# Effects of corn particle size and forage level on performance and carcass traits of yearling steers during finishing

C.L. Engel[1], V. L. Anderson[1] and C.S. Schauer[2]

*The objective of this project was to evaluate corn processed by fine grinding or rolling or fed whole in relation to dietary forage level for finishing yearling steers. Results indicate when forage levels are greater than 15.5 percent on a dry-matter basis, dry rolling or finely grinding corn to maintain a particle size greater than 1.35 ± 0.16 millimeters (mm) and less than 5.49 ± 0.14 mm (2.84 ± 0.12 mm on average) will result in optimum feed efficiency and dry-matter intake (DMI) for finishing yearling steers.*


## Summary

One hundred twenty black crossbred yearling steers were used to evaluate the effects of corn processing and particle size (whole, WC; dry rolled, RC; and ground corn, GC; 5.49 ± 0.14 mm, 2.84 ± 0.12 mm and 1.35 ± 0.16 mm mean particle size, respectively) on performance and carcass traits in finishing steers fed diets with decreasing forage levels. The experiment was conducted at the NDSU Carrington Research Extension Center research feedlot during the winter of 2013-14. The amount of forage in the diet on a dry-matter basis started at 31.5 percent and decreased at 41-day intervals to 25 and 15.5 percent and a final level of 13.5 percent for the last 22 days on feed across all three corn-processing level treatments. Forage levels are defined as the sum of the hay fed and 50 percent of the dietary corn silage component. Diets within respective forage levels were similar in ingredients and nutrient composition. Totally mixed rations were offered in concrete fence-line bunks once daily and fed to appetite for each pen. Average daily gain was not different ($P = 0.21$) throughout the entire feeding period. DMI throughout the entire feeding period was greater ($P = 0.01$) for WC, compared with DR and GC, which were not different ($P > 0.05$; 31.8, 29.9, 29.2 pounds/head/day; WC, DR, GC, respectively). Efficiency of gain (gain-to-feed) was not different ($P > 0.05$) for RC (0.169) and GC (0.166) but lower ($P = 0.002$) for WC (0.154). Carcass traits, with the exception of percent of kidney pelvic and heart fat (KPH), were not different ($P \geq 0.07$) among corn-processing levels. The percent of KPH was greater ($P = 0.01$) for WC vs. RC and GC. When forage levels were greater than 15.5 percent of diet dry matter, processing corn vs. feeding whole corn resulted in reduced DMI and improved gain efficiency in finishing rations for yearling cattle.


## Introduction

Corn often is processed by dry rolling, grinding or steam flaking for most feedlot rations. Corn processing has been reported to increase starch digestibility and improve performance of feedlot cattle. Processing corn through a roller or hammer mill breaks open the kernel, exposing the starch fraction and increasing the surface area for moistening and bacterial attachment, which increases the rate of digestion in the rumen. The topic of how much processing and when to process still is debated among producers and nutritionists. Forage level and moisture content of other dietary ingredients, as well as other unknown factors, may interact with the processing level and contribute to the variability in animal response. Our objective was to evaluate the response to differences in corn particle size when higher dietary forage levels are utilized for finishing yearling steers.

## Experimental Procedures

All procedures were approved by the NDSU Animal Care and Use Committee. One hundred twenty black crossbred yearling steers (897 ± 2.52 pounds body weight) were used to evaluate three corn-processing levels in feedlot finishing diets across three decreasing forage levels in a randomized complete block design. Steers were blocked by receiving body weight (four weight blocks) and allotted to one of 12 pens (10 animals per pen) at the NDSU Carrington Research Extension Center. Within each block, pens were assigned randomly to one of three corn-processing treatments to achieve different corn particle sizes: 1) whole corn (WC), 2) dry-rolled corn (RC) and 3) finely ground corn (GC); (Table 1).

