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The Influence of Corn Kernel Traits on Feedlot Cattle Performance

Stephanie L. Jaeger
University of Nebraska-Lincoln

Casey N. Macken
University of Nebraska-Lincoln

Galen E. Erickson
University of Nebraska-Lincoln, gerickson4@unl.edu

Terry J. Klopfenstein
University of Nebraska-Lincoln, tklopfenstein1@unl.edu

Wayne A. Fithian
JC Robinson Seed Co., Waterloo, NE

See next page for additional authors

Authors
Stephanie L. Jaeger, Casey N. Macken, Galen E. Erickson, Terry J. Klopfenstein, Wayne A. Fithian, and David S. Jackson

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Summary

Seven commercially available corn hybrids representing a range within and among kernel traits were used in a finishing trial to evaluate effects of corn kernel traits on feedlot animal performance. Average daily gain, DMI, and hot carcass weight were similar among all corn hybrids. A significant difference in feed conversion of 8.4% from lowest to highest among hybrids was observed. Kernel traits correlated with feed conversion were 1,000 grain weight, stenvert time to grind, and stenvert proportion of soft to coarse particles. Efficiency of finishing cattle gain can be significantly improved by selection of corn hybrids with more desirable kernel traits.

Introduction

Much work has been done to examine effects of corn processing on digestibility and feedlot animal performance. However, studies examining the influence of chemical and physical properties of corn on performance are small in number. If performance differences relating to physical and/or chemical properties can be identified, they would be useful for discriminating among grain sources when purchasing feed. Physical (i.e. test weight, kernel size) and chemical properties (i.e. percentage protein, oil, and starch) are generally very consistent within a corn hybrid yet variable over corn hybrids, making them useful as a tool for predicting feed efficiency differences among hybrids. Some additional kernel traits include total starch content, vitreousness, ratio of amylose to amylopectin, 1,000 kernel weight and kernel hardness. Ruminal digestibility can be predicted by vitreousness (r^2=.89) of the kernel (Philippeau et al., 1999 JAS). In addition, Philippeau also found that ruminal starch degradability could be more easily and just as accurately predicted by combining apparent density and 1,000 grain weight (r^2=.91) compared to vitreousness. However, this second study did not examine animal performance. The objective of this research was to examine seven different commercially available corn hybrids varying in chemical and physical properties and determine the impact of these traits on finishing cattle performance.

Procedure

Corn Grain Production, Hybrids, Harvest, and Storage

Seven different commercially available dent corn hybrids representing a wide range in physical and chemical kernel traits were planted and grown under center pivot irrigation in two similar fields at the Agricultural Research and Development Center during the 2002 growing season. The seven different hybrids consisted of Golden Harvest H-9164Bt (1), H-9235Bt/RR (2), H-9230Bt (3), Pioneer 33B51 (4), and 33P67 (5), and Golden Harvest H-8562 (6), and H-9533Bt (7). Each hybrid was represented equally in the two fields. The grain was harvested between 14 and 18% moisture (variance was across, not within hybrids) within a two-day period and stored in separate grain bins and dried in preparation for the feeding trial. Whole corn was transported to the feed mill facility as needed, dry-rolled and placed in separate commodity bays until fed. At harvest, two raw grain samples were taken of each hybrid from each field and stored separately for laboratory analysis. Samples were placed in nylon mesh bags in the same room for 2 months to allow for moisture to equilibrate between the different hybrids, prior to analysis.

Grain Analyses

Tests were conducted to detect differences in kernel traits among hybrids. Kernel traits analyzed included percentage starch, DM, CP and amylose. Test weight, weight of 1,000 kernels, kernel size, *in-vitro* starch disappearance (IVSD), *in-situ* rate and extent of disappearance, and three different hardness tests were also conducted. Samples were analyzed by replicate within field (n=4) for each hybrid based on samples that were taken at harvest. The *in-situ* procedure used a simulated masticate grind designed to have a particle size similar to masticated dry rolled corn. This grind was produced using a Wiley mill with a 1/4 inch screen. Time points for the *in-situ* procedure were 0, 8, 16, 24, and 72 hours. The IVSD procedure was a 12-hour digestion which utilized two different sized grinds, a fine grind (2mm) and the masticate grind as discussed for the *in-situ* procedure. The hardness tests conducted were floating index, stenvert hardness test and the tangential abrasive dehulling device (TADD).

