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The effect of pectin on amino acid digestibility and digesta viscosity, motility and morphology of the small intestine, and on N-balance and performance of young pigs ☆

L. Buraczewska, E. Święch *, A. Tuśnio, M. Taciak, M. Ceregrzyn, W. Korczyński

The Kielanowski Institute of Animal Physiology and Nutrition, Polish Academy of Sciences, Jabłonna, Poland

Abstract

Two experiments were carried out using a balanced feed mixture composed of wheat, corn, soyabean meals, casein, and crystalline amino acids (AA) and supplemented with 0, 4, or 8% of apple pectin. The daily dietary allowance provided pigs with the same level of nutrients, apart from the pectin. One experiment was conducted on pigs (within 25 to 40 kg BW) with the post valve T-caecum (PVTC) cannula to determine AA digestibility and ileal digesta viscosity. In the second experiment, the N-balance was measured twice on male pigs at about 20 and 28 kg BW using 6 animals per diet and feed intake and body weight were measured twice during the 28 d. After 40 d of feeding the diets, the pigs were sacrificed and the small intestines were weighed and sampled. The added pectin decreased standardized ileal AA digestibility (on average up to 5% dig. units) and increased digesta viscosity from about 1 to 88 mPa s. The higher pectin level did not affect motility of the duodenum and mid-jejunum, measured as responses to electrical field stimulation and to acetylcholine. However, the response of the duodenum to electrical field stimulation was after feeding the diet with 4% pectin increased compared with other diets. Pectin supplementation did not alter the weight and the length of the small intestine, but induced changes in the intestinal morphology. Muscle layer width increased significantly in the duodenum, the mid-jejunum, and the ileum while villi length increased in the duodenum and ileum. The addition of pectin decreased N retention and increased the F/G ratio but did not affect significantly the ADG of the pigs.

Keywords: Pectin; Digesta viscosity; Ileal digestibility; Intestinal morphology; Performance parameters; Pigs

1. Introduction

Many studies suggest that body protein deposition in pigs is influenced by the type of diet, even when the ileal digestible amino acid (AA) intake is kept constant across dietary AA sources. These dietary effects may be attributed to specific non-starch polysaccharides (NSP), especially water-soluble NSP, which increase luminal viscosity, influencing the gastrointestinal environment and resulting in the decrease of nutrient digestibility. It was found in pigs that the NSP of cereals may elevate the ileal flow of endogenous AA (Jondreville et al., 2001) which may decrease N retention. In broilers, elevated digesta viscosity induced enlargements of the small intestine and pancreas and stimulated their protein

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* Corresponding author. Tel.: +48 22 7824422; fax: +48 22 7742038.
E-mail address: e.swiech@ifzz.pan.pl (E. Święch).

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turnover rates (Dänicke et al., 2000). Also, high digesta viscosity negatively affected the performance, development of the stomach, and motility of the small intestine in young chickens (Smulikowska et al., 2002). Less attention was paid to changes in morphology and motility of the gastrointestinal tract of pigs fed diets with water-soluble NSP. Therefore, the objective of the present study was to determine the effect of feeding graded levels of apple pectin on digesta viscosity, amino acid digestibility, motility and morphology of the small intestine and on the N-balance and performance of young pigs.

2. Materials and methods

The experiments were approved by the Local Animal Care Commission. Male pigs with a high lean gain potential (synthetic line 990, Poland) were used in ileal digestibility and in nitrogen (N) balance experiments. The animals were fed a balanced feed mixture (about 18% protein) composed of wheat, corn, soyabean meals, casein, and crystalline AA, and supplemented with 0, 4, or 8% of highly esterified apple pectin (Pectowin, Poland). The daily dietary allowance provided pigs with the same level of nutrients, apart from the pectin. The basal diet for pigs below 20 and over 20 kg of BW contained 1.30 and 1.15% lysine, respectively, and provided other essential AA according to Rademacher et al. (1999).

The digestibility experiment was carried out on pigs 25 to 40 kg BW. Pigs were surgically fitted with a PVTC cannula according to Van Leeuwen et al. (1991). At ten day recovery period was followed by a 7 d period of feeding the pigs with the experimental diets. Each diet was given to 6 animals according to a change-over design. During the last 3 d ileal digesta was collected between meals given at 08:00 and 20:00 h. From each daily 12 h collection a pooled sample was taken for measurement of viscosity of fresh digesta using a viscometer. The digesta were stored frozen, and after thawing were pooled per animal within each experimental period, and freeze dried for analysis. Chromic oxide was used as a marker. The supernatant viscosity of digesta, amino acids and chromic oxide were determined according to the methods used by Bartelt et al. (2002).

The nitrogen balance experiment was performed during 28 d on 18 pigs (6 per treatment) of initial body weight about 15 kg. Nitrogen balance was determined twice at 20 and 28 kg of BW. Urine and faeces were collected during 6 d. Feed intake and body weight were

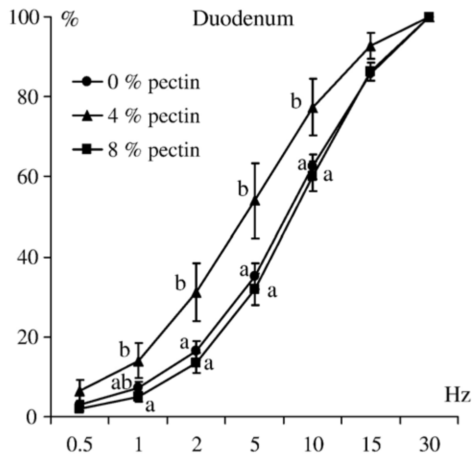

Fig. 1. Contractions of longitudinal muscle of duodenum induced by electrical field stimulation (from 0.5 to 30 Hz) in pigs fed diets containing 0, 4, and 8% pectin. Results are expressed as percent of maximal response to 30 Hz. Data points marked with different letters (a, b) are significantly different at $P \leq 0.05$.

Table 1
Standardized ileal digestibility (%) of protein and the main amino acids in pigs fed diets containing 0, 4, and 8% pectin, $n=6$

Pectin (%)	0	4	8	SEM
Protein	83.5^{b}	78.0^{a}	76.5^{a}	0.7
Lysine	88.2^{c}	84.5^{b}	82.8^{a}	0.6
Methionine	90.5^{c}	87.3^{b}	85.5^{a}	0.6
Threonine	84.7^{b}	79.5^{a}	79.5^{a}	0.9
Tryptophan	82.7^{b}	77.2^{a}	76.7^{a}	1.3

abc — values in the same row without an identical superscript letter are significantly different at $P \leq 0.05$.

Table 2
Histological parameters (µm) of the small intestine in pigs fed diets containing 0, 4, and 8% pectin, $n=6$

Pectin (%)	0	4	8	SEM
Duodenum				
Villi length	347^{a}	329^{b}	352^{a}	6
Crypt depth	314	335	320	8
Tunica mucosa width	752	755	729	11
Muscle layer width	556^{a}	635^{b}	569^{a}	13
Mid-jejunum				
Villi length	373	367	385	7
Crypt depth	267^{a}	240^{b}	251^{ab}	6
Tunica mucosa width	705^{a}	675^{b}	694^{ab}	10
Muscle layer width	359^{a}	443^{b}	421^{b}	8
Ileum				
Villi length	331^{a}	325^{a}	375^{b}	6
Crypt depth	247^{a}	262^{a}	232^{b}	6
Tunica mucosa width	644	650	654	10
Muscle layer width	707^{a}	819^{b}	818^{b}	14

ab — values in the same row without an identical superscript letter are significantly different at $P \leq 0.05$.