Evaluation of KWS hybrid rye on growth performance, carcass traits, and efficiency of net energy utilization in finishing feedlot steers

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Objective

Our objectives were to determine the effects of hybrid rye inclusion on finishing steer performance and carcass characteristics, and to estimate net energy (NE) value.

Study Description

Predominately Angus steers (n = 240, initial shrunk bodyweight [BW] = 891 ± 40.8 pounds) were used in 117-d finishing experiment. Hybrid rye was used to replace either one-third, two-thirds, or 100% of dry-rolled corn (DRC) resulting in four treatments: [DRC:Rye, DM basis (60:0), (40:20), (20:40), and (0:60)] with six pens per treatment and 10 steers/pen. Performance adjusted NE values were calculated from performance and carcass data. Replacing DRC with rye linearly decreased ($P \leq 0.01$) carcass-adjusted final BW, ADG, DMI and G:F. Feeding rye linearly decreased HCW and ribeye area ($P \leq 0.04$). Liver abscess scores and carcass grades were unaffected by treatment ($P \geq 0.09$). Estimated NEm and NEg values for rye when included at 60% of the diet DM were 0.86 and 0.57 Mcal/lb, respectively.

Take Home Points

Hybrid rye can be used in finishing diets. Net energy value of hybrid rye is approximately 84% compared to DRC and partial replacement of DRC with rye resulted in positive associative effects where ADG and G:F were greater than expected.

Introduction

There has been increased interest in planting cereal rye as a complement to a corn-soybean rotation. Adding a third crop has resulted in enhanced corn yields compared to a corn-soybean rotation under South Dakota conditions (Sexton, 2020) and would also spread out labor and equipment requirements more broadly during the growing season. Hybrid cereal rye genetics introduced recently to the North American market offer increased yield potential and reduced ergot risk compared to traditional varieties.

Cereal rye offers harvest flexibility in that it could be grazed, cut for hay or silage, or harvested as grain. Most rye grain now enters the milling or distilling channels, but the ability to use rye in livestock diets would enhance the utility of the crop by providing additional market outlets. Little research has been conducted on the feed value of rye grain with no published data on the value of hybrid rye in North American beef systems utilizing corn co-products. The objective of this study was to determine the effects of rye grain inclusion on finishing steer performance and carcass characteristics, as well as to estimate the net energy value of hybrid rye.

Experimental Procedures

All procedures were approved by SDSU Institutional Animal Care and Use Committee (IACUC, approval # 19-047E).

Experimental design and treatments

Four treatments were used in a completely randomized design to evaluate animal performance, carcass traits, and to estimate the NE value for hybrid rye. Hybrid rye (Rye) was substituted for dry-rolled corn (DRC) as follows: a basal finishing diet formulated (DM basis) with 60% corn grain (DRC:Rye, 60:0) and three additional diets formulated with increasing proportions of Rye (40:20, 20:40, and 0:60). All rye grain used was from the same hybrid (KWS Bono, KWS Cereals, LLC; Champaign, IL) and from a single source. Each truckload of Rye was sampled on arrival at Southeast Research Farm (SERF) and composited for ergot alkaloid analysis. Total ergot alkaloid concentration from the composited sample was 392 ppb on a DM basis, less than the recommended maximum ergot alkaloid concentration of 2 ppm for cattle diets (Coufal-Majewski et al., 2016).

Animals, initial processing, and study initiation

A total of 240 predominately Angus steers (initial shrunk BW 891 ± 40.8 lbs.) were used in this a completely randomized design. Steers were sourced from a single consignment at one South Dakota sale barn and delivered to the SERF facilities near Beresford, SD. Steers were processed on September 6, 2019, where BW was collected to be used for allotment purposes, a unique identification tag was applied to each steer, vaccines administered against respiratory pathogens: infectious bovine rhinotracheitis (IBR), bovine viral diarrhea (BVD) types 1 and 2, parainfluenza-3 virus (PI3), and bovine respiratory syncytial virus (BRSV) (Bovi-Shield Gold 5, Zoetis, Parsippany, NJ) and clostridial species (Ultrabac 7/Somubac, Zoetis), and administered pour-on moxidectin (Cydectin, Bayer, Shawnee Mission, KS). The study was initiated on September 10, 2019 with a 19-d adaptation period and a 98-d finishing period, resulting in a total experiment length of 117 d. Steers were administered a steroidal implant (200 mg trenbolone acetate and 28 mg estradiol benzoate; Synovex Plus, Zoetis) on d 19.

