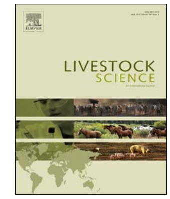
Livestock Science 207 (2018) 98–104

Contents lists available at ScienceDirect

Livestock Science

journal homepage: www.elsevier.com/locate/livsci



Effect of wheat as a feedstuff in starter diets on nursery pig growth performance and digestibility

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ARTICLE INFO

Keywords:
Wheat
Growth performance
Digestibility
Nursery pigs

ABSTRACT

Two studies were conducted to determine if corn can be replaced by wheat and if wheat can be combined with corn distillers dried grains with solubles (DDGS) and a commercial carbohydrase in phase 2 and 3 nursery diets. In Exp. 1, 144 pigs were blocked by weight and randomly allotted to 6 dietary treatments: 0%, 20%, 40%, 60%, 80%, and 100% wheat replacing corn. In Exp. 2, 210 pigs were blocked by weight and randomly allotted to 5 dietary treatments: control diet (CO); 30% wheat (W); wheat with carbohydrase (W + Enz); 30% wheat with 30% corn DDGS (WCD); and WCD with carbohydrase (WCD + Enz). In both experiments, pigs were fed a standard phase 1 diet from d 0 to 7 post-weaning. In both experiments, TiO_2 was used as an indigestible marker to determine apparent total tract digestibility (ATTD) of N, ether extract (EE), gross energy (GE), P, neutral detergent fiber (NDF), and acid detergent fiber (ADF). In Exp. 1, there was a quadratic effect of increasing wheat on overall (d 0–35) average daily gain (ADG, $P < 0.05$). There was a linear effect of increasing wheat on gain to feed ratio (G:F, $P < 0.05$). Overall there were no changes in average daily feed intake (ADFI). Apparent digestibility of N, P, and ADF increased with increasing wheat in phase 2 ($P < 0.05$). The digestibility of N, EE, GE, P, and NDF increased linearly with increasing wheat in phase 3 ($P < 0.05$). In Exp. 2, the ADG of pigs fed W did not differ from the control, while those fed WCD had greater gain ($P < 0.05$). Pigs fed the diets supplemented with carbohydrase had reduced ADG ($P < 0.05$) compared to the unsupplemented diets. There was an increase in N, P, and GE digestibility with DDGS diets in phase 2 ($P < 0.001$). Carbohydrase supplementation increased N, EE, ADF, and NDF digestibility in phase 2 ($P < 0.01$), and ADF and NDF digestibility in phase 3 ($P < 0.01$). In phase 3, P digestibility increased and GE digestibility decreased when DDGS was added. The results demonstrate that wheat can be fully or partially substituted for corn in nursery diets. In this study, the addition of carbohydrase enzymes improved nutrient digestibility, but resulted in poorer growth performance.

1. Introduction

Corn is the major energy source for swine diets in the US. In Canada and Europe, use of wheat as the major energy source is more common (Hongtrakul et al., 1998; Rosenfielder et al., 2013). Because the price of wheat and corn vary by season and region, there are times when wheat would be a more economical energy source than corn in swine diets in parts of the US (USDA, 2013a, 2013b). In addition, wheat has a higher content of some limiting amino acids and greater availability of phosphorus compared to corn (NRC, 2012). Few studies have directly compared diets of wheat or wheat blended with corn to corn. Studies that have been conducted show that feeding wheat results in similar growth performance to feeding corn in pigs from weaning to market weight (Erickson et al., 1980; Seerley et al., 1988). However, these studies did not feed wheat in increasing percentages compared to corn. The amount of wheat that can be added to the diet of nursery pigs without affecting growth performance is unclear as well.

Wheat has approximately 50% greater non-starch polysaccharide (NSP) content than corn (Choct and Annison, 1990), which can decrease the absorption of other nutrients, making the overall diet less digestible. Exogenous carbohydrases have been commonly added to swine diets to increase nutrient digestibility of high-fiber ingredients (Bedford and Partridge, 2001). Exogenous enzymes, such as xylanases and β-glucanases, are added to feeds to break down part of the NSP fraction. However, the benefit of carbohydrases in swine diets can be variable (Rosenfielder et al., 2013).

