Animal Feed Science and Technology 203 (2015) 79–87

Contents lists available at ScienceDirect

Animal Feed Science and Technology

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

# Nutrient digestibility in diets containing low-phytate barley, low-phytate field pea and normal-phytate field pea, and the effects of microbial phytase on energy and nutrient digestibility in the low and normal-phytate field pea fed to pigs

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ARTICLE INFO

*Article history:*
Received 28 October 2014
Received in revised form 20 February 2015
Accepted 21 February 2015

*Keywords:*
Low-phytate field pea
Low phytate barley
Nutritive value
Phytase
Pigs

ABSTRACT

Five ileal cannulated barrows ($43.6 \pm 1.3$ kg BW) were used in a $5 \times 5$ Latin square design experiment to determine the apparent (AID) and standardized (SID) ileal digestibility of N and amino acids (AA) in low-phytate field pea (LPP), low-phytate barley (LPB) and normal-phytate field pea (NPP) and the apparent total tract digestibility (ATTD) of Ca, P and energy in diets containing these ingredients. In addition, the effects of phytase supplementation (500 FTU/kg) to diets containing LPP or NPP were determined. The experimental diets contained 869, 868 or 870 g/kg LPB, LPP and NPP, respectively, as the sole source of N. The phytate P contents were 0.4, 0.7 and 2.0 g/kg for LPB, LPP and NPP, respectively. Limestone was added to all diets meeting the recommended values, while inorganic P was added only in pea-based diets to provide 65% of the available P recommended by NRC (1998) for 20–50 kg pigs. Titanium dioxide (3 g/kg) was used as an indigestible marker. Daily feed allowance was calculated as 40 g/kg BW at the beginning of each period and was offered in two equal meals at 0800 and 1600 h. Each experimental period lasted for 8 d; d 1–4 for adaptation, d 5–6 for urine and fecal collections, and d 7–8 for ileal digesta collection. The ATTD of DM and GE was not different among diets and was not affected by phytase addition. The ATTD of Ca and P was higher ($P<0.05$) in LPB than in LPP and NPP diets. Supplementing the LPP and NPP diets with phytase increased ($P<0.05$) the ATTD of Ca and P. The AID of N and all AA except Met were higher ($P<0.05$) in LPP and NPP than in LPB, but no difference between LPP and NPP were observed. Phytase supplementation increased ($P<0.05$) the AID for Arg, Ile, Leu, Phe, Pro, Ser, Tyr, and Val. The SID of AA in LPB, LPP, and NPP were 0.734, 0.895 and 0.895 for Lys, 0.732, 0.757 and 0.744 for Met and 0.755, 0.789 and 0.787 for Thr, respectively. Results indicate that both varieties of field pea had greater AID and SID of AA than LPB. Also, the LPP diet had higher ATTD of Ca and P compared with the NPP diet and phytase supplementation improved digestibility of P, Ca and some AA.



*Abbreviations:* AA, amino acids; AID, apparent ileal digestibility; ATTD, apparent total tract digestibility; LPB, low phytate barley; LPP, low phytate field pea; ME, metabolizable energy; NPP, normal phytate field pea; NRC, National Research Council; SID, standardized ileal digestibility.

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http://dx.doi.org/10.1016/j.anifeedsci.2015.02.009
0377-8401/

## 1. Introduction

Barley and pea are common ingredients included in diets fed to nonruminant animals in western Canada (Thacker et al., 2003; Friesen et al., 2006). However, they are poor sources of phosphorus (P) because 60–80 g/100 g P is bound as phytate P, a form that is largely undigested by nonruminants (Veum et al., 2002). Phytate not only interferes with mineral availability but also hinders the digestibility of other nutrients such as protein (Woyengo et al., 2008; Woyengo and Nyachoti, 2011; Selle et al., 2012). At low pH, phytate forms linkages with basic AA like Lys and Arg resulting in compounds which are indigestible by proteolytic enzymes (Ravindran et al., 1999). In addition, results of a study by Liu et al. (2008) showed that phytate depressed the concentration of amylase and sucrase in the jejunum and therefore could lower energy digestibility. To minimize the effects of phytate, dietary supplementation with phytase has been successfully used to improve P digestibility in pigs (Harper et al., 1997; Woyengo et al., 2009). However, the effect of phytase supplementation on AA and energy digestibility is variable (Sands et al., 2009; Kiarie et al., 2010; Cervantes et al., 2011; Selle et al., 2012; Woyengo and Nyachoti, 2013).