Diets and intake management

Steers were fed once daily. Steers were stepped up to the final diet over a 19-d period. From d 8 to d 14 Rye was introduced to the step up diets at 40% of the ultimate inclusion rate (0, 8, 16, and 24%, respectively) with the final proportions of Rye fed in experimental diets from d 15 to d 19. The final diets fed (d 20 to 117) are presented in Table 1. Bunks were managed to be slick at 0800h most mornings. Feed intake and diet formulations were summarized weekly. 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. Two steers (one from 60:0 and one from 40:20) died or were removed from the study for reasons unrelated to dietary treatment, thus all data are reported on a deads and removals excluded basis.

Rye was processed by passing whole rye through a roller mill (Lone Star Enterprises, Lennox, SD). Rolls were adjusted so that the processing index (PI) for Rye was 78.8 ± 2.29 where PI was defined as the test weight (lb/bu) of the grain (as-is) after processing expressed as a percentage of the test weight of the unprocessed grain.

Cattle management and data collection

Steers were weighed at the time of study initiation, d 19, 47, 75, and the morning of study termination on d 117. Body weights were measured before the morning feeding with a 4% pencil shrink applied to initial and final BW. Wet weather combined with temperatures generally greater than 32º F during the final 40 d of this experiment resulted in greater than normal amounts of mud at harvest. Therefore, carcass-adjusted performance using HCW adjusted to a common dressing percentage of 62.5% was used to determine cumulative performance and efficiency measures with unshrunk BW used for interim performance measures.

Steers were weighed off test on d 117 when they were visually appraised to have 0.5 in of fat at the 12th rib (RF). Cattle were shipped 48 h after final BW determination and harvested the next day at Tyson Fresh Meats in Dakota City, NE. Steers were commingled at the time of study termination and remained as such until 0700h the morning after shipping. Prevalence of abscessed livers and abscess severity were determined by a trained technician using the Elanco system as Normal (no abscesses), A- (1 or 2 small abscesses or abscess scars), A (2 to 4 well organized abscesses less than 1 in diameter), or A+ (1 or more large active abscesses greater than 1 in diameter with inflammation of surrounding tissue). Video image data were obtained from the plant for ribeye area, RF, calculated USDA Yield Grade (YG), and USDA marbling scores. Dressing percentage was calculated as HCW/(final BW × 0.96). Estimated empty body fat (EBF) percentage and final BW at 28% EBF (AFBW) were calculated from observed carcass traits (Guiroy et al., 2002), and proportion of closely trimmed boneless retail cuts from carcass round, loin, rib, and chuck (Retail Yield, RY; (Murphey et al., 1960).

Performance-adjusted Net Energy (paNE) was calculated from daily energy gain (EG; Mcal/d): EG = (carcass-adjusted ADG from d 20 to 117)1.097 × 0.0557W0.75, where W is the mean equivalent shrunk BW [shrunk BW × (478/AFBW), kg; (NRC, 1996)] for the period from d 20 to 117. Maintenance energy required (EM; Mcal/d) was calculated by the following equation: EM = 0.077BW0.75 (Lofgreen and Garrett, 1968) where BW is the mean shrunk BW (using the average of carcass-adjusted final BW and BW from d 20). Using the estimates required for maintenance and gain the paNEm and paNEg values (Owens and Hicks, 2019) of the diet were generated using the quadratic formula: $x = \frac{-b \pm \sqrt{b^2-4ac}}{2c}$, where x = NEm, Mcal/kg, a = -0.41EM, b = 0.877EM + 0.41DMI + EG, c = -0.877DMI, and NEg was determined from: 0.877NEm – 0.41 (Zinn and Shen, 1998; Zinn et al., 2008).