The objective of these studies was to determine the effect of partial or full substitution of wheat for corn on growth performance and nutrient digestibility in phase 2 and 3 nursery diets. Further objectives were to evaluate a wheat/corn DDGS combination and the effects of supplementing these diets with carbohydrases on these same endpoints.

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https://doi.org/10.1016/j.livsci.2017.11.016
Received 23 April 2017; Received in revised form 17 November 2017; Accepted 18 November 2017

Table 1
Analysis of wheat used in Exp. 1 and 2.[a]

	Exp. 1	Exp. 2
Crude protein, %	10.19	11.50
Ether extract, %	1.58	1.29
Neutral detergent fiber, %	9.59	14.22
Acid detergent fiber, %	3.79	4.73
Indispensable AA, %		
Arginine	0.48	0.61
Histidine	0.23	0.28
Isoleucine	0.35	0.42
Leucine	0.65	0.79
Lysine	0.35	0.38
Methionine	0.17	0.19
Phenylalanine	0.42	0.52
Threonine	0.29	0.35
Tryptophan	0.15	0.16
Valine	0.43	0.52
Dispensable AA, %		
Alanine	0.38	0.45
Aspartate	0.52	0.65
Cysteine	0.23	0.25
Glutamine	2.54	2.99
Glycine	0.41	0.51
Proline	0.85	1.06
Serine	0.43	0.49
Tyrosine	0.26	0.31

[a] Amino acid analysis performed by University of Missouri – Columbia, Office of the Missouri State Chemist, Analytical Services, Columbia, MO, US.

Table 2
Mycotoxin levels in wheat and diets in Exp. 1 and 2.[a,b]

Sample	Zearalenone, ppm	Vomitoxin, ppm
Wheat, Exp. 1	Not detected	0.75
Wheat, Exp. 2	2.34	1.90
Diet, 0% Wheat (Phase 3, Exp. 1)	Not detected	Not detected
Diet, 100% Wheat (Phase 3, Exp. 1)	Not detected	0.65
Diet, Control (Phase 3, Exp. 2)	Not detected	0.25
Diet, Wheat (Phase 3, Exp. 2)	1.00	0.70
Diet, Wheat w/DDGS (Phase 3, Exp. 2)	0.88	1.05

[a] Values are in parts per million. There was no detectable Aflatoxin or Ochratoxin in any of the samples.
[b] Analysis was performed Missouri Veterinary School Feed Laboratory, Columbia, MO, US.

2. Materials and methods

All experiments were conducted in environmentally controlled rooms at the University of Georgia. Experimental protocols were approved by the University of Georgia Institutional Animal Care and Use Committee.

2.1. Wheat processing and analysis

Wheat used in both experiments was obtained whole from a commercial feed mill (Godfery's Feed Mill, Madison, GA, US) and ground through a hammer mill with a 4.76 mm screen. Proximate and amino acid analysis (University of Missouri Office of the Missouri State Chemist, Analytical Services, Columbia, MO, US) was performed (Table 1). Wheat was analyzed for mycotoxins prior to diet formulation (Table 2), (University of Missouri Veterinary Medical Diagnostic Lab, Columbia, MO, US). Diets were formulated using the nutrient values for hard red wheat (NRC, 2012).

2.2. Animals and experimental design

2.2.1. Experiment 1

The objective of this study was to determine if wheat could substitute for corn, and if there was an optimal inclusion rate for wheat in nursery pig diets. A total of 144 commercial crossbreed barrows and gilts (PIC C29 × PIC 380, PIC Hendersonville, TN, US) were allotted to 24 pens in each of 2 trials for a total of 48 pens for the experiment. Pigs [6.20 ± 0.2 kg initial body weight (BW); 78 barrows and 66 gilts] were weaned at approximately 20 ± 2 d of age, moved to the nursery, blocked by weight and allotted to pens of 3 pigs each. Sex was balanced within weight block. Pens were 0.94 × 1.83 m with woven wire flooring. Pigs were allowed ad libitum access to feed and water throughout the experiment. Two experimental diets were made in each phase, one containing corn as the primary grain source and the other using wheat. The 2 diets were blended to make the 6 treatment diets with 0, 20, 40, 60, 80, 100% of the corn replaced with wheat (Table 3). Other ingredients (whey, blood cells and fish meal) were kept constant. Diets were formulated to be isoenergetic, having the same standardized ileal digestible (SID) Lys in each phase (Table 3) and included phytase

Table 3
Diet composition and calculated analysis of 0:100 and 100:0 for phase 2 and 3 in Exp. 1 (as-fed basis).