Developing feed grains with low phytate content offers an alternative to mitigate the depressing effects of phytate on nutrient digestibility. Studies with low-phytate cereals have reported improved P and AA digestibilities when fed to pigs and poultry or compared to normal phytate varieties (Spencer et al., 2000; Thacker et al., 2003, 2004; Bohlke et al., 2005). Recently, a low-phytate field pea (LPP) with 0.09 mg/kg phytate P content compared with a 2.9 mg/kg phytate P content in normal field pea (NPP) has been developed (Delgerjav et al., 2011). In poultry, the LPP increased P digestibility and bone strength compared to NPP (Thacker et al., 2013). However, there is little information on the nutritive value of LPP, especially when fed to pigs and it is therefore necessary to evaluate the nutritive value of LPP in comparison with NPP cultivar and low-phytate barley (LPB). The objectives of this study were, firstly, to determine the ileal digestibility of N, AA and total tract digestibility P and energy in growing pigs fed LPB, LPP or NPP based diets. Secondly, to determine the effect of phytase supplementation on nutrient digestibility in the LPP and NPP based diets.

## 2. Materials and methods

The experimental procedures used in this experiment were reviewed and approved by the University of Manitoba Animal Care Protocol Management and pigs were handled according to the Canadian Council on Animal Care guidelines (CCAC, 2009).

### 2.1. Experimental diets

Three diets were formulated to contain 869 g/kg LPB (cultivar CDC Lophy-1), 870 g/kg LPP (cultivar 1-2346-144) or 868 g/kg NPP (cultivar CDC Bronco), all developed at the University of Saskatchewan's Crop Development Center (Saskatoon, SK, Canada). Normal-phytate P pea was included for comparison with LPP whereas LPB served as a low-phytate grain for comparison with LPP. The LPP and NPP diets were fed with or without 500 FTU/kg phytase (Phyzyme® XP; Danisco Animal Nutrition, Marlborough, Wiltshire, UK) (Table 2). For each diet, limestone was added to meet the requirement for calcium, whereas, inorganic P was added only in the pea-based diets to provide 65% of the available P recommended by NRC (1998) for 20–50 kg pigs. The available P content in LPB was enough to satisfy the 65% inclusion. In addition, all diets contained vitamins and micro-minerals to meet or exceed NRC (1998) specifications and 3 g/kg titanium dioxide was included as an indigestible marker.

### 2.2. Experimental animals

Five Yorkshire-Landrace dam × Duroc sire crossbred pigs with an initial BW of 43.6 ± 2.3 kg (mean ± standard deviation), were obtained from the University of Manitoba's Glenlea Swine Research Unit (Winnipeg, Manitoba) and fitted with a T-cannula at the terminal ileum as described by Nyachoti et al. (2002). Pigs were individually housed in 1.5 m × 1.2 m pens with raised, plastic-covered expanded metal floors and smooth walls in a temperature controlled room set at 22 °C.

### 2.3. Experimental procedure

Pigs were assigned to the experimental diets in a 5 × 5 Latin square design. Pigs were weighed at the beginning of each experimental period and provided with feed equivalent to 40 g/kg BW at the beginning of each period. Daily feed allowance was offered in two equal portions offered at 0800 and 1600 h and pigs had unlimited access to water via a low-pressure nipple drinker. Each experimental period lasted 8 d; d 1–4 for adaptation, 5–6 for total but separate collection of urine and feces as described by Woyengo et al. (2010) and 7–8 for ileal digesta collection. On each day, digesta were collected continuously for 12 h from 0800 to 2000 h and stored at −20 °C until processed.

### 2.4. Sample preparation and chemical analyses

Ileal digesta, feces and urine samples were independently pooled for each pig per period. Ileal digesta were freeze dried whereas fecal samples were oven dried at 60 °C and all ground to pass through a 1 mm sieve before chemical analyses. All samples were analyzed for DM, GE, and N contents. The samples were further analyzed as follows: LPB, NPP and LPP for AA,