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Exogenous pancreatic-like enzymes are recovered in the gut and improve growth of exocrine pancreatic insufficient pigs¹

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ABSTRACT: The exocrine pancreatic insufficient (EPI) pigs grow less due to different disturbances in feed digestion, absorption, and retention. Use of pancreatic-like enzymes of microbial origin in pigs may improve feed use and performance in slow-growing pigs. The aim was to study gut recovery and effectiveness of pancreatic-like enzymes of microbial origin supplementation on pig performance. Six male pigs 10 to 12 kg BW underwent pancreatic duct ligation surgery to induce total exocrine pancreatic insufficiency (EPI). Three cannulas to access the gastrointestinal tract content were installed in stomach, duodenum, and ileum in EPI pigs and in 3 control (healthy) pigs. One month after surgery, enzymes were given before feeding and digesta samples were collected for analyses. The BW of EPI pigs did not increase during 1 mo following surgery (11.7 vs. 11.6 kg BW); however, BW increased

after 1 wk of enzyme supplementation (12.1 kg BW). Coefficient of fat and N absorption increased ($P < 0.05$) in EPI pigs after enzyme supplementation. Activity of amylase, lipase, and protease in chyme samples of EPI pigs was very low compared to controls. In EPI pigs after enzyme supplementation, amylase activity increased from 5.32 to 72.9 units/mL but remained lower than that of healthy pigs (162.7 units/mL). Lipase activity increased from 79.1 to 421.6 units/mL, which was similar to that of controls (507.3 units/mL). Proteolytic activity increased from 7.8 to 69.7 units/mL but still did not reach control pigs (164.3 units/mL). In conclusion, exogenous microbial enzymes mimic endogenous pancreatic enzymes being recovered along the lumen of the gastrointestinal tract. These enzymes might be a useful tool to stimulate growth of slower-growing pigs after the weaning period.

Key words: exocrine pancreatic insufficiency, microbial enzyme

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INTRODUCTION

Intensive farming or high animal density creates conditions for stress and pathogens. The highest risk of disturbances of gastrointestinal tract function is present in pigs at weaning when young pigs are forced to deal with changes in their living environment and feed type, which may induce inadequate pancreatic enzyme secretion. A direct relation between enzyme production in the pancreas and pig growth exists during suckling (Van den Borne et al., 2007). Lack of pancreatic

enzymes is associated with unsatisfactory digestion and absorption. In older pigs, high exocrine pancreatic secretion is positively related to ADG whereas the reserve occurs for lower pancreatic secretion (Botermans and Pierzynowski, 1999). Microbial enzymes are widely available and may mimic activity of endogenous digestive enzymes. Therefore, microbial enzyme supplementation in feed may increase digestion in pigs with exocrine pancreatic insufficiency (EPI), which are growth retarded (Boersma and Witt, 1997). The aim was to study recovery of exogenous microbial enzymes supplemented to the feed in EPI pigs and their efficacy on growth.

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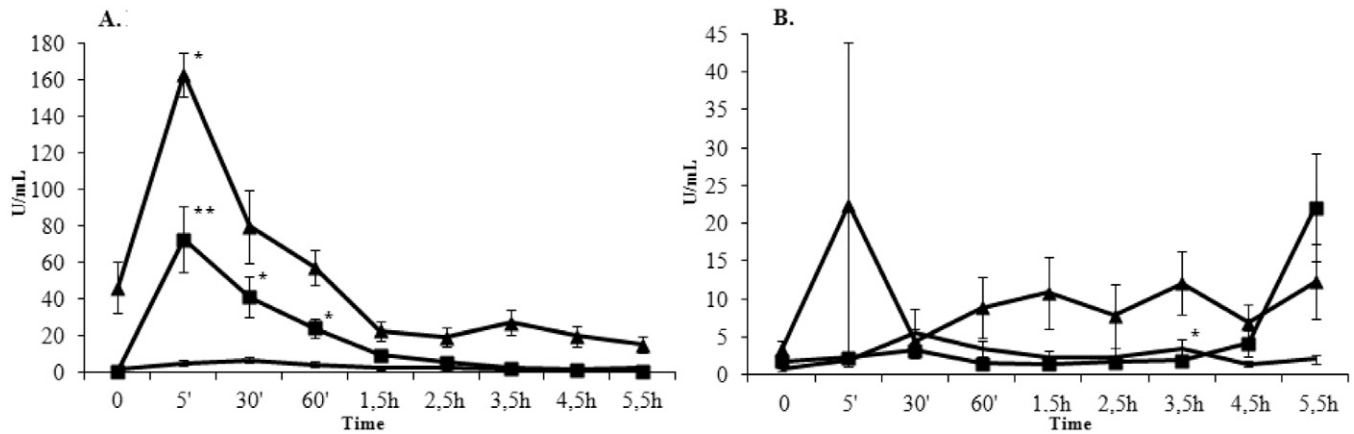


Figure 1. Exogenous and endogenous amylase activity in the duodenum (A) and ileum (B) of ▲ control (n = 3) and — exocrine pancreatic insufficient (EPI) pigs untreated (n = 6) and ■ treated (n = 6) with microbial enzymes. * $P < 0.05$ and ** $P < 0.01$; different from control at specific time point. U = units.

