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Short communication

Preference for feed, but not growth performance, is reduced if hybrid rye replaces corn in diets for growing pigs

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A R T I C L E I N F O

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A B S T R A C T

Two experiments were conducted to test the hypotheses that there is no difference in feed preference for diets containing hybrid rye or corn as the exclusive cereal grain source, and that hybrid rye may replace a portion of corn in diets for growing pigs without adversely affecting growth performance. In experiment 1, thirty-six pigs (initial body weight 32.0 ± 1.8 kg) were housed for 8 days in 18 pens with one gilt and one barrow in each pen. Each pen contained 2 identical feeders with one feeder containing a corn-based diet and the other feeder containing a diet based on hybrid rye. On each day, feed disappearance was calculated, feed allotment was recorded, and feeder positions were switched to minimize feeder preference. In experiment 2, one hundred and twenty eight growing pigs (initial body weight: 27.2 ± 2.2 kg) were allotted to 32 pens and 4 dietary treatments. A diet identical to the corn diet used in experiment 1 was used as the control diet, and 3 additional diets in which increasing proportions of corn were replaced with hybrid rye, were also formulated. Diets were fed for 27 days and body weights were determined at the start and at the end of the experiment. Results of experiment 1 demonstrated that preference (%) for the hybrid rye-based diet was less ($P < 0.05$) than for the corn-based diet on each day and for the overall experiment. Results of experiment 2 indicated that there were no differences among treatments for initial or final body weight of pigs. Average daily gain (ADG) was not affected by dietary treatment, and the same was true for gain:feed (G:F). There was a tendency (linear, $P < 0.10$) for average daily feed intake to be reduced as hybrid rye inclusion in the diet increased. The reluctance of pigs to consume hybrid rye in the first experiment may be due to simple taste preference, but the satiating effects of the dietary fiber in hybrid rye in the gastro-intestinal tract may also have contributed to the reduced feed intake observed in the second experiment. Nevertheless, ADG and G:F were unchanged by hybrid rye substitution for corn, indicating that growing pigs may be fed diets with high inclusion rates of hybrid rye without negatively impacting growth.

1. Introduction

Varieties of hybrid rye originally developed in Europe are superior to older cultivars of rye because they have greater grain yield, better uniformity, and greater lodging resistance (Geiger and Miedaner, 2009). Hybrid rye's ability to withstand drought, poor soil quality, or extreme cold better than other crops makes it an alternative to growing corn or other cereal grains (Geiger and Miedaner,

Abbreviations: ADG, average daily gain; ADFI, average daily feed intake; DDGS, distillers dried grains with solubles; G:F, gain:feed.

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2009). Results of research from Europe and Canada have demonstrated that replacing barley with hybrid rye in diets for growing and finishing pigs does not reduce animal growth performance (Schwarz et al., 2015, 2016; Bussières, 2018), but substituting hybrid rye for wheat reduced average daily gain (ADG) and average daily feed intake (ADFI) in finishing pigs (Smit et al., 2019). In many parts of the world, including the United States, corn is the primary energy source in diets for pigs, but there are limited data comparing growth performance of growing pigs fed diets in which hybrid rye replaces corn. Unfamiliarity with hybrid rye makes some producers in the United States reluctant to feed hybrid rye to pigs, as there is a long-standing belief that rye is less palatable than other feed ingredients (e.g., Brooks, 1911; Halpin et al., 1936; Sharma et al., 1981). In addition, rye has not been used in diets for pigs in large amounts due to concerns of ergot contamination, antinutritional factors, and poor palatability (Antoniou et al., 1981). However, varieties of hybrid rye developed in recent years in Germany have reduced susceptibility of ergot contamination (Miedaner and Geiger, 2015). Taste preference of weanling pigs for a diet in which 500 g per kg of the corn in the diet was replaced by hybrid rye was reduced compared with a diet with only corn, but replacing some of the corn (i.e., 150–600 g per kg) in diets for weanling pigs did not impact growth of pigs (McGhee and Stein, 2021). Therefore, it is hypothesized that replacing some of the corn in diets for growing pigs with hybrid rye will not impact growth performance; however, data demonstrating this are limited. To our knowledge, there are also no published data for the preference of growing pigs above 25 kg for consuming hybrid rye versus corn. Therefore, 2 experiments with growing pigs were conducted to test the hypotheses that there is no difference in feed preference for diets containing hybrid rye or corn, and that hybrid rye may replace a portion of corn in diets for growing pigs without adversely affecting growth. Because hybrid rye contains approximately 94 % of the metabolizable energy compared with corn (McGhee and Stein, 2020a), and pigs generally consume feed to

Table 1
Composition of diets in experiment 1 (as-is basis).