Table 1. Differences in kernel crude protein and amylose among hybrids within a field.

Hybrid[a]	1	2	3	4	5	6	7	SEM	P-values[b] Corn*Field	Corn	Field
Crude Protein, %								0.06	0.05	<0.01	0.10
Field 1	8.04^{c}	8.88^{e}	8.19^{c}	8.48^{d}	8.97^{ef}	9.12^{f}	8.52^{d}				
Field 2	8.07^{c}	8.83^{e}	8.24^{c}	8.56^{d}	8.96^{e}	8.94^{e}	8.19^{c}				
Amylose,%								1.3	0.04	<0.01	0.04
Field 1	25.6^{c}	23.1^{c}	24.6^{c}	30.5^{e}	29.9^{e}	29.1^{de}	26.0^{cd}				
Field 2	27.2^{de}	25.7^{cde}	24.0^{c}	25.3^{cd}	28.6^{e}	25.2^{cd}	22.7^{c}				

[a]Hybrids consisted of Golden Harvest H-9164-Bt (1), H-9235Bt/RR (2), H-9230-Bt (3), Pioneer 33B51 (4), and 33P67 (5), and Golden Harvest H-8562 (6), and H-9533Bt (7).
[b]F-test statistic for the effect of hybrid.
[c,d,e,f]Means within a row with unlike superscripts differ (P<0.05).

Table 2. Differences in kernel characteristics among hybrids.

Hybrid[a]	1	2	3	4	5	6	7	SEM	P-values[b] Corn
Starch,%	80.2^{k}	77.7^{klm}	78.8^{kl}	79.2^{kl}	76.8^{lm}	74.8^{m}	69.6^{n}	1.2	<0.01
1,000 grain wt., g	324.1^{n}	322.5^{n}	323.3^{n}	317.2^{o}	332.4^{m}	354.5^{k}	348.5^{l}	1.3	<0.01
Test weight, lb/bu	60.2^{o}	62.1^{l}	62.1^{l}	62.5^{l}	63.7^{k}	60.8^{n}	61.6^{m}	0.2	<0.01
Fine IVSD [c]	72.3	72.2	73.3	72.7	70.7	72.8	74.6	0.9	0.15
Masticate IVSD [c]	58.5	57.8	56.0	53.3	54.4	57.0	61.2	2.5	0.37
In-situ rate, %/hr[d]	3.63^{kl}	3.74^{kl}	3.16^{k}	4.15^{l}	3.17^{k}	3.63^{kl}	3.24^{k}	0.2	0.02
% Floaters [e]	96.7^{k}	82.5^{l}	70.7^{m}	70.5^{m}	12.7^{p}	49.0^{n}	35.3^{o}	2.2	<0.01
Tadd, % removed [f]	80.3^{k}	71.9^{mn}	74.5^{lm}	82.7^{k}	70.5^{n}	75.8^{l}	73.2^{lmn}	1.0	<0.01
Stenvert, % hard (g)[g]	26.9^{kl}	27.6^{k}	28.5^{k}	22.6^{m}	26.1^{kl}	20.9^{m}	23.9^{lm}	1.0	<0.01
Stenvert, RPM [h]	294.5^{kl}	292.1^{n}	293.3^{klm}	294.5^{k}	292.6^{mn}	293.3^{mn}	293.3^{lmn}	0.4	<0.01
Stenvert time, s [i]	7.59^{no}	7.82^{mn}	9.68^{k}	8.07^{m}	8.68^{l}	7.31^{o}	7.90^{mn}	0.1	<0.01
Stenvert, % soft ht.[j]	71.6^{k}	67.4^{l}	64.0^{m}	67.9^{l}	63.0^{m}	72.6^{k}	71.0^{k}	0.8	<0.01