Diets were formulated to be similar in protein and energy to meet or exceed National Research Council (NRC) nutrient requirements, and included Rumensin, vitamins and minerals. The amount of forage in

[1]Carrington Research Extension Center, NDSU
[2]Hettinger Research Extension Center, NDSU

**Table 1. Formulation and nutrient composition of diets for yearling steers fed whole, dry-rolled or finely ground corn with decreasing forage levels.**

| Ingredient | 31.5% Forage, period 1[1] | 25% Forage, period 2[1] | 15.5% Forage, period 3[1] | 13.5% Forage, period 4[2] | Overall[3] |
|---|---|---|---|---|---|
| | Dry matter basis | | | | |
| Corn, %[4] | 23.0 | 35.0 | 53.0 | 55.0 | 41.0 |
| MDGS, % | 24.0 | 25.0 | 24.0 | 24.0 | 24.0 |
| Corn silage, % | 39.0 | 28.0 | 13.0 | 11.0 | 23.0 |
| Hay, % | 12.0 | 11.0 | 9.0 | 8.0 | 10.0 |
| Supplement, % | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 |
| Item | | | | | |
| CP, % | 13.4 | 13.8 | 14.1 | 14.1 | 13.8 |
| NEg, Mcal/lb | 0.49 | 0.53 | 0.57 | 0.58 | 0.54 |
| DM, % | 45.2 | 50.5 | 60.7 | 62.3 | 53.2 |
| Diet concentrate, % | 68.5 | 75.0 | 84.5 | 86.5 | 78.5 |
| Diet forage, % | 31.5 | 25.0 | 15.5 | 13.5 | 21.5 |

[1]41 days in each period.
[2]22 days in the period.
[3]Diet composition averaged throughout the entire 145-day finishing trial.
[4]All three treatment diets, within respective forage level periods, were similar in composition. The only difference was how the corn was processed (whole, dry rolled or finely ground).

the diet for all three corn-processing treatments in the initial feeding period was 31.5 percent (dry-matter basis) and decreased at 41-day intervals to 25 and 15.5 percent, followed by a final level of 13.5 percent for the last 22 days of the experiment.

Forage levels are defined as the sum of the hay and 50 percent of the diet corn silage components. Totally mixed diets were offered for *ad libitum* intake and delivered to fence-line bunks once per day. Dietary ingredient samples were collected every 28 days and analyzed for nutritional composition at a commercial lab. Each corn processing type was analyzed for particle size following the procedures of Behnke (1985) at a commercial laboratory using a Tyler Ro-Tap Shaker Model RX-29 and 14 Sieves [4, 6, 8, 12, 16, 20 (with brush), 30 (with brush), 40 (with brush), 50 (with brush), 70 (with brush), 100 (with brush and ball), 140 (with brush), 200 (with brush and ball) and 270 screens plus bottom pan and cover lid]. Mean particle size for the whole, rolled and ground corn was 5.49 ± 0.14 mm, 2.84 ± 0.12 mm and 1.35 ± 0.16 mm, respectively.

Steers were weighed and implanted with 120 milligrams (mg) of trenbolone acetate and 24 mg of estradiol (Revalor S; Merck Animal Health, Whitehouse Station, N.J.) at the start of the trial. Steers were weighed every 41 days for the 145-day feeding period, with the final feeding period of 22 days. One steer died due to causes not related to treatment. All cattle were harvested on the same date at Tyson Fresh Meats, Dakota City, Neb. Hot carcass weights were obtained at harvest. Carcass attributes were evaluated by a trained grader after a 24-hour chill: 12th rib-fat depth; rib-eye area; kidney, pelvic and heart fat (KPH); marbling; and USDA yield grade. Performance and carcass characteristics were analyzed using the GLM procedure of SAS (SAS Inst. Inc., Cary, N.C.) and pen was the experimental unit.

