Animal Feed Science and Technology 242 (2018) 59–68

Contents lists available at ScienceDirect

Animal Feed Science and Technology

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

Diet nutrient and energy digestibility and growth performance of weaned pigs fed hulled or hull-less barley differing in fermentable starch and fibre to replace wheat grain

L.F. Wang[a], H. Zhang[a], E. Beltranena[a,b], R.T. Zijlstra[a,*]

[a] Department of Agricultural, Food and Nutritional Science, University of Alberta, Edmonton, Alberta, T6G 2P5, Canada
[b] Alberta Agriculture and Forestry, Edmonton, Alberta, T6H 5T6, Canada

ARTICLE INFO

Keywords:
Amylose
β-Glucan
Growth performance
Hulled barley
Hull-less barley
Pig

ABSTRACT

Starch and fibre composition of feed grain may alter site of digestion and fermentation of energy-yielding nutrients within the swine gut. Especially dietary amylose and β-glucan increase fermentation; however, their effect on growth performance has not been well defined. Starting 1 week post-weaning (BW, 7.3 kg), 240 pigs were fed 5 diets that contained 630–706 g cereal grain/kg differing in fermentable carbohydrates: high-fermentable β-glucan hull-less barley (HFB), high-fermentable amylose hull-less barley (HFA), moderate-fermentable hull-less barley (MFB); low-fermentable hulled barley (LFB) or low-fermentable hard red spring wheat (LFW). Diets were formulated to provide 9.7 and 9.4 MJ net energy (NE)/kg and 1.32 and 1.22 g standardised ileal digestible lysine/MJ NE for Phase 1 (day 1–14) and Phase 2 (day 15–35), respectively. The coefficient of apparent total tract digestibility (CATTD) of gross energy (GE) was greatest ($P < 0.05$) for MFB and LFW for both phases and was lower ($P < 0.05$) for LFB than HFB and HFA for Phase 1 and HFA for Phase 2. The CATTD of crude protein (CP) was greater ($P < 0.05$) for LFW than the 4 barley diets for both phases. The CATTD of CP was greater ($P < 0.05$) for HFA and LFB than HFB and MFB for Phase 2. Calculated NE value for Phase 1 was greatest ($P < 0.05$) for MFB, greater ($P < 0.05$) for LFW than LFB and HFB and greater ($P < 0.05$) for HFA than HFB. Calculated NE value for Phase 2 was greater ($P < 0.05$) for MFB than LFB, HFB and HFA and greater ($P < 0.05$) for LFW than HFA. For the entire trial (day 1–35), gain:feed (G:F) did not differ ($P > 0.05$) among diets. Average daily feed intake (ADFI) was greater ($P < 0.05$) for LFB, LFW or MFB than HFA. The ADFI was greater ($P < 0.05$) for LFB than HFB. Average daily gain tended to be greater ($P = 0.07$) for LFB than HFA. Faeces consistency was greater ($P < 0.05$) for LFW than HFB or HFA and greater ($P < 0.05$) for LFB than HFB. In conclusion, moderate dietary fermentable carbohydrates did not alter feed intake, gain and G:F of weaned pigs; however, high dietary fermentable carbohydrates may reduce feed intake, gain and faeces consistency. Nevertheless, hulled and hull-less barley replacing wheat grain in diets did not affect feed intake, gain and G:F in weaned pigs.

Abbreviations: AA, amino acids; ADF, acid detergent fibre; ADFI, average daily feed intake; ADG, average daily gain; BW, body weight; CATTD, coefficient of apparent total tract digestibility; CP, crude protein; DE, digestible energy; DM, dry matter; GE, gross energy; G:F, gain:feed; HFA, high-fermentable and high-amylose hull-less barley; HFB, high-fermentable and high-β-glucan hull-less barley; LFB, low-fermentable hulled barley; LFW, low-fermentable wheat; Lys, lysine; MFB, moderate-fermentable hull-less barley; NDF, neutral detergent fibre; NE, net energy; RS, resistant starch; SID, standardised ileal digestible

* Corresponding author.
E-mail address: ruurd.zijlstra@ualberta.ca (R.T. Zijlstra).

https://doi.org/10.1016/j.anifeedsci.2018.05.012
Received 27 March 2018; Received in revised form 22 May 2018; Accepted 25 May 2018
0377-8401/

1. Introduction

Hulled and hull-less barley grains are energy sources for swine (Thacker et al., 1988; Darroch et al., 1996; Nasir et al., 2015; Zhou et al., 2016). Chemical composition varies among barley grain samples causing changes in nutritional value that may affect pig growth (Thacker et al., 1988; Spindler et al., 2016; Wang et al., 2017a). Among chemical components, fermentable carbohydrates can shift digestion from the small intestine to large intestine, alter ileal and total tract digestibility of nutrients and increase hindgut fermentation in pigs (Jha et al., 2010; Fouhse et al., 2017b). New cultivars of hull-less barley with increased amylose or β-glucan have been developed (Izydorczyk and Dexter, 2008). However, growth performance of weaned pigs fed cereal grains of these cultivars with increased fermentable carbohydrates has not been defined.