MATERIAL AND METHODS

Procedures were approved by the Local Animal Ethics Review Committee of Lund, Sweden. The study used 9 male, castrated pigs (11.0 ± 1.0 kg initial BW) obtained from the Swedish Agricultural University in Alnarp. Pigs were housed in individual metabolic cages (1.0 by 1.5 m) at a room temperature of 22°C and had free access to tap water. Six pigs underwent pancreatic duct ligation (EPI pigs) surgery (Gewert et al., 2004). The T-shaped cannulas were inserted in the stomach, duodenum, and ileum (n = 9). Pigs were adapted for 1 mo to develop EPI (n = 6).

All pigs were fed twice daily (2% BW) a commercial diet (Växtill 320, Lantmännen, Stockholm, Sweden) with additional fat (Donaldson et al., 2009). Enzymes were given 4 times to all EPI pigs in 20 g yoghurt (0.5% fat) for 1 wk (each second day). The enzymes (Sigma-Aldrich) portion contained 30,000 units of amylase (A9857), 260,000 units of lipase (534641), and 200,000 units of protease (P4032). Feces from EPI pigs were collected for 3 d at the end of the adaptation and the last 3 d of enzyme treatment. The EPI pigs were weighed before surgery, the

last day of adaptation, and at day following completions of collections. Chyme was collected from the stomach, duodenum, and ileum 5 min before feeding and 0.5, 1.0, 1.5, 2.5, 3.5, 4.5, and 5.5 h after morning feeding the last day of enzyme treatment. Amylase (Thermo Scientific, Middletown, VA), lipase (Randox Laboratories Ltd., Crumlin, UK), and protease activity in chime samples was measured. Coefficient of fat absorption (CFA) and coefficient of N absorption (CNA) were calculated (Donaldson et al., 2009). Chyme from control pigs were collected parallel to the last collection from EPI pigs treated with enzymes.

The BW data are presented as mean \pm SD and enzyme activity was expressed as mean \pm SEM. The 1-way ANOVA was completed prior to the Student's *t*-test. Differences were considered as significant when $P < 0.05$.

RESULTS

The BW of EPI pigs did not differ during the 1 mo following surgery (11.6 vs. 11.7 kg BW, respectively). After 1 wk of enzyme supplementation, BW was increased (12.1 kg BW; $P < 0.01$). The CNA was higher

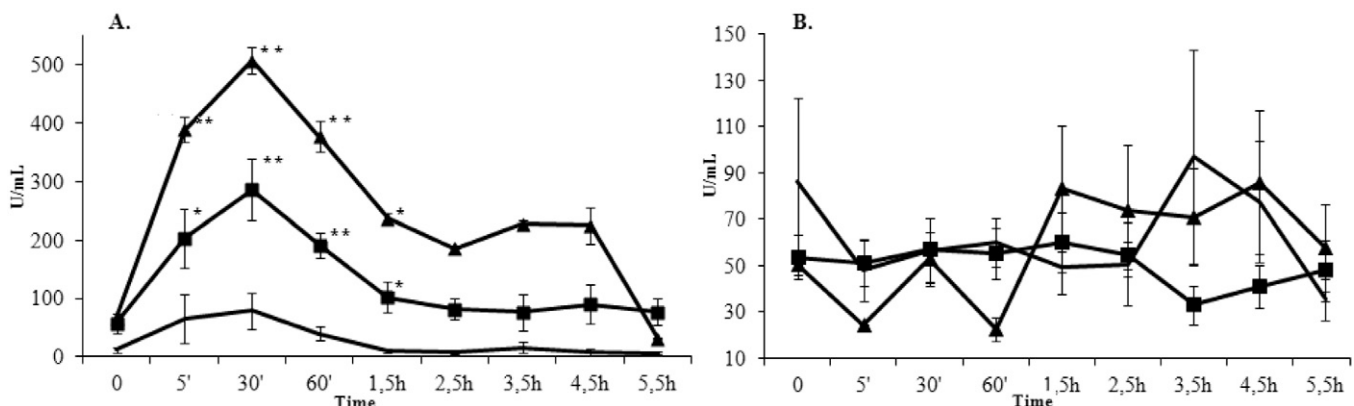


Figure 2. Exogenous and endogenous lipase activity in the duodenum (A) and ileum (B) of ▲ control (n = 3) and — exocrine pancreatic insufficient (EPI) pigs untreated (n = 6) and ■ treated (n = 6) with microbial enzymes. * $P < 0.05$ and ** $P < 0.01$; different from control at specific time point. U = units.