The comparative NEm values for rye were estimated using the replacement technique. Given that the NEm value of dry-rolled corn was 0.98 Mcal/lb (NASEM, 2016), the comparative NEm values for rye were estimated as follows (Estrada-Angulo et al., 2019): Rye NEm, Mcal/kg = [(test diet paNEm – control diet paNEm)/RYEy] + 2.17, where RYEy represents the inclusion of rye that replaced dry-rolled corn in the diet (0.1991, 0.3993, and 0.6004), respectively. The same was done for NEg, assuming the dry-rolled corn had a NEg value (Mcal/lb) of 0.68 (NASEM, 2016). Associative effects of feeding combinations of DRC and Rye on ADG and G:F were determined by subtracting the observed performance from the expected values (Huck et al., 1998). Expected ADG for steers fed 20% Rye was calculated as (0.667 × ADG for steers fed 60:0) + (0.333 × ADG for steers fed 0:60). The same formula was used to calculate ADG for the two-thirds Rye combination. Similar formulas were used to calculate the associative effect of gain to feed.

Statistical analysis

Growth performance, carcass traits, and efficiency of dietary energy utilization were analyzed as a completely randomized design using the MIXED procedure of SAS 9.4 (SAS Inst. Inc., Cary, NC) with pen as the experimental unit. The model included fixed effect of dietary treatment. Least squares means were generated using the LSMEANS statement of SAS and treatment effects were evaluated using orthogonal polynomials (Steel and Torrie, 1960). Dry matter intake was evaluated in the MIXED procedure of SAS 9.4, using repeated measures, the model included the fixed effects of treatment, day, and their interaction; day was included as the repeated variable; pen was considered the experimental unit. The covariance structure with the lowest Akaike information criterion was used. Distribution of USDA Yield and Quality grade, as well as liver abscess severity and prevalence data were analyzed as binomial proportions in the GLIMMIX procedure of SAS 9.4 with fixed effects in the model as described previously. An α of 0.05 or less determined significance and tendencies are discussed between 0.05 and 0.10.

Results and Discussion

Animal growth performance

During the adaption phase (d 1 to d 19), Rye increased ADG ($P = 0.01$) and reduced F:G ($P = 0.01$) as shown in Figure 1. Over the course of the experiment, DMI for 20:40 and 0:60 plateaued resulting in linear decreases in DMI with increased inclusions rate of rye ($P = 0.02$, Figure 2).

The effect of replacing DRC with Rye on animal growth performance and dietary energy are shown in Table 2. Replacement of DRC with Rye decreased (linear effect, $P = 0.01$) carcass-adjusted final BW, decreased (linear effect, $P = 0.01$) DMI, increased (linear effect, $P = 0.01$) F:G, and decreased (linear effect, $P \leq 0.01$) observed dietary NE.

Replacement of DRC with Rye did not influence ($P \geq 0.31$) observed/expected dietary NE. The lack of differences for observed/expected dietary NE ratio lends support to the reliability of tabular NE values for feed ingredients used in the present study. Based on observed performance from d 19 to 117 (the time the steers were on the final diet and DMI was near the steers acclimated plateau), the estimated replacement NEm and NEg value for Rye were 86.18 and 56.69 Mcal/cwt, respectively (Table 2). The positive associative effect for replacing one-third of the DRC with Rye for ADG and G:F was 3.8 and 3.1 percent, respectively. This is consistent with the 9.5 and 12.8% increased NEm and NEg estimates observed in this study for rye fed at 20% of diet DM compared to 60% inclusion.

Carcass trait responses

Treatment effects on carcass characteristics and liver abscess severity and prevalence are shown in Table 3. Replacement of DRC with Rye decreased (linear effect, $P \leq 0.04$) HCW, REA, and final BW adjusted to 28% EBF. Replacement of DRC with Rye decreased dressing percentage (quadratic effect, $P = 0.02$), with responses maximal at the 20:40 and 0:60 level. There were no treatment effects ($P \geq 0.09$) on distribution of USDA Yield or Quality Grade, or liver abscess prevalence or severity.