Item	Corn	Hybrid rye
Ingredient, g/kg		
Hybrid rye	–	674.5
Corn	673.8	–
Soybean meal	270.0	270.0
Soybean oil	30.0	30.0
Ground limestone	8.5	9.9
Dicalcium phosphate	10.0	7.7
L-lysine HCl, 780 g/kg Lys	1.8	1.5
DL-methionine, 980 g/kg Met	0.2	0.5
L-threonine, 980 g/kg Thr	0.2	0.4
Sodium chloride	4.0	4.0
Vitamin-mineral premix[a]	1.5	1.5
Analyzed composition		
Dry matter, g/kg	875.1	877.7
Ash, g/kg	44.9	43.0
Gross energy, MJ/kg	16.76	16.67
Metabolizable energy[b], MJ/kg	14.36	13.68
Starch, g/kg	423.8	326.3
Insoluble dietary fiber, g/kg	110.0	158.0
Soluble dietary fiber, g/kg	13.0	34.0
Total dietary fiber, g/kg	123.0	192.0
Acid-hydrolyzed ether extract, g/kg	57.7	43.5
Crude protein, g/kg	177.2	190.5
Amino acids, g/kg		
Arg	12.0	11.6
His	4.8	4.5
Ile	8.3	7.9
Leu	16.2	13.4
Lys	11.3	11.3
Met	2.7	3.0
Cys	2.8	3.1
Phe	9.7	9.4
Thr	7.2	7.1
Trp	2.2	2.3
Val	8.7	8.7

[a] The vitamin-micromineral premix provided the following quantities of vitamins and micro minerals per kg of complete diet: vitamin A as retinyl acetate, 11,150 IU; vitamin D_3 as cholecalciferol, 2210 IU; vitamin E as selenium yeast, 66 IU; vitamin K as menadione nicotinamide bisulfate, 1.42 mg; thiamin as thiamine mononitrate, 1.10 mg; riboflavin,6.59 mg; pyridoxine as pyridoxine hydrochloride, 1.00 mg; vitamin B_{12}, 0.03 mg; D-pantothenic acid as D-calcium pantothenate, 23.6 mg; niacin, 44.1 mg; folic acid, 1.59 mg; biotin, 0.44 mg; Cu, 20 mg as copper chloride; Fe, 125 mg as iron sulfate; I, 1.26 mg as ethylenediamine dihydriodide; Mn, 60.2 mg as manganese hydroxychloride; Se, 0.30 mg as sodium selenite and selenium yeast; and Zn, 125.1 mg as zinc hydroxychloride.

[b] Metabolizable energy was calculated rather than analyzed and based on the value 13.18 MJ/kg metabolizable energy in hybrid rye (McGhee and Stein, 2020a), and values for all other ingredients according to NRC (2012).

meet their energy requirement (Patience, 2012), it was also hypothesized that growing pigs fed hybrid rye will consume more feed compared with pigs fed corn to compensate for the reduced metabolizable energy in hybrid rye.

2. Materials and methods

Two experiments were conducted following protocols that were approved by the Institutional Animal Care and Use Committee at the University of Illinois (protocol number 19130). Pigs used in the experiment were the offspring of Line 359 boars and Camborough sows (Pig Improvement Company, Henderson, TN, USA).

