19.3	23.3	18.9	1.73	Q, .08
Purine, %					
First half	14.3	13.5	14.5	1.16	Q, .58
Second half	14.2	11.8	12.5	.70	Q, .08
Total	14.2	12.7	13.7	.76	Q, .19

Table 8. The effects of corn particle size on fecal characteristics of for steers limit (83% of ad libitum) fed sizes for the first half of the feeding period: linear (L) or quadratic (Q) effects.

Item	Fine 1,550 µm	Coarse 3,100 µm	Whole 5,700 µm	SEM	P=
Starch, %					
First half	17.8	18.6	22.8	1.79	L, .07
Second half	16.8	16.3	25.9	3.71	L, .09
Total	17.5	17.6	24.6	2.18	L, .03
Protein, %					
First half	18.2	17.9	18.2	3.50	Q, .94
Second half	19.5	19.4	18.2	.55	L, .09
Total	18.8	18.5	18.1	1.73	L, .79
Purine, %					
First half	15.1	13.2	13.7	1.16	Q, .36
Second half	13.9	12.8	11.2	.70	L, .02
Total	14.7	13.0	12.5	.76	L, .09