Implications

Our results show that hybrid rye can be successfully fed to finishing beef steers. Blends of two-thirds DRC to one-third rye were the optimal inclusions rate of hybrid rye in the current experiment compared to increased inclusions of hybrid rye. These results should provide additional confidence that utilizing hybrid rye in finishing cattle diets is a viable marketing option for hybrid cereal rye if this crop is more widely adopted in the region.

Acknowledgements

The authors with to acknowledge Scott Bird, Research Assistant, Southeast Research Farm for the daily care and management of the cattle in this study. The research was sponsored in part by KWS Cereals USA, LLC, Champaign, IL 61822.

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Tables

Table 1. Composition of experimental finishing diets fed to steers from d 19 to 117 (DM basis).

Item	DRC:Rye grain inclusion (DM basis)			
	60:0	**40:20**	**20:40**	**0:60**
Ingredient composition (%, DM)				
Dry rolled corn	60.34	40.33	20.22	0.00
Hybrid rye	0.00	19.91	39.93	60.04
MDGS[1]	18.90	18.95	19.00	19.04
Corn silage	16.84	16.89	16.93	16.97
Liquid Supplement[2]	3.91	3.92	3.93	3.94
Nutrient composition (DM basis)[3]				
NE_M, Mcal/cwt	94.20	91.40	88.59	85.75
NE_G, Mcal/cwt	63.82	61.42	59.01	56.59
CP, %	12.78	13.62	14.47	15.32
NDF, %	18.90	20.91	22.94	24.98
ADF, %	9.88	11.10	12.32	13.54
Ash, %	4.83	4.92	5.01	5.09
Ether extract, %	4.69	4.35	4.01	3.67

[1] MDGS, modified distillers grains plus solubles
[2] Provided 30 g/ton of monensin as well as vitamins and minerals to exceed requirements (NASEM, 2016)
[3] Tabular NE from (Preston, 2016) and actual nutrient compositions from weekly assays of the ingredients.

Table 2. Influence of replacing dry-rolled corn (DRC) with Rye grain on growth performance and dietary energy of feedlot steers.

Item	DRC:Rye grain inclusion, % DM basis				SEM	P –value		
	60:0	40:20	20:40	0:60		0 vs. Rye	Linear	Quadratic
Pens, n	6	6	6	6	-	-	-	-
Steers, n	59	59	60	60	-	-	-	-
Cumulative								
Initial BW, lb[1]	885	890	892	896	-	-	-	-
Final BW, lb[2]	1432	1429	1393	1367	10.8	0.01	0.01	0.32
ADG, lb	4.68	4.60	4.28	4.03	0.094	0.01	0.01	0.36
DMI, lb	28.01	27.71	27.29	26.74	0.148	0.01	0.01	0.42
F:G	6.01	6.03	6.38	6.63	0.110	0.01	0.01	0.32
G:F	0.167	0.166	0.157	0.150	0.0030	0.02	0.01	0.38
Energetics assessment period (d19 to 117)								
d 19 BW, lbs[1]	941	952	963	972	5.0	0.01	0.01	0.84
Final BW, lb[2]	1432	1429	1393	1367	10.8	0.01	0.01	0.32
ADG, lb	5.01	4.86	4.38	4.03	0.117	0.01	0.01	0.40
Associative effect, %[3]	-	3.8	0.5	-	-	-	-	-
DMI, lb	29.40	29.02	28.51	27.86	0.176	0.01	0.01	0.43
F:G	5.89	5.99	6.51	6.92	0.128	0.01	0.01	0.25
G:F	0.170	0.167	0.154	0.145	0.0034	0.01	0.01	0.39
Associative effect, %[3]	-	3.1	0.7	-	-	-	-	-
Observed dietary NE, Mcal/cwt								
Maintenance	93.98	93.20	89.71	86.54	1.225	0.01	0.01	0.34
Gain	63.82	63.14	60.08	57.30	1.075	0.01	0.01	0.34
Observed/Expected dietary NE ratios								
Maintenance	0.99	1.02	1.01	1.01	0.014	0.31	0.65	0.36
Gain	1.00	1.03	1.02	1.01	0.018	0.35	0.73	0.35
Estimated NE value of Rye, Mcal/cwt								
Maintenance	-	94.35	87.54	86.18	-	-	-	-
Gain	-	63.96	58.06	56.70	-	-	-	-