[a]Hybrids consisted of Golden Harvest H-9164-Bt (1), H-9235Bt/RR (2), H-9230-Bt (3), Pioneer 33B51 (4), and 33P67 (5), and Golden Harvest H-8562 (6), and H-9533Bt (7).
[b] F-test statistic for the effect of hybrid.
[c]Percent starch disappearance.
[d]Rate of DM disappearance.
[e]Measured as % kernels floating in a solution of 31.3 Baume' sodium nitrate solution which responds to a specific gravity of 1.275.
[f]Measured as percentage of original sample weight removed following abrasion by the TADD.
[g]Measured as weight of 425 micrometer overs divided by total sample weight.
[h]Reduction in hammermill speed from 360 RPM.
[i]Measured time to grind 17 ml of sample.
[j]Measured as height in cm and calculated as a percentage of total height.
[k,l,m,n,o,p]Means within a row with unlike superscripts differ (P<0.05).

Feedlot Experiment

Two hundred twenty-four crossbred steer calves (609 lb) were stratified by weight and assigned randomly to 1 of 28 pens (8 steers/pen). Pens were assigned randomly to 1 of 7 hybrids. Diets were formulated to meet or exceed NRC (1996) recommendations. All diets among the seven treatment groups were identical except for the hybrid fed as dry-rolled corn. Cattle were adapted to grain by feeding 35, 25, 15, and 5% alfalfa hay (DM basis) replacing corn in each treatment diet and fed for 3, 4, 7 and 7 days; respectively. The final diet consisted of 66.0% dry-rolled corn, 20.0% wet corn gluten feed, 10.0% corn silage and 4.0% supplement (DM basis). Rumensin® and Tylan® were included at 29 and 10 g/ton of diet DM, respectively.

Initial weights were determined using an average of two consecutive morning weights taken before feeding at the beginning of the trial, following a 5-day limit-feeding period. During the experiment, cattle were fed once daily and allowed ad libitum access to feed and water. Steers were implanted with Synovex-S on day 1 and reimplanted with Revalor-S on day 71. Cattle were fed for 167 days and harvested at a commercial packing plant (IBP, West Point, Neb.) where carcass data were collected. Hot carcass weight and liver abscess scores were taken on the day of slaughter. Following a 24-hour chill, 12th rib fat thickness, USDA called marbling score, and yield grade data were collected.

Results

Corn Grain Production and Analyses

The average yield for each of the test hybrids 1 through 7 were 229, 208, 221, 209, 222, 203 and 207 (15.5% corrected moisture) bushels per acre, respectively. However, growing production was not designed to test for yield differences. As expected, a wide range of values for the analyses existed. The average values across all hybrids for percentage CP, and amylose were 8.6%, and 26.2% respectively. There was a hybrid by field interaction for CP, and percentage amylose (Table 1). *In-vitro* starch disappearance was not different among hybrids which averaged 72.7% disappearance for the fine grind and 56.9% for the masticate grind. There were significant differences among hybrids for all other traits measured (Table 2). The percent floaters ranged from 12.7 to 96.7%, with hybrid 5 as the softest and hybrid 1 the hardest. However, results from the Tadd loss indicate hybrid 4 as the softest (82.7% loss), while hybrid 5 is the hardest (70.5% loss). Additionally, the measurements from the stenvert hardness test conflict with the floating and Tadd test. The stenvert hardness test measurements for % hard, grinding time, and % soft height all indicate that hybrid 6 is the softest.

Table 3. Differences in *In-situ* percentage DMD at various time points among hybrids.

Hybrid[a]	1	2	3	4	5	6	7	SEM	P-values[b]
Time 0	9.95[c]	7.90[de]	5.81[f]	9.16[cd]	6.55[ef]	9.76[c]	6.85[ef]	0.50	<0.01
8	38.2[c]	34.2[cd]	31.8[d]	36.0[cd]	33.5[d]	36.0[cd]	32.0[d]	1.60	0.06
16	50.3[cd]	47.4[de]	45.8[e]	50.4[cd]	47.1[de]	53.1[c]	47.5[de]	1.38	<0.01
24	63.7[c]	60.4[cde]	56.9[de]	59.0[cde]	55.3[e]	61.9[cd]	61.9[cd]	2.04	0.06
72	91.9[cde]	94.8[c]	90.0[de]	94.9[c]	89.6[de]	93.1[cd]	89.1[e]	1.40	0.01

[a]Hybrids consisted of Golden Harvest H-9164-Bt (1), H-9235Bt/RR (2), H-9230-Bt (3), Pioneer 33B51 (4), and 33P67 (5), and Golden Harvest H-8562 (6), and H-9533Bt (7).
[b] F-test statistic for the effect of hybrid.
[c,d,e,f]Means within a row with unlike superscripts differ (P<0.05).