2.1. Animals, housing, experimental design

2.1.1. Experiment 1

Thirty six pigs (i.e., 18 gilts and 18 barrows; initial body weight: 32.0 ± 1.8 kg) were allotted to a completely randomized design. One barrow and one gilt were housed in each pen; therefore, there were 18 replicate pens in the experiment. All pens had slatted floors, 2 nipple waterers, and 2 identical stainless-steel feeders. One diet based on corn and soybean meal, and one diet based on hybrid rye and soybean meal, were formulated to meet or exceed the estimated nutrient requirements for 25–50 kg pigs (NRC, 2012; Table 1). Both diets were in meal form. Diets were formulated based on published values for metabolizable energy, standardized ileal digestible amino acids, and standardized total tract digestible P in hybrid rye (McGhee and Stein, 2018, 2019) and corn and soybean meal (NRC,

Table 2
Composition of diets in experiment 2 (as-is basis) in which 33, 66, or 100 % of corn in a corn-soybean meal control diet was replaced with hybrid rye.

	Corn replacement rate, %			
Item	0	33	66	100
Ingredient, g/kg				
Corn	673.7	451.4	222.5	–
Hybrid rye	–	222.4	451.6	674.5
Soybean meal	270.0	270.0	270.0	270.0
Soybean oil	30.0	30.0	30.0	30.0
Limestone	8.5	8.9	9.4	9.9
Dicalcium phosphate	10.0	9.4	8.6	7.7
L-lysine HCl, 780 g/kg Lys	1.9	1.8	1.7	1.5
DL-methionine, 980 g/kg Met	0.2	0.3	0.4	0.5
L-threonine, 980 g/kg Thr	0.2	0.3	0.3	0.4
Salt	4.0	4.0	4.0	4.0
Vitamin-mineral premix[a]	1.5	1.5	1.5	1.5
Analyzed composition				
Dry matter, g/kg	877.2	871.4	878.9	878.8
Ash, g/kg	44.2	44.9	46.8	47.9
Gross energy, MJ/kg	16.70	16.63	16.59	16.63
Metabolizable energy[b], MJ/kg	14.36	14.13	13.90	13.68
Starch, g/kg	423.8	395.6	373.6	326.3
Insoluble dietary fiber, g/kg	121.0	134.0	158.0	155.0
Soluble dietary fiber, g/kg	10.0	10.0	21.0	46.0
Total dietary fiber, g/kg	131.0	144.0	179.0	200.0
Acid-hydrolyzed ether extract, g/kg	60.1	54.2	47.1	46.5
Crude protein, g/kg	169.0	176.0	190.6	191.4
Amino acids, g/kg				
Arg	12.2	11.6	11.9	12.0
His	4.8	4.8	4.8	4.8
Ile	8.8	8.2	8.4	8.4
Leu	16.3	15.1	14.8	13.8
Lys	11.9	12.0	11.7	11.5
Met	2.8	3.0	3.2	3.4
Cys	3.0	3.2	3.3	3.5
Phe	9.7	9.3	9.6	9.6
Thr	7.1	7.1	7.4	7.8
Trp	2.2	2.4	2.2	2.3
Val	9.3	8.8	9.1	9.2

[a] The vitamin-micromineral premix provided the following quantities of vitamins and microminerals per kg of complete diet: Vitamin A as retinyl acetate, 11,136 IU; vitamin D_3 as cholecalciferol, 2208 IU; vitamin E as DL-alpha tocopheryl acetate, 66 IU; vitamin K as menadione dimethylpri-midinol bisulfite, 1.42 mg; thiamin as thiamine mononitrate, 0.24 mg; riboflavin, 6.59 mg; pyridoxine as pyridoxine hydrochloride,0.24 mg; vitamin B_{12}, 0.03 mg; D-pantothenic acid as D-calcium pantothenate, 23.5 mg; niacin, 44.1 mg; folic acid, 1.59 mg; biotin, 0.44 mg; Cu, 20 mg as copper sulfate and copper chloride; Fe, 126 mg as ferrous sulfate; I, 1.26 mg as ethylenediamine dihydriodide; Mn, 60.2 mg as manganese sulfate; Se, 0.30 mg as sodium selenite and selenium yeast; and Zn, 125.1 mg as zinc sulfate.

[b] Metabolizable energy was calculated rather than analyzed and based on the value 13.18 MJ/kg kcal/kg metabolizable energy in hybrid rye (McGhee and Stein, 2020a), and values for all other ingredients according to NRC (2012).

