EFFECTS OF PARTICLE SIZE AND DISTRIBUTION OF HIGH MOISTURE CORN ON PERFORMANCE AND CARCASS CHARACTERISTICS OF FEEDLOT STEERS

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Story in Brief

High moisture corn (70% DM) harvested from a single field was processed by four different methods prior to ensiling in Ag Bags®. Processing methods resulted in mean particle diameters and particle distributions (SD) that included fine rolled (1,280 µm, SD=2.04), medium rolled (1,630 µm, SD=2.15), coarse rolled (2,120 µm, SD=2.25), and ground corn (1,830 µm, SD=2.36). Continental-crossbred yearling steer (736 lb initially) stratified by weight were fed corn processed by each of the four corn processing treatments with 12 steers in each of four pens being fed each diet for 97 days when all the corn had been fed. Because particle size and size distribution were confounded (coarser grains having a wider spread) results were analyzed related to 1) mean particle size and 2) standard deviation (SD), an estimate of the distribution in particle size. Rate and efficiency of gain were calculated based on live weight. First, considering particle size, daily gain increased as particle size increased, especially during the final two-thirds of the trial. Percentage of choice carcasses also tended to increase with particle size. This suggests that a mean particle size equal to or larger than one-third that of whole corn kernels is ideal for high moisture corn, a size considerably larger than ideal for dry rolled corn noted in previous studies. Second, considering the distribution of particle size, a greater spread in particle size increased daily gain and improved feed efficiency during the last two-thirds of the study; averaged over the total trial, a wider spread in particle size tended to increase daily gain, percentage of carcasses grading choice, and percentage of kidney, heart and pelvic fat. Little difference in performance was detected between steers fed coarsely rolled vs ground high moisture corn. Overall, the coarser particle size and wider distribution in particle size tended to improve steer performance.

(Key Words: High Moisture Corn, Particle Size, Steers, Processing Method.)

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Introduction

For maximum digestibility by feedlot cattle, grains should be processed as thoroughly as possible; however, fine particles often decrease ration acceptability and increase the incidence of acidosis. Thus, maximum diet digestibility may not yield maximum feed efficiency (Owens et al., 1986; Secrist et al., 1995a). Method of corn processing method (rolling vs grinding) also may affect diet digestibility, and rate and efficiency of gain (Van Koevering et al., 1994; Owens et al., 1995; Secrist et al., 1995b). Ensiling high moisture corn also affects digestion by increasing the grain surface area and starch solubility in the rumen (Theurer, 1986). Smaller particles of high moisture corn have faster rates of starch in the rumen (Galyean et al., 1981). The objectives of these experiments were to examine feedlot performance responses to high moisture grain processing method, namely three particle sizes of rolled corn and two processing methods (rolling vs grinding).

Materials and Methods

Corn grain was harvested from one irrigated field near Guymon, OK on September 9, 1995 at approximately 30% moisture. Approximately 75% of the corn was transported to the Oklahoma Panhandle State University feedlot research facilities at Goodwell, OK and rolled through a commercial, two tiered roller mill (2 roller pairs) provided by Automatic Equip. Mfg., Pender, NE. The corn was processed to three degrees (fine, medium and coarse), ensiled in separate plastic ensiling bags (Ag Bag®), and stored until feeding commenced on January 21, 1995 (d 0). The remaining corn was ground in a commercial tub grinder and transported to Goodwell, OK where it was ensiled and fed in the same manner.

Continental crossbred yearling steers (n=192) were received at Goodwell, OK on January 6, 1995 (d -13) after transport from a local feedyard (15 miles). Upon arrival, the steers were individually weighed, tagged, vaccinated with a 4-way respiratory and 7-way clostridial vaccines, injected with Ivomec-F® and implanted with Synovex-S®. The cattle were reimplanted with Revalor-S® on d 39. The cattle were stratified by weight into four blocks and assigned randomly to one of four corn particle size (PS) treatments. The steers were housed in 16 large outside pens (12 head/pen, 4 pens per treatment) equipped with cement fenceline feedbunks and automatic waterers.

