Animal Feed Science and Technology 207 (2015) 196–203

Contents lists available at ScienceDirect

Animal Feed Science and Technology

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

Standardized and true ileal amino acid digestibilities in field pea and pea protein isolate fed to growing pigs

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ARTICLE INFO

Article history:
Received 4 March 2015
Received in revised form 9 June 2015
Accepted 10 June 2015

Keywords:
Amino acid digestibility
Pea protein isolate
Pigs

ABSTRACT

Four ileal-cannulated Cotswold barrows (50.41 ± 5.05 kg body weight) were used to determine apparent (AID), standardized (SID) and true (TID) ileal digestibility of amino acids (AA) in field pea and pea protein isolate (PPI) processed from the same batch of the whole field pea. Pigs were allotted to 2 experimental diets in a simple cross-over design. Diets contained either field pea or PPI as the sole source of protein and were formulated to contain 155 g/kg CP. The AID of nutrients was determined by the indicator method. The SID of AA was calculated using published values for basal endogenous AA losses obtained from our laboratory. The total endogenous flow of lysine and the TID of lysine were determined by the homoarginine method. The TID of AA other than lysine were estimated using their published ratios in endogenous protein relative to lysine. The AID coefficient of CP (0.88 vs. 0.80), Ile (0.91 vs. 0.79), leucine (0.92 vs. 0.81), lysine (0.93 vs. 0.84), phenylalanine (0.92 vs. 0.84) and valine (0.89 vs. 0.76) were greater ($P < 0.05$) in PPI than in field pea. The total (363 vs. 2167 mg/kg [dry matter intake (DMI)] and endogenous (312 vs. 1777 mg/kg DMI) lysine flow were lower ($P < 0.05$) in PPI compared with field pea. Likewise, field pea had greater ($P < 0.05$) total and endogenous nitrogen (N) and AA (other than lysine) flow compared with PPI. The SID of indispensable AA for PPI was greater ($P < 0.05$) than that for field pea. However, PPI and field pea were similar in the TID of all indispensable amino acid except lysine whose TID coefficient in PPI (0.99) was greater ($P < 0.05$) than for field pea (0.94). In conclusion, the results indicate that processing of field pea to produce pea protein isolate improved apparent AID of AA and reduced ileal endogenous AA losses. However, the processing of field pea to produce pea protein isolate had limited effect on TID of AA.

Abbreviations: AA, amino acids; AID, apparent ileal digestibility; ANF, anti-nutritional factors; BAA_{EL}, average basal endogenous AA loss; CP, crude protein; DM, dry matter; DMI, dry matter intake; HA, homoarginine; PPI, pea protein isolate; SBM, soybean meal; SID, standardised ileal digestibility; TID, true ileal digestibility.

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http://dx.doi.org/10.1016/j.anifeedsci.2015.06.008
0377-8401/

1. Introduction

Field pea (*Pisum sativum* L.) is considered an alternative source of energy and protein for swine and could be used as a substitution protein source to soybean meal (SBM). However, the presence of anti-nutritional factors (ANF) such as tannins, trypsin inhibitors and lectins in field pea can decrease its digestibility (Mariscal-Landíin et al., 2002). Thus, reduction in ANF content in field pea may increase its nutrient utilization in pigs.