[1] Body weight (BW) was shrunk 4% to account for digestive tract fill.
[2] Calculated as: HCW/0.625.
[3] Calculated as [(observed – expected)/expected] × 100.

Table 3. Influence of replacing dry-rolled corn (DRC) with Rye grain on carcass traits and liver abscess prevalence in feedlot steers.

Item	DRC:Rye grain inclusion, % DM basis				SEM	P –value		
	60:0	40:20	20:40	0:60		0 vs. Rye	Linear	Quadratic
Carcass Traits								
Final BW, lb[1]	1489	1509	1491	1459	11.4	0.82	0.05	0.04
HCW, lbs	895	892	871	855	6.7	0.01	0.01	0.33
DP, %[2]	60.10	59.12	58.42	58.56	0.221	0.01	0.01	0.02
RF, in	0.51	0.51	0.51	0.49	0.014	0.78	0.46	0.55
REA, in^2	12.91	13.12	12.72	12.53	0.155	0.52	0.04	0.22
Marbling	474	478	485	445	11.3	0.74	0.14	0.07
KPH, %	1.79	1.80	1.81	1.79	0.014	0.59	0.71	0.48
YG	3.40	3.32	3.37	3.32	0.063	0.43	0.54	0.85
RY[3], %	49.67	49.83	49.72	49.82	0.136	0.46	0.60	0.82
EBF[4], %	30.29	30.19	30.43	29.78	0.253	0.59	0.27	0.29
AFBW[5], lb	1321	1320	1281	1279	9.9	0.02	0.01	0.99
YG dist.								
1, %	1.67	0.00	0.00	0.00	0.833	-	0.41	-
2, %	13.70	23.89	11.67	21.67	5.261	-	0.31	-
3, %	64.26	64.26	78.33	70.00	8.218	-	0.59	-
4, %	20.37	11.85	10.00	8.33	5.453	-	0.43	-
QG dist.								
Select, %	20.56	15.00	13.33	30.00	4.966	-	0.11	-
Choice, %	50.37	50.93	53.34	48.33	7.590	-	0.97	-
Prem. Ch.,%	29.07	34.07	30.00	21.67	6.517	-	0.60	-
Prime, %	0.00	0.00	3.33	0.00	1.054	-	0.09	-
Liver Scores								
Normal, %	69.44	74.63	65.00	70.00	4.909	-	0.60	-
A-, %	13.52	5.00	13.33	13.33	4.419	-	0.46	-
A, %	8.52	10.00	6.67	6.67	3.360	-	0.87	-
A+, %	8.52	10.37	15.00	10.00	4.365	-	0.75	-

[1] Live BW from d 117 pencil shrunk 4%.
[2] Calculated as: [(HCW/Final BW) × 100].
[3] Retail yield
[4] Empty body fat, %
[5] Adjusted final body weight