Table 4. Effects of corn hybrid on steer performance and carcass characteristics.

Hybrid[a]	1	2	3	4	5	6	7	SEM	P-values[b]
DMI, lb/day	21.8	22.0	22.5	21.9	21.3	21.5	21.2	0.4	0.23
ADG, lb	3.90	3.83	3.81	3.80	3.72	3.97	3.79	0.07	0.37
Feed:gain[c]	5.63[fg]	5.77[ef]	5.95[e]	5.84[ef]	5.77[ef]	5.45[g]	5.62[fg]	0.08	<0.01
Hot carcass weight, lb	794	788	785	784	775	802	783	8	0.33
Marbling score[d]	575	552	525	563	546	543	516	14	0.10
12th rib fat, in.	0.56	0.58	0.49	0.56	0.49	0.53	0.51	0.03	0.20

[a]Hybrids consisted of Golden Harvest H-9164-Bt (1), H-9235Bt/RR (2), H-9230-Bt (3), Pioneer 33B51 (4), and 33P67 (5), and Golden Harvest H-8562 (6), and H-9533Bt (7).
[b]F-test statistic for the effect of hybrid.
[c]Statistically analyzed as gain:feed, which is the reciprocal of feed:gain.
[d]450 = Slight^{50}, 500 = Small^{0}, 550 = Small^{50}, etc.
[e,f,g]Means within a row with unlike superscripts differ (P<0.05).