2012). Experimental diets were fed to pigs for 8 days. All pigs were allowed ad libitum access to the corn-soybean meal diet in one feeder and the hybrid rye-soybean meal diet in the second feeder. Ample amount of feed was offered to pigs daily ensuring that feeders never were empty. The positions of the 2 feeders were switched daily to minimize the effect of feeder location preference. Feed allotment and disappearance were recorded daily during the 8 day experiment.

2.1.2. Experiment 2

A total of 128 growing pigs with an initial body weight of 27.2 ± 2.2 kg were allotted to a completely randomized design with 4 treatment groups. Pigs were housed in an environmentally controlled barn with partially slatted floors, a nipple waterer, and a stainless-steel feeder. Thirty-two pens were used with 4 pigs per pen and 8 replicate pens per treatment. Sex was balanced within pen. All pigs had free access to water and feed.

Pigs were fed experimental diets for 27 days, and all diets were fed in mash form. A control diet primarily based on corn and soybean meal was formulated (Table 2). Three additional diets were formulated by replacing 330, 660, or 1000 g per kg of the corn in the control diet with hybrid rye. All diets were formulated to meet or exceed the estimated requirements for standardized ileal digestible amino acids, vitamins, and minerals for 25–50 kg pigs (NRC, 2012). Diets were formulated based on published values for metabolizable energy, standardized ileal digestible amino acids, and standardized total tract digestible P in hybrid rye (McGhee and Stein, 2018, 2019) and corn and soybean meal (NRC, 2012). Diets were not formulated to be isocaloric or isonitrogenous; therefore, as hybrid rye inclusion rate increased, the calculated concentration of total dietary fiber and crude protein increased, whereas the calculated concentration of metabolizable energy decreased. This approach was used to determine if the lower metabolizable energy in hybrid rye would result in reduced feed efficiency in pigs. Individual pig weights were obtained at the beginning and at the conclusion of the experiment. Feed allowance was recorded daily, and feed left in the feeders at the conclusion of the experiment was weighed to calculate feed disappearance.

2.2. Chemical analyses

Samples of diets from both experiments were analyzed for dry matter by oven drying at 135 °C for 2 h (method 930.15; AOAC Int, 2007). These samples were also analyzed for ash (method 942.05; AOAC Int, 2007). Nitrogen was measured (method 990.03; AOAC Int, 2007) using a Leco Nitrogen Determinator (model FP628, Leco Corp., St. Joseph, MI, USA) and crude protein was calculated as 6.25 × N. Diets were analyzed for insoluble dietary fiber and soluble dietary fiber on an Ankom Total Dietary Fiber Analyzer (Ankom Technology, Macedon, NY, USA) using method 991.43 (AOAC Int, 2007). Total dietary fiber was calculated as the sum of insoluble and soluble dietary fiber. Starch was analyzed by the glucoamylase procedure (method 979.10; AOAC Int, 2007), which yields the enzymatically hydrolyzed starch in the sample. The gross energy in diets were measured using an isoperibol bomb calorimeter (model 6400, Parr Instruments, Moline, IL, USA) with benzoic acid used as the standard for calibration, and the acid-hydrolyzed ether extract in diets was measured by crude fat extraction using petroleum ether (Ankom^{XT15}, Ankom Technology, Macedon, NY, USA) following hydrolysis using 3 *N* HCl (Ankom^{HCl}, Ankom Technology, Macedon, NY, USA). Diets were analyzed for amino acids on a Hitachi Amino Acid Analyzer, Model No. L8800 (Hitachi High Technologies America, Inc., Pleasanton, CA, USA) using ninhydrin for post-column derivatization and norleucine as the internal standard. Prior to analysis, samples were hydrolyzed with 6 *N* HCl for 24 h at 110 °C [method 982.30 E(a); AOAC Int (2007)]. Methionine and Cys were determined as Met sulfone and cysteic acid after cold performic acid oxidation overnight before hydrolysis [method 982.30 E(b); AOAC Int (2007)]. Tryptophan was determined after NaOH hydrolysis for 22 h at 110 °C [method 982.30 E(c); AOAC Int (2007)].