Figures

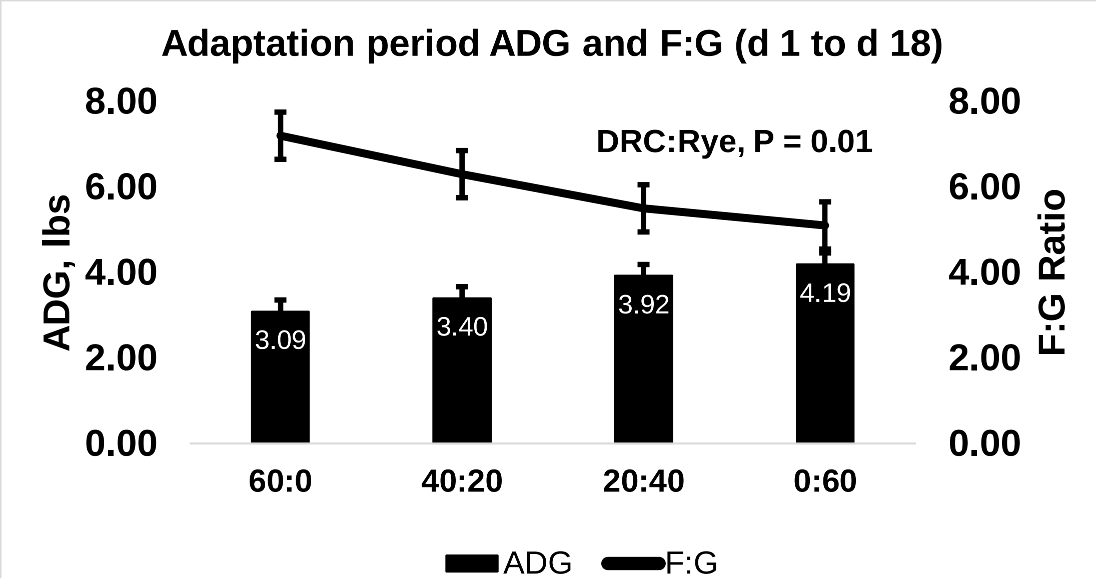

Figure 1. Average daily gain and feed efficiency during adaptation phase (d 1 to d 18)

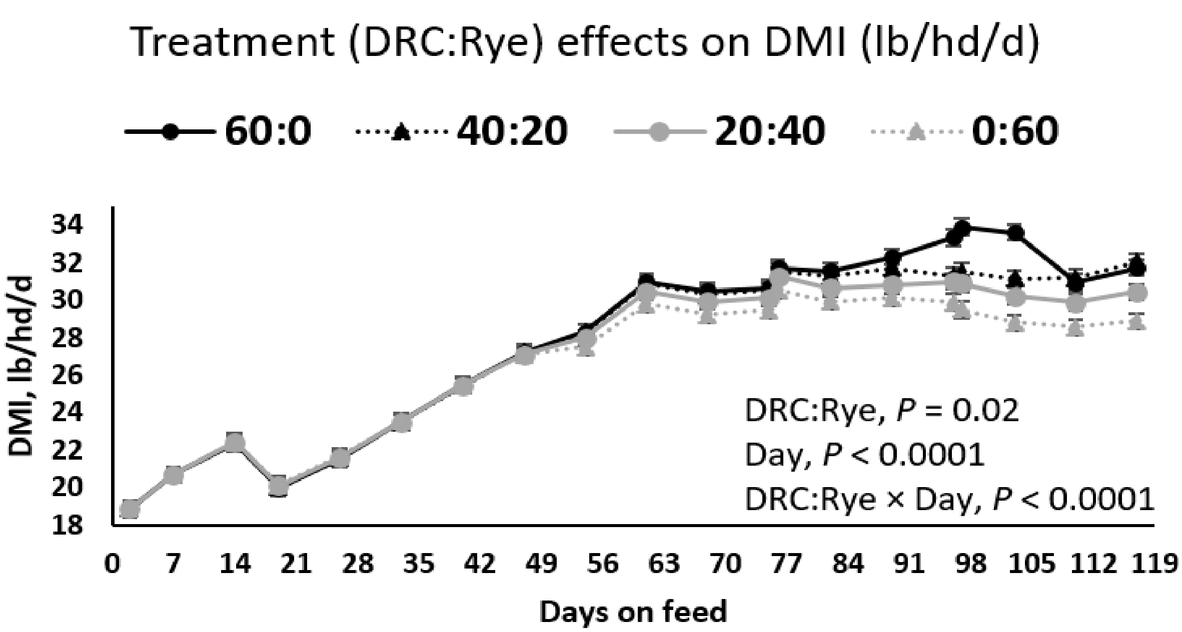

Figure 2. Treatment effects on dry matter intake (lb/head/day)