Pea protein isolate (PPI) is obtained by alkaline extraction of proteins from field pea, followed by acidic precipitation (Sumner et al., 1981). It is almost devoid of ANF and has a potential to be an excellent source of high quality protein for swine. Pea protein isolate contains about 4 times more crude protein (CP) and amino acids (AA) than field pea (Le Guen et al., 1995; Owusu-Asiedu et al., 2003). Previous studies have evaluated the nutritive value of PPI through performance and apparent nutrient digestibility. Performance of pigs fed PPI as an alternative to spray-dried blood plasma has been evaluated by Owusu-Asiedu et al. (2003). Furthermore, Le Guen et al. (1995) reported greater apparent ileal digestibility (AID) coefficient of CP in PPI (0.85) compared with raw pea (0.69). However, for accurate dietary supply of AA in pig feed, standardized or true as opposed to apparent ileal digestibilities should be used because they are more additive in a mixture of feed ingredients (Furuya and Kaji, 1991; Nyachoti et al., 1997b; Stein et al., 2007). The standardized ileal digestibility (SID) assay is the most commonly used method for determining AA availability in feedstuffs for formulating swine diets (Stein et al., 2007), and SID AA coefficients for various swine feedstuffs are available in NRC (2012). However, the SID assay does not consider endogenous AA losses that are diet- or ingredient-specific. True ileal digestibility (TID) assay does (Stein et al., 2007). The homoarginine (HA) method in which dietary lysine is chemically converted to its synthetic AA analogue, HA, in a guanidination reaction with methylisourea, is generally acceptable as a method for determining TID of lysine in feed ingredients for pigs (Marty et al., 1994; Nyachoti et al., 1997a; Rutherfurd and Moughan, 2005). The purpose of the present study was to determine SID and TID (using HA method) of AA in field pea and PPI fed to growing pigs.

2. Material and methods

All experimental protocols used in the present study were reviewed and approved by the Animal Care Committee of the University of Manitoba. Animals were cared for according to the guidelines of the Canadian Council on Animal Care (CCAC, 2009).

2.1. Ingredient source and guanidination procedure

Field pea (180 g/kg CP) and PPI (810 g/kg CP) that were used in the present study were obtained from NutriPea (Portage La Prairie, MB, Canada). The PPI was produced from the same batch of field pea used in the present study. Field pea and PPI were ground through a 3-mm screen in a Vicking hammermill (Horvick Manufacturing, Fargo, ND, USA). For the determination of TID of CP and AA and endogenous ileal N (ENL) and AA losses (EAAL) flow, field pea and PPI samples were guanidinated according to the procedures described by Nyachoti et al. (1997a) and Fontaine et al. (2007). Briefly, 0.4 M methylisourea (MIU) solution was prepared by reacting 68.9 g of O-methylisourea hydrogen sulfate (Sigma Chemicals CO, St. Louis, MO, USA) with 128.8 g of barium hydroxide (980 g/kg pure, Sigma Chemicals CO, St. Louis, MO, USA) in distilled water followed by centrifugation at 4000 × *g* for 10 min. The supernatant was decanted into a 1 L volumetric flask and brought to volume with distilled water. The pH of the resulting solution was adjusted to 10.5 with 2 M NaOH. Samples of ground field pea and PPI containing 200 g of CP were soaked in 1 L distilled water and then thoroughly mixed with 1 L solution of 0.4 M MIU. The mixture was adjusted to a pH of 10.5 using a 2 M NaOH and then incubated at 4 °C for 6 days. During the incubation period, the pH of the mixture was checked twice daily (0830 and 1630) and adjusted to 10.5 if necessary. After the incubation period, the guanidination reaction was stopped by lowering the pH to the isoelectric point of field pea protein (4.5) using 1 M HCl. The guanidinated protein was recovered by centrifuging the samples for 10 min at 4000 × *g*. The precipitated protein was washed and centrifuged 3 times with deionized water whose pH had been adjusted to the isoelectric point of field pea protein. Washed samples were frozen (−20 °C) immediately, freeze-dried and stored at 4 °C until required for diet formulation. The conversion rate of lysine to HA for field pea and PPI samples was calculated using the equation described by Nyachoti et al. (2002).

2.2. Experimental diets

The study incorporated two diets using either field pea or PPI as the sole source of protein (Table 1). Diets were formulated to contain 155 g/kg of CP, and vitamins and minerals were supplemented to meet or exceed the NRC (1998, 2012) recommendations. Two sets of 2 diets were prepared: one set of diets contained chromic oxide (3 g/kg) as an indigestible marker and intact field pea or PPI. The other set contained titanium oxide (3 g/kg) as an indigestible marker and half (i.e., 500 g/kg) of the dietary field pea or PPI was replaced with its respective guanidinated material. Diets were provided to the animals in a mash form.