2.3. Calculations and statistical analysis

2.3.1. Experiment 1

At the conclusion of the experiment, feed preference for each diet was calculated using the following equation for each day of the experiment as well as the overall 8-day period (Solà-Oriol et al., 2009a):

$$\text{Preference}(\%) = \left[\frac{\text{intake of individual diet(kg)}}{\text{intake of both diets(kg)}}\right] \times 100$$

Data were analyzed using SAS 9.4 (SAS Institute Inc, 2016). Pen was the experimental unit, and diet was the fixed effect and replicate was the random effect. Normality of residuals was confirmed using the UNIVARIATE procedure. Data were analyzed by the paired *t*-test in SAS. Results were considered significant at $P \leq 0.05$.

2.3.2. Experiment 2

Pen was considered the experimental unit, and data were summarized for each treatment group. Average daily gain, ADFI, and G:F were calculated. Normality of residuals was confirmed and data were tested for outliers using the UNIVARIATE procedure of SAS. Outliers were defined as observations with internally studentized residuals less than − 3 or greater than 3, but no outliers were identified in the data set. Data were analyzed by the MIXED procedure, and the statistical model included the fixed effect of diet and replicate was the random effect. Least square means were estimated for each treatment group using the LSMEANS statement in PROC MIXED. Contrast statements were used to determine linear and quadratic effects of including graded levels of hybrid rye in the diets. Results were considered significant at $P \leq 0.05$ and considered a trend at $0.05 < P \leq 0.10$.

3. Results

3.1. Experiment 1

Pigs consumed more ($P < 0.05$) of the corn-based diet than of the rye-based diet from day 1 through day 8, and for the overall period (Table 3). Subsequently, the calculated preference for the hybrid-rye based diet was less ($P < 0.05$) than for the corn-based diet for each day and for the overall period.

3.2. Experiment 2

No differences were observed among treatments for initial or final body weight (Table 4). There was a tendency (linear, $P < 0.10$) for ADFI to be reduced as hybrid rye inclusion in the diet increased. However, ADG was not affected by dietary treatment, and the same was true for G:F, despite the reduced calculated metabolizable energy in diets containing hybrid rye.

4. Discussion

The preference for corn versus rye indicates that the historical reluctance to feed rye due to poor palatability may have merit. However, results of research conducted with pigs naïve to test ingredients demonstrated that the preference of weanling pigs for rye or corn did not differ when fed at 300, 600, or 1000 g per kg replacement rates (Solà-Oriol et al., 2009b), but reduced preference for corn compared with rye was observed at 500 g per kg inclusion of cereal grains (Solà-Oriol et al., 2009b). It is possible the different age of pigs used in this experiment (i.e., > 8 weeks of age) may explain some of the discrepancies between data from the present experiment and the data by Solà-Oriol et al. (2009a; 2009b; i.e., 4 weeks of age) because although young pigs often exhibit reluctance to consume feed immediately after weaning, preference toward particular ingredients is generally more pronounced as pigs get older (Seabolt et al., 2010). The pigs used in the present experiment were familiar with diets containing corn and had never been exposed to hybrid rye prior to the experiment, which may explain why pigs preferred corn to rye. Neophobia may be a confounding factor to evaluating preference for feed (Solà-Oriol et al., 2011), and prior experience with a particular ingredient may affect how quickly pigs adapt to consuming a new bulkier diet (Tsaras et al., 1998). However, an animal's previous experience consuming an ingredient has minimal impact on feed preference after 1 or 2 days, at which point the sensory characteristics (i.e., taste and smell) of the ingredient dictate feed preference more than familiarity with the ingredient (Solà-Oriol et al., 2009b; Seabolt et al., 2010). Furthermore, increased exposure (i.e., inclusion rate and duration) to a low-palatable diet resulted in a linear reduction in preference, rather than an increased tolerance, in two-way choice experiments (Seabolt et al., 2010; Solà-Oriol et al., 2011). It is possible that maternal experience with dietary ingredients and flavors has lasting impact on the flavor preferences of pigs (Figueroa et al., 2013). As a consequence, pigs used in the present experiment may have been predisposed to preferring corn instead of a novel ingredient such as hybrid rye as these pigs were the offspring of sows fed diets consisting of corn and soybean meal. In contrast, much research demonstrating a low preference for corn by weanling pigs was conducted in Europe, where the usage of cereal grains other than corn in diets for pigs is more common (Solà-Oriol et al., 2009a).