Isocaloric and isonitrogenous high moisture corn based (Table 1) diets were available ad libitum with fresh feed added once each afternoon. The basal ingredients (corn, alfalfa hay and protein supplement) were sampled each month and analyzed in a commercial laboratory for dry matter, crude protein calcium, phosphorus, and potassium. The diets differed only in the extent of corn processing. The starting diet consisting of 50% alfalfa hay and 50% steam-flaked corn was fed from d -13 to d 0 after which cattle were adapted gradually to their test diets by decreasing the roughage level to 8% over a 21-day period. Cattle were fed in this manner through d 97, at which time all corn ensiled and processed for this trial had been fed. From d 98 to finish (d 129 or 130), all steers were fed ground high moisture corn transported daily from a local commercial feedyard.

Steers were weighed following transport to the feedlot (d -13) and on d 0, 14, 39, 69, 97 and 124 of the trial. A 4% pencil-shrink was applied to live weights before gains were calculated. Due to the shortage of specially processed corn, weights taken on d 97 were utilized as a final live weight. ADG for the first 39 days of the feeding period was calculated as the slope of the regression line through the corresponding (d 0, 14 and 39) interim weights. Second half (d 39 to 97) gain was calculated in the same manner using the corresponding (d 39, 69 and 97) interim weights. ADG for the total period was calculated as the slope of the regression line through weights obtained on d 0, 14, 39, 69 and 97.

Corn samples were taken weekly; particle size was determined at a commercial laboratory by the procedure of Ensor et al. (1970). Mean particle size and standard deviation of each particle size for each treatment are presented in Table 2. Cottonseed hull-based pellets containing chromic oxide were fed d 59 through 69 to provide 10 g chromic oxide per d to each animal.. Fecal samples were collected from all pens on d 67 (PM), 68 (AM and PM) and 69 (AM). Fecal samples were composited within each pen across time, dried, ground through a 2 mm screen and analyzed for starch. protein. nucleic acid nitrogen (purine) and chromium content. Total tract organic matter and starch digestibilities were calculated. All animals were slaughtered by Excel Corporation, Dodge City, KS on d 129 or 130. Carcass data were collected following a 48 hr chill.

Data were analyzed utilizing both mean particle size and the particle size standard deviation as the independent numeric variables. Because different processing methods were employed (rolling and grinding), we felt it was important to consider both the effect of particle size distribution as well as of mean particle size. Because these effects are confounded, they cannot be separated. Results of both analyses appear in the text and will be discussed separately.

Results and Discussion

Particle Distribution. Feedlot performance is summarized in Table 2. Because performance responses seemed more closely related to particle distribution than particle size, responses to the standard deviation of mean particle size as the numeric variable (SD) will be discussed first. ADG tended (P=.10) to respond quadratically during the first 39 days on feed. Steers fed the medium (SD-2.15) and coarsely rolled (SD-2.25) corn tended to have higher gain with ground (SD-2.36) corn being numerically lowest. Feed intake responded in the same manner though differences were not significant (P=.20). Feed efficiency during the first 39 days favored the coarsely rolled (SD-2.25) corn tending (P=.18) to respond quadratically. The data suggests that a wide distribution in particle size tended to improve gains and feed efficiency early in the feeding period.

ADG from d 39 to 97 responded linearly, increasing as SD increased. Intake tended (P=.16) to respond in the same manner. Feed efficiency also responded, improving as spread in particle size increased. Results from Period 1 tended to dilute differences noted in Period 2 when overall performance was considered. For the total trial, intake and daily gain tended (P=.15 and P=.10) to increase as SD increased but feed efficiency was not different.

Carcass data also are summarized in Table 2. Kidney, heart and pelvic fat tended (P=.06) to increase as SD increased. No other data reflected this increased fat deposition by cattle fed ground corn (SD-2.36). Steers fed coarsely rolled (SD-2.25) corn tended (P=.10, quadratic) to have an increased percentage of carcasses grade choice but no other carcass data were altered by SD.