Dietary manipulation may enhance gut health of weaned pigs (Pluske et al., 1997; Jha and Berrocoso, 2015). Increasing dietary amylose can stimulate hindgut fermentation and *Bifidobacteria* spp. in pigs post-weaning (Fouhse et al., 2015). Similarly, soluble fibre and resistant starch (RS) may alter immune and intestinal function, thereby improving gut health in weaned pigs (Jha et al., 2010; Ewaschuk et al., 2012). However, soluble fibre and RS may also increase incidence of swine dysentery (Durmic et al., 2002). Cereal β-glucans increase digesta viscosity (Ullrich et al., 1986; Izydorczyk et al., 2000; Hooda et al., 2011). Excessively-increased digesta viscosity may stimulate proliferation of enterotoxigenic *Escherichia coli* and increase diarrhoea incidence in weaned pigs (McDonald et al., 2001). Whether cereal grains differing in fermentable carbohydrates affect faeces consistency in weaned pigs remains unknown.

The hypotheses for the present study were that fermentable carbohydrates in cereal grains would not affect nutrient digestibility, growth and faeces consistency of weaned pigs; and low-fermentable hulled barley or moderate- to high-fermentable hull-less barley can replace low-fermentable wheat grain in diets without affecting growth performance. The objective was to evaluate diet coefficient of apparent total tract digestibility (CATTD) of nutrients, growth performance and faeces consistency of pigs fed diets differing in fermentable carbohydrates using novel hull-less barley, hulled barley and wheat cultivar samples.

2. Materials and methods

2.1. Experimental design and diets

The animal procedures were reviewed by the University of Alberta Animal Care and Use Committee for Livestock and followed principles established by the Canadian Council on Animal Care (CCAC, 2009). The study was conducted at the Swine Research and Technology Centre, University of Alberta (Edmonton, AB, Canada).

In total, 240 pigs were selected from 435 pigs (Duroc × Large White/Landrace F_1; Hypor, Regina, SK, Canada) that were weaned in three groups at 20 ± 1 days, based on post-weaning average daily gain (ADG) and body weight (BW) on day 5 after weaning. Pigs were divided within gender into heavy or light BW into 4 subgroups. Pigs within each subgroup were then randomly placed into pens, with four pigs per pen. Pigs received creep feed prior to weaning. Immediately after weaning, pigs were fed sequentially commercial pre-starter [10.9 MJ net energy (NE)/kg, 14.8 g standardised ileal digestible (SID) lysine (Lys)/kg] and starter (10.2 MJ NE/kg, 13.2 SID Lys/kg) diets (Masterfeeds, Sherwood Park, AB, Canada) for 2 and 5 days, respectively. Wheat, soybean meal, whey permeate, and highly digestible protein sources were included in these diets.

Five diets were formulated to include one of five cereal grains (Table 1; Fouhse et al., 2017a, b): low-fermentable, hard red spring wheat (LFW; CDC Utmost) that was sourced from the Crop Development Centre (Saskatoon, SK, Canada), low-fermentable hulled barley (LFB; CDC Champion) that was sourced from Viterra (Wetaskawin, AB, Canada) and three hull-less barley cultivars that were sourced from the Crop Development Centre (Saskatoon, SK, Canada). The hull-less barley samples were: 1) CDC Fibar, high-fermentable, high-β-glucan (HFB); 2) CDC Hilose, high-fermentable, high-amylose (HFA) and 3) CDC McGwire, moderate-fermentable (MFB). Diets were formulated without antimicrobials or growth promoters to provide 9.7 and 9.4 MJ NE/kg, and 1.32 and 1.22 g SID Lys/MJ NE for Phase 1 and Phase 2, respectively. Other indispensable amino acids (AA) were formulated as ideal ratios to Lys (NRC, 2012). Table NE values and SID AA coefficients (NRC, 2012) were used for main ingredients. Acid-insoluble ash (Celite 281; World Minerals, Santa Barbara, CA, USA) was included at 8 g/kg in diets as an indigestible marker. Diets were mixed and steam-pelleted at 70 °C (70 hp; California Pellet Mill, Crawfordsville, IN, USA). Pigs (initial BW: 7.63 ± 0.29 kg) were fed the Phase-1 diets starting from 1 week after weaning for 2 weeks (day 1–14) and subsequently fed the Phase-2 diets for 3 weeks (day 15–35).

The study was set up as a randomised complete block design with 60 pens in three nursery rooms of 20 pens with an interval of two weeks between two consecutive groups. Pens (1.1 × 1.5 m) were equipped with a self-feeder with 4 feeding spaces, a nipple drinker, PVC partition and plastic slatted flooring. Rooms were ventilated using negative pressure, with room temperature maintained at 22 ± 1 °C, and a 12-h light (0600–1800 h) and 12-h dark cycle. Pens were blocked by area within each nursery room and were randomly assigned to one of the five experimental diets. Per diet, 12 pen-replicates were achieved. Pigs had free access to feed and water.

Faeces consistency was monitored twice daily (0800 and 1400 h) and recorded using an 8-grade score: 1: very hard and dry, often pelleted, no residue left on floor when picked up; 2: firm, but not hard, pliable, segmented appearance, little or no residue left on floor when picked up; 3: log-like, little or no segmentation visible, moist surface, leaves residue but holds form when picked up; 4: very moist or soggy, distinct log shape, leaves residue and loses form when picked up; 5: very moist but has distinct shape, present in piles rather than logs, leaves residue and loses form when picked up; 6: has texture, but no defined shape, occurs as piles or spots, leaves residue when picked up; 7: watery, no texture, flat, occurs as puddles and 8: watery with little to no colour.

Individual pigs, feed added and remaining feed orts were weighed weekly to calculate average daily feed intake (ADFI), ADG and