In addition to previous exposure to hybrid rye, the physical and chemical characteristics of hybrid rye compared with corn may also have impacted preference because there is a positive correlation between digestible starch and feed preference, and a negative correlation between dietary fiber and feed preference (Solà-Oriol et al., 2013). Corn contains more digestible starch than hybrid rye (McGhee and Stein, 2018, 2020a), which may contribute to the increased preference for corn. Hybrid rye also contains more dietary fiber than corn (McGhee and Stein, 2018, 2020a), and dietary fiber impacts the amount of water consumed during and after eating, the energy spent chewing, and the viscosity and transit time of the digesta in the gastrointestinal tract (Kyriazakis and Emmans, 1995; Tsaras et al., 1998; Whittemore et al., 2001; Solà-Oriol et al., 2009a). Soluble arabinoxylans in rye may increase intestinal digesta viscosity more than other cereal grains containing less soluble fiber (Bach Knudsen et al., 2005; Le Gall et al., 2009, 2010), and a

Table 3
Daily and overall feed disappearance and feed preference, experiment1.[a]

Item	Corn	Hybrid rye	SD	*P*-value
Feed disappearance[b], kg				
Overall, day 1–8	20.21 ± 8.21	4.07 ± 5.40	-	< 0.001
Feed preference[c], %				
Day 1	85.9	14.1	26.92	< 0.001
Day 2	61.8	38.2	25.04	0.031
Day 3	90.7	9.3	14.98	< 0.001
Day 4	74.0	26.0	22.93	< 0.001
Day 5	91.9	8.1	17.00	< 0.001
Day 6	86.0	14.0	14.66	< 0.001
Day 7	90.9	9.1	11.19	< 0.001
Day 8	81.3	18.7	24.04	< 0.001

[a] Means for dietary treatments represent 18 observations.
[b] Feed disappearance = feed intake per pen.
[c] Feed preference = (intake of individual diet in kg/intake of both diets in kg) × 100.

Table 4
Growth performance of pigs fed diets in which hybrid rye replaced increasing concentrations of corn in a corn-soybean meal diet, experiment 2.[a]

	Corn replacement rate, %					*P* – values	
Item	0	33	66	100	SEM	Linear	Quadratic
Body weight, day 1, kg	27.14	27.19	27.12	27.18	0.797	0.993	0.995
Body weight, day 27, kg	52.46	53.83	52.18	51.98	1.138	0.547	0.495
Average daily gain, kg	0.938	0.988	0.926	0.918	0.022	0.228	0.192
Average daily feed intake, kg	1.841	1.905	1.783	1.766	0.041	0.068	0.338
Gain:feed	0.510	0.518	0.522	0.521	0.009	0.388	0.609

[a] Least square means for dietary treatments represent 8 observations.

negative correlation between ileal digesta viscosity and feed preference of cereal grains have been reported (Solà-Oriol et al., 2007). The mechanism of digesta viscosity impacting feed intake in humans may be related to fiber swelling and binding of water in the gastrointestinal tract, followed by gastric distension and slow digesta passage rate (Kristensen and Jensen, 2011). The viscous nature of the digesta may also reduce digestive enzyme efficiency, delay or block nutrient absorption, and result in reduced nutrient digestibility and subsequent activation of the ileal brake (Kristensen and Jensen, 2011; van Avesaat et al., 2015).

Hybrid rye's flavor profile differs from corn as well, which likely also influences feed preference. Several volatile compounds in the fibrous outer pericarp of rye may contribute to the reduced palatability of rye compared with corn, as they are perceived as tasting bitter (Grosch and Schieberle, 1997; Heiniö et al., 2003; Poutanen et al., 2014). The texture of a diet also impacts preference – increased hardness and fragility of an ingredient is negatively correlated with preference (Solà-Oriol et al., 2007). Rye, if ground too finely or with too low moisture content, gets pulverized and increases the dustiness of the diet (Bazylo, 1992).