		Phase 2		Phase 3	
Item	Common diet	Corn	Wheat	Corn	Wheat
Ingredients, %					
Corn	38.36	53.57	–	64.52	–
Soybean meal	18.75	27.49	24.80	30.77	27.45
Wheat	–	–	54.18	–	65.44
Whey	27.50	10.00	10.00	–	–
Fish meal	5.00	2.50	2.50	–	–
Plasma protein	5.00	–	–	–	–
Blood cells	–	2.50	2.50	–	–
Fat	2.00	0.32	2.42	0.45	3.00
Limestone	0.83	1.06	1.04	0.97	0.96
Dicalcium phosphate	0.23	–	–	0.64	0.56
Salt	0.20	0.25	0.25	0.35	0.35
Vitamin premix[a]	0.25	0.25	0.25	0.25	0.25
Mineral premix[b]	0.15	0.15	0.15	0.15	0.15
Lysine HCl	0.23	0.20	0.20	0.40	0.40
DL-Methionine	0.12	0.15	0.14	0.13	0.05
L-Threonine	–	–	0.01	0.06	0.08
Mecadox	1.00	1.00	1.00	1.00	1.00
Titanium dioxide	0.30	0.30	0.30	0.30	0.30
Phytase	–	0.01	0.01	0.01	0.01
Zinc oxide	0.38	0.25	0.25	–	–
Calculated composition					
Metabolizable Energy, Mcal/kg	3.42	3.30	3.30	3.30	3.30
Lysine, %	1.70	1.52	1.51	1.40	1.39
SID lysine, %	1.53	1.35	1.35	1.26	1.25
Methionine + Cysteine, %	0.93	0.87	0.87	0.79	0.79
Threonine, %	1.02	0.96	0.95	0.87	0.87
Calcium %	0.85	0.68	0.68	0.60	0.60
Total Phosphorus, %	0.65	0.49	0.53	0.51	0.44
STTD Phosphorus, %	0.45	0.24	0.25	0.22	0.22
Analyzed composition					
Crude Protein, %[d]	–	22.96	23.36	19.18	20.19
Lysine, %[c]	–	1.49	1.50	1.40	1.47
Threonine, %[c]	–	0.87	0.86	0.77	0.72
Methionine + cysteine, %[c]	–	0.74	0.74	0.66	0.63
Tryptophan, %[c]	–	0.28	0.29	0.26	0.23
Ether Extract, %	–	2.58	3.52	2.22	2.98
Neutral Detergent Fiber, %	–	7.67	8.17	8.97	10.11
Acid Detergent Fiber, %	–	2.71	2.64	3.23	3.44

[a] The vitamin premix (ADM, Quincy, IL, US) provided the following per kilogram of complete diet: 1100 IU vitamin A, 1376 IU vitamin D3, 44 IU vitamin E, 4.4 mg vitamin K, 8.3 mg riboflavin, 50 mg niacin, 28 mg pantothenic acid, 23 µg vitamin B_{12}.
[b] The trace mineral premix (ADM, Quincy, IL, US) provided the following per kilogram of complete diet: 165 mg Fe ($FeSO_4 \cdot H_20$), 16.5 mg Cu (CuSO4·5H20), 36 mg Mn ($MnSO_4$), 165 mg Zn (ZnO), 0.3 mg I ($Ca(IO_3)_2$), and 0.3 mg Se (Na_2SeO_3).
[c] Analysis performed by University of Missouri – Columbia, Office of the Missouri State Chemist, Analytical Services, Columbia, MO, US.
[d] Crude Protein, Ether Extract, Neutral and Acid Detergent Fiber analyzed by the author's lab.