Fecal concentration of nutrients and total tract digestibilities are summarized in Table 3. Fecal starch content increased and starch digestibility decreased linearly as SD increased. Purine content tended (P=.06) to increase as SD decreased. Fecal purine concentration should reflect degree of increased microbial activity in the large intestine (Zinn and Owens, 1986). Although one would expect higher purine to accompany high fecal starch, results do not support this premise. Despite lower fecal starch concentration with more highly processed corn, starch from processed corn reaching the large intestine may be more accessible for microbial fermentation. A small amount of whole corn was present in the feed and feces of steers fed ground (SD-2.36) high moisture corn.

Particle Size. Comparison on the basis of particle size ignores the wider spread of particles for ground than rolled corn. Feed efficiency tended (P=.13) to respond quadratically with ground corn (1,830 µm) producing the poorest efficiency during the first 39 d (Table 2). Later in the feeding period, from d 39 to 97, daily gain tended (P=.10, quadratic) to be highest for ground (1,830 µm) and intake tended (P=.20) to be lowest for fine (1,280 µm)corn. Feed efficiency tended (P=.15) to favor ground (1,830 µm) corn. Overall, as particle size increased, both ADG and feed intake tended to be greater (P<.10; P=.15) although feed efficiency was not altered.

Cattle fed coarsely rolled corn (2,120 μm) tended (P=.11, linear) to be heavier and to have a higher (P<.06) percentage of carcasses grade choice. Other carcass data were not altered by PS. Fecal concentration of nutrients and digestibility data (Table 3) were not altered by particle size.

Results are explained most readily when related to differences in the spread of particle size of corn in the diet. Starch digestibility values previously have indicated that corn processed to produce a less variable (and finer) product will maximize digestibility of the starch in the diet. At the time fecal samples were taken in this study (d 70), cattle with the lowest starch digestibility (ground; SD-2.36) had the best rate and efficiency of gain. With some coarser particles, starch digestion may have been shifted from the rumen to the small intestine which could increase energetic efficiency. Further, cattle fed the most highly processed corn may have experienced subclinical acidosis and more erratic feed intake as reflected by lower mean feed intakes by steers fed finely rolled corn). Though liver data were not collected in this trial, severe liver damage associated with acidosis can depress animal performance and could have been a factor in this study.

Implications

High moisture corn mean particle size and distribution impact feed intake, and rate and gain of efficiency. Coarsely processed high moisture corn appeared to increase feed intake and gain during adaptation to high concentrate finishing diets. Particle size distribution may be important later in the feeding period. Compared with rolled high moisture corn, ground high moisture corn had a wider distribution in particle size which may have retarded the rate of ruminal fermentation rate and increased the flow of starch to the small intestine. However, coarsely rolled high moisture corn produced a more desirable diet consistency with fewer fines which should simplify bunk management and thereby increase feed intakes while reducing the probability of acidosis.

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Table 1. Diet and calculated nutrient composition (% of DM)

Ingredient	% of diet dry matter
High moisture corn	86.10
Alfalfa hay	8.00
Soybean meal	2.00
Cottonseed meal	2.00
Limestone	.95
Urea	.60
Salt	.30
Manganous oxide	.004
Copper sulfate	.001
Zinc sulfate	.002
Vitamin A-30	.011
Rumensin-80	.017
Tylan-40	.012
Nutrient content., dry matter basis[a]	
NEm, Mcal/cwt	96.4
NEg, Mcal/cwt	62.3
Crude protein, %[b]	12.6
Potassium, %[c]	.70
Calcium, %[c]	.60
Phosphorous, %[c]	..34
Magnesium, %	.14
Cobalt, ppm	.11
Copper, ppm	7.9
Iron, ppm	101.2
Manganese, ppm	40.2
Selenium, ppm	.16
Zinc, ppm	29.8

[a] NRC (1984).