## Results and Discussion

Body weight and average daily gain (ADG) were not different ($P \geq 0.19$) within each forage level period and throughout the entire feeding period (Table 2). Gorocica- Buenfil and Loerch (2005) observed a similar effect on animal performance among cattle fed whole corn, cracked corn or a shifting diet combination of whole or cracked corn with high-forage (18.2 percent corn silage) or low-forage (5.2 percent corn silage) diets. Swanson et al. (2013) found that decreasing corn particle size, through different degrees of dry rolling, did not impact ADG, DMI or G-to-F.

In this study, DMI was similar ($P$= 0.24) for DR and GC and greatest ($P \leq 0.01$) for WC (29.9 = 29.2 < 31.8 pounds, respectively; Table 2). Throughout the entire study, efficiency of gain was greatest ($P$ = 0.003) with RC (0.169) and GC (0.166) and lowest with WC (0.154). A similar efficiency response was observed ($P \leq 0.01$) in the 31.5 and 25 percent forage feeding periods, but the effect diminished as forage levels decreased below 15.5 percent.

Vander Pol et al. (2008) found that feed intake decreased as the level of corn processing increased. They also found feed efficiency was improved for cracked corn vs. whole and fine-ground corn diets. In a review of the literature, Owens et al. (1997) reported that feed efficiency was not improved by dry rolling vs. feeding whole corn. The lack of difference partially was attributed to dietary roughage levels being lower in diets containing whole corn compared with dry-rolled corn (6 vs. 7.9 percent).

In the current study, forage levels were greater throughout the entire feeding period than the stud-

ies reviewed by Owens et al. (1997) and may explain why dry-matter intake decreased with processed corn treatments and RC and GC showed similar improvements in feed efficiency vs. WC. All carcass characteristics, with the exception of percent kidney pelvic and heart fat (KPH), were not different ($P \geq 0.07$) among corn processing levels (Table 3). The percent KPH was not different ($P > 0.05$) for RC and GC but greater for WC ($P = 0.01$).

These results may indicate that when forage levels are greater than 15.5 percent on a dry-matter basis, processing corn by dry rolling or fine grinding to maintain a particle size greater than 1.35 ± 0.16 mm and less than 5.49 ± 0.14 mm (2.84 ± 0.12 mm on average), as compared with whole corn, will result in decreased DMI and improved gain efficiency for finishing yearling steers.

## Acknowledgments

The authors express their appreciation to the North Dakota Corn Utilization Council for partial funding for this study and to the technicians and administrative support personnel at the Carrington Research Extension Center for their contributions to this experiment. Appreciation is also expressed to the Hettinger Research Extension Center for providing the cattle for this work.

## Literature Cited

Behnke, K.C. 1985. Measuring and defining particle size of feedstuffs. In: First international symposium on particle size reduction in the feed industry. Kansas State University, Manhattan, Kan.

Gorocica-Buenfil, M.A., and S.C. Loerch. 2005. Effect of cattle age, forage level, and corn processing on diet digestibility and feedlot performance. J. Anim. Sci. 83:705-714.

Owens, F.N., D.S. Secrist, W.J. Hill and D.R. Gill. 1997. The effect of grain source and grain processing on per-

**Table 2. Animal performance for yearling steers fed diets containing whole, dry-rolled or finely ground corn with decreasing forage levels.**