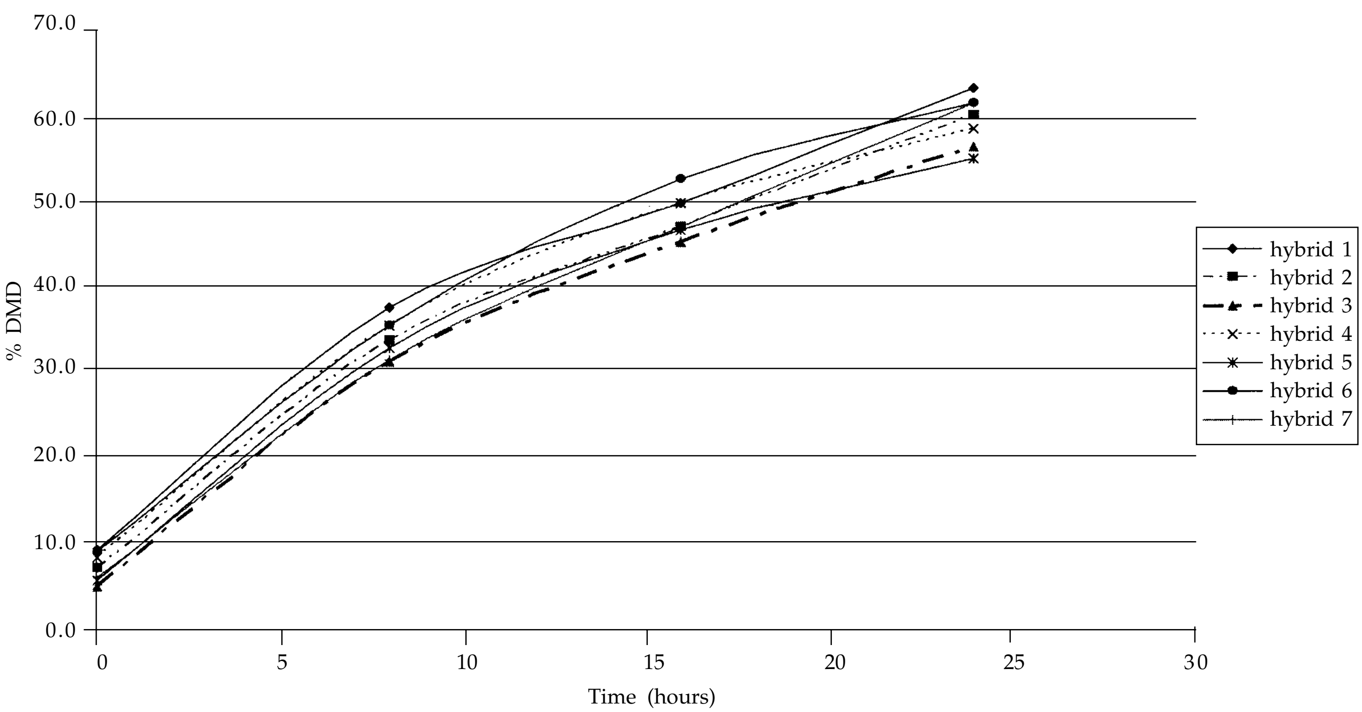

Figure 1. Twenty-four hour *In-Situ* dry matter disappearance by hybrid.

Percentage starch averaged 76.7%, while test weight and 1,000 grain weight averaged 61.9 lb/bu and 331.8 g across all hybrids after the air drying process. There was a significant difference in disappearance rates from the *in-situ* procedure (P=0.02). The hybrid that had the slowest disappearance rate was hybrid 5 (3.17%/hour) while the hybrid with the fastest rate was number 4 with a rate of 4.15%/hour. The improvement in overall disappearance rate of hybrid 4 over hybrid 5 was 31.3%. This difference may be due to differences in extent of digestion, because a greater extent of digestion generally results in an increased rate of digestion. The extent of digestion was calculated using the 72-hour time point. Additionally, differences in percentage DMD among hybrids at each of the individual time points were observed. When examining the DMD from the *in-situ*, there is no single hybrid that separates itself from the rest at all of the 5 different timepoints (Table 3). However, the DMD at the 16-hour time point may be the best indicator of actual DMD in a commercial feedlot setting, since this is the most realistic retention time when compared with the other time points from the *in-situ* procedure. A diagram depicting the percentage DMD over 24 hours by hybrid is shown in Figure 1.

Feedlot Experiment

Animal performance and carcass data are shown in Table 4. The average across all hybrids for DMI and ADG were 21.7 and 3.8 lb/day respectively, and were similar across all hybrids. There was a significant difference in feed conversion (P<0.01) among hybrids. Cattle fed hybrid 6 had the lowest feed conversion while hybrid 3 had the highest among the seven hybrids. The improvement in feed conversion of hybrid 6 over hybrid 3 was 8.4%. Carcass characteristics did not differ among hybrids.

There was no relationship between feed conversion and in situ DMD, which conflicts with previous research (Ladely et al., 1994 JAS). However, there was a highly correlated relationship of F/G with 1,000 grain weight (r = -0.81). As 1,000 grain weight increases, the ratio of F/G declines. Interestingly, hybrid 6 produced the lowest F/G and had the highest 1,000 grain weight. However, the increased 1,000 grain weight does not appear to be related to increased density (weight/volume) because hybrid 6 was also one of the lower test weight hybrids. Perhaps kernels from this hybrid are larger and softer resulting in greater 1,000 grain weight without increased test weight.

A similar relationship is evident between the ratio of stenvert soft to coarse particle height and feed conversion (r = -0.83). As the proportion of soft particles increase, F/G decreases. Stenvert grinding time and feed conversion were related; as time to grind the corn increases, feed conversion increases (r = 0.83). The stenvert time to grind is related to kernel hardness, with a longer grinding time being indicative of harder kernels. Additionally, the ratio of soft to coarse particles is an indicator of hardness, with the higher proportion of coarse particles representing a harder kernel. The relationships from this study between cattle performance and kernel traits imply that cattle fed hybrids with higher proportions of soft endosperm and higher 1,000 grain weight gain more efficiently than cattle receiving corn hybrids with a harder endosperm or a low thousand grain weight in a dry rolled corn based diet.

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[1]Stephanie L. Jaeger, graduate student; Casey N. Macken, research technician; Galen E. Erickson, assistant professor; Terry J. Klopfenstein, professor; Animal Science, Lincoln; Wayne A. Fithian, agronomy systems manager, JC Robinson Seed Co., Waterloo, NE; David S. Jackson, professor, Dept. of Food Science and Technology, Lincoln.