[b] Based on Kjeldahl analysis of individual feeds.

[c] Analyzed by Servi-Tech Laboratories, Dodge City, KS.

Table 2. Feedlot performance for steers fed rolled (fine, medium or coarse) or rolled high moisture corn: Linear (L) or quadratic (Q) effects. Particle size standard deviation (SD) or mean particle size (PS) used as the independent variables.

Item		Fine	Medium	Coarse	Ground	SEM	P=	P=
	SD	2.04	2.15	2.25	2.36		SD	PS
	PS	(1280 µm)	(1630 µm)	(2120 µm)	(1830 µm)		Analysis	Analysis
Live weight, lb								
Start		736	734	736	739	5.3	L, .98	L, .98
Day 129		1250	1243	1259	1257	8.4	L, .33	L, .11
ADG, lb								
Day 0 to 39		4.08	4.21	4.30	3.79	.18	Q, .10	Q, .32
Day 39 to 97		3.86	4.03	4.12	4.39	.11	L, .005	Q, .10
Day 0 to 97		4.01	4.14	4.28	4.19	.09	L, .10	L, .05
Intake, lb								
Day 0 to 39		16.8	17.4	17.2	17.0	.31	Q, .15	Q, .50
Day 39 to 97		20.7	21.6	21.6	21.8	.55	L, .16	L, .20
Day 0 to 97		19.2	19.8	19.8	19.8	.19	L, .15	L, .15
Feed: Gain								
Day 0 to 39		4.13	4.18	4.02	4.53	.16	Q, .18	Q, .13
Day 39 to 97		5.39	5.36	5.27	5.02	.08	L, .007	Q, .15
Day 0 to 97		4.78	4.80	4.67	4.77	.08	Q, .63	L, .38
Hot weight, lb		787	789	800	796	5.3	L, .22	L, .11
Dress, %		65.4	65.3	65.1	65.4	0.2	Q, .37	L, .36
Marbling Score[b]		336	344	351	344	7.2	Q, .31	L, .19
Choice, %		12.7	21.2	31.8	18.8	5.8	Q, .10	L, .06
Select, %		63.1	61.9	49.0	54.2	10.8	L, .44	L, .34

Table 2. cont'd.

Item		Fine	Medium	Coarse	Ground	SEM	P=	P=
	SD	2.04	2.15	2.25	2.36		SD	PS
	PS	(1280 μm)	(1630 μm)	(2120 μm)	(1830 μm)		Analysis	Analysis
Standard, %		23.2	16.9	17.0	27.1	7.5	Q, .27	L, .67
Backfat, in		.40	.40	.39	.42	.02	Q, .59	Q, .71
KPH, %		1.3	1.4	1.4	1.5	.07	L, .06	L, .28
Yield grade		1.9	2.0	2.0	2.0	.07	L, .92	L, .91
Ribeye area, in^2		14.9	14.9	14.6	14.9	.17	Q, .38	L, .35

[a] Live-weight minus 4% for shrink.

bSelect = 300-399; Choice = 400-499.

Table 3. Fecal concentration of nutrients and calculated digestibilities: Linear (L) or quadratic (Q) effects. Particle size standard deviation (SD) or mean particle size (PS) used as the independent variables.

Item		Fine	Medium	Coarse	Ground	SEM	P=	P=
	SD	2.04	2.15	2.25	2.36		SD	PS
	PS	(1,280 μm)	(1,630 μm)	(2,120 μm)	(1,830 μm)		Analysis	Analysis
Protein, %		16.91	19.16	17.07	15.19	1.7	L, .36	L, .74
Purine, %		10.04	11.73	8.25	7.20	1.2	L, .06	L, .22
Starch, %		5.20	5.61	8.45	11.56	.85	L, .0005	Q, .19
Digestibility, %								
Starch		98.8	98.9	98.1	96.9	.27	L, .0008	Q, .18
Organic matter		84.1	85.5	84.8	80.8	2.1	Q, .23	Q, .62