| | Whole | Rolled | Ground | Std Err | *P*-Value |
|---|---|---|---|---|---|
| **31.5% Forage, period 1**[1] | | | | | |
| Body weight, lb. | 1,141 | 1,153 | 1,148 | 6.56 | 0.52 |
| ADG, lb. | 5.73 | 6.17 | 5.93 | 0.15 | 0.19 |
| DMI, lb. | 27.5 | 26.5 | 26.2 | 0.34 | 0.07 |
| G:F | 0.208[b] | 0.233[a] | 0.227[a] | 0.005 | 0.04 |
| **25% Forage, period 2**[1] | | | | | |
| Body weight, lb. | 1,318 | 1,340 | 1,337 | 8.35 | 0.24 |
| ADG, lb. | 4.12 | 4.35 | 4.39 | 0.12 | 0.30 |
| DMI, lb. | 31.7 | 30.6 | 30.8 | 0.51 | 0.31 |
| G:F | 0.130[b] | 0.143[a] | 0.143[a] | 0.002 | 0.01 |
| **15.5% Forage, period 3**[1] | | | | | |
| Body weight, lb. | 1,510 | 1,530 | 1,512 | 15.99 | 0.71 |
| ADG, lb. | 4.83 | 4.64 | 4.27 | 0.25 | 0.35 |
| DMI, lb. | 35.0[a] | 32.3[b] | 30.9[b] | 0.64 | 0.01 |
| G:F | 0.138 | 0.144 | 0.138 | 0.006 | 0.65 |
| **13.5% Forage, period 4**[2] | | | | | |
| Body weight, lb. | 1,610 | 1,625 | 1,604 | 10.17 | 0.36 |
| ADG, lb. | 5.00 | 5.04 | 4.84 | 0.39 | 0.93 |
| DMI, lb. | 34.2[a] | 30.2[b] | 28.6[b] | 0.66 | 0.002 |
| G:F | 0.146 | 0.167 | 0.17 | 0.016 | 0.66 |
| **Overall**[3] | | | | | |
| Initial body weight, lb. | 901 | 894 | 899 | 2.52 | 0.17 |
| Final body weight, lb. | 1,610 | 1,625 | 1,604 | 10.17 | 0.36 |
| ADG | 4.89 | 5.05 | 4.86 | 0.07 | 0.21 |
| DMI | 31.8[a] | 29.9[b] | 29.2[b] | 0.37 | 0.01 |
| G:F | 0.154[b] | 0.169[a] | 0.166[a] | 0.002 | 0.002 |

[1] 41 days in the period.
[2] 22 days in the period.
[3] overall days on feed, 145 days.
[abc] Means within rows with common superscripts are similar, $P > 0.05$.

**Table 3. Carcass performance for yearling steers fed diets containing whole, dry-rolled or ground corn with decreasing forage levels.**

| | Whole | Rolled | Ground | Std Err | *P*-Value |
|---|---|---|---|---|---|
| Marbling score[1] | 552.9 | 538.0 | 579.3 | 12.01 | 0.12 |
| Hot carcass weight, lb. | 959.3 | 964.2 | 948.5 | 7.13 | 0.34 |
| Backfat, in. | 0.69 | 0.74 | 0.72 | 0.01 | 0.15 |
| REA, sq. in. | 14.16 | 14.06 | 14.38 | 0.13 | 0.26 |
| Yield grade[2] | 3.84 | 3.98 | 3.76 | 0.05 | 0.07 |
| KPH, % | 2.46[a] | 2.29[b] | 2.35[b] | 0.03 | 0.01 |
| Dressing percent, % | 62.8 | 62.5 | 62.5 | 0.22 | 0.67 |

[1] USDA Quality grades based on scores of 300-399 = select, 400-499 = low choice, 500-599 = average choice, 600-699 = high choice, 700+ = prime.
[2] Yield grade is composite calculation of fat to lean yield in a carcass based on a relationship of hot carcass weight, rib-eye area, fat thickness and KPH; low values = lean carcasses.
[abc] Means within rows with common superscripts are similar, $P > 0.05$.

formance of feedlot cattle: A review. J. Anim. Sci. 75:868-879.
Swanson, K C., A. Islas, Z.E. Carlson, R.S Goulart, T.C. Gilbery and M L. Bauer. 2014. Influence of dry-rolled corn processing and increasing dried corn distillers grains plus solubles inclusion for finishing cattle on growth performance and feeding behavior. J. Anim. Sci. 92:2531-2537.
Vander Pol, K.J., M.A. Greenquist, G.E. Erickson, T.J. Klopfenstein and T. Robb. 2008. Effect of corn processing in finishing diets containing wet distillers grains on feedlot performance and carcass characteristics of finishing steers. Prof. Anim. Sci. 24:439-444.