Pigs prefer diets containing corn and soybean meal to diets containing corn, soybean meal, and distillers dried grains with solubles (DDGS), and one main explanation for the reduced preference for DDGS is its greater concentration of dietary fiber (Seabolt et al., 2010; Kim et al., 2012). Although pigs strongly prefer diets without DDGS when given the choice, feed intake is not compromised when a single diet consisting of corn, soybean meal, and DDGS is provided (Kim et al., 2012). Therefore, even though pigs demonstrated preference for corn over hybrid rye in experiment 1, it was hypothesized in experiment 2 that when pigs were offered a single diet, feed intake would be greater as inclusion of hybrid rye in the diets increased due to the reduced metabolizable energy in hybrid rye compared with corn as has been demonstrated in weanling pigs (McGhee and Stein, 2021). However, this hypothesis was not supported due to the observed reduction in ADFI in experiment 2. The reduction in ADFI at high inclusion rates of hybrid rye may be a reflection of the preference for corn observed in experiment 1, in combination with greater gut fill and satiation.

The objective of experiment 2 was to determine the effect of replacing corn with hybrid rye on growth performance of pigs. Therefore, dietary inclusion rates of soybean oil and soybean meal were not changed as hybrid rye inclusion increased and diets, therefore, were not isocaloric. The observation that ADG was not influenced by hybrid rye inclusion in the diets is in agreement with results of recently conducted research in gestating sows, which also demonstrated no difference in ADG when hybrid rye was included in the diets at the expense of corn, despite reduced estimations for the metabolizable energy in diets containing hybrid rye (McGhee and Stein, 2020a, 2020b). In weanling pigs, G:F was reduced when pigs were fed diets in which corn was partially replaced by hybrid rye and pigs in that experiment consumed more feed to satisfy their energy requirement (McGhee and Stein, 2021). However, in an experiment with growing-finishing pigs, a reduced feed intake was also observed from 24 to 55 kg, but pigs compensated during the finishing period and no differences in ADFI or G:F were observed for the entire growing-finishing period from 24 to 120 kg (McGhee et al., 2021). A reduced feed intake and ADG of 44–111 kg pigs was also observed when increasing inclusion rates of hybrid rye instead of corn was used (Sullivan et al., 2022). It is possible that some of these discrepancies are a result of differences in palatability among different varieties of hybrid rye, or different concentrations of dietary fiber, but additional research is needed to confirm this hypothesis. Nevertheless, the observation that ADG and G:F were not changed as hybrid rye increased in the diets, despite the presumed reduction in dietary ME concentration, indicates that it is possible body composition of pigs changed so that pigs fed hybrid rye were leaner than pigs fed the corn diet. If that is the case, pigs fed hybrid rye would have needed less energy than pigs fed the corn diet, and therefore were able to maintain G:F. However, because body composition was not determined in the experiment, we are unable to verify this hypothesis.

Growth performance and carcass characteristics of growing-finishing pigs fed hybrid rye as a replacement for barley is either not changed or slightly improved by hybrid rye (Schwarz et al., 2015; Bussières, 2018). In contrast, when hybrid rye replaces wheat in diets for growing-finishing pigs, a depression in ADG and ADFI is observed as the inclusion of hybrid rye in the diet increases (Smit et al., 2019), which may be due to the greater concentration of dietary fiber, reduced starch, and consequently reduced metabolizable energy in hybrid rye compared with wheat (McGhee and Stein, 2020a). The opposite is true for barley – hybrid rye contains less dietary fiber, more starch, and more metabolizable energy than barley, and feeding hybrid rye instead of barley, therefore, does not reduce growth performance in growing-finishing pigs.

5. Conclusions

Pigs that had not been adapted to a rye-based diet preferred a diet containing corn as the exclusive cereal grain compared with a diet based on hybrid rye. When pigs were provided with a single diet, average daily feed intake also tended to be reduced as the inclusion of hybrid rye in the diet increased. Despite reduced average daily feed intake, the average daily gain, the average gain to feed ratio, and final body weights did not differ among pigs fed diets with different inclusion levels of hybrid rye and it appeared that pigs were able to obtain the same energy from hybrid rye as they obtained from corn.

CRediT authorship contribution statement

H.H. Stein: conceptualized the experiments, contributed with data interpretation, edited the final version of the manuscript, supervised the project. **M.L. McGhee**: conducted the experiment and summarized data, wrote the first draft of the manuscript.

Conflict of interest

The authors have no conflicts of interest.

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