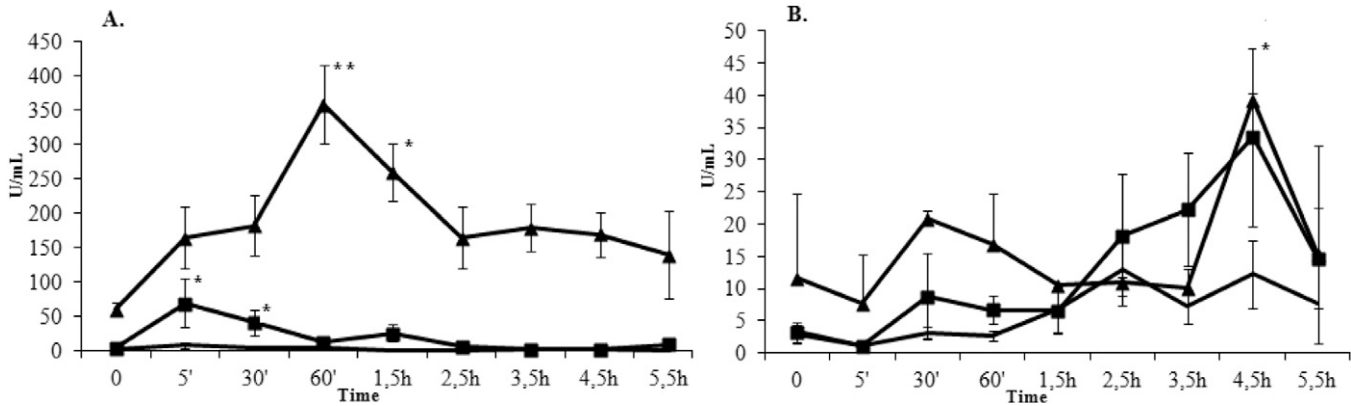


Figure 3. Exogenous and endogenous protease activity in the duodenum (A) and ileum (B) of ▲ control (n = 3) and ■ exocrine pancreatic insufficient (EPI) pigs untreated (n = 6) and ■ treated (n = 6) with microbial enzymes. * $P < 0.05$ and ** $P < 0.01$; different from control at specific time point. U = units.

($P < 0.05$) in EPI pigs after than before enzyme treatment (56.7 vs. 36.4%, respectively). The CFA values were higher ($P < 0.01$) after enzyme treatment than before treatment (84.8 vs. 14.0%).

Amylase in control pigs reached the highest ($P < 0.05$) activity in the duodenum during the middle of feeding (162.7 ± 12.0 units/mL) whereas amylase activity in EPI pigs without enzyme treatment was 5.32 ± 1.5 units/mL. In EPI pigs after enzyme treatment, amylase activity increased ($P < 0.01$) in the duodenum (73.0 ± 17.7 units/mL), which then decreased considerably within the ileum (4.17 ± 1.7 units/mL) (Figure 1). Before enzyme treatment, the highest lipase activity in control pigs was measured in duodenal samples (507.3 ± 22.1 units/mL) whereas in EPI pigs the highest lipase activity was found in the ileum (96.8 ± 46.2 units/mL; Figure 2). Proteolytic activity in the duodenum of EPI pigs was higher ($P < 0.001$) 5 min after enzyme treatment (69.7 ± 35.6 units/mL vs. 7.8 ± 3.7 units/mL) but did not reach levels observed in control pigs (357.6 ± 57.3 units/mL; $P < 0.01$). Proteolytic activity in EPI pigs treated with enzymes remained high in the jejunum 4 h after enzyme treatment (Figure 3).

DISCUSSION

In the small intestine, activity of exogenous lipase, amylase, and protease used in EPI pigs reached in some cases 90% of their in vitro activity. Pancreatic-like enzymes mimic endogenous pancreatic enzymes and might be a useful tool to stimulate growth of slow-growing pigs. Considering the improved CFA and CNA in EPI pigs after enzyme supplementation, we predict that meat production might be accelerated when animals,

especially those growth retarded, will be supplemented with pancreatic-like enzymes in their feed.

In conclusion, exogenous microbial enzymes activity in gut chyme mimics endogenous pancreatic enzymes. Moreover, microbial enzyme supplementation enhanced fat and protein digestion of EPI pigs similar to the endogenous pancreatic enzymes and increased BW of EPI pigs. Therefore, we postulate that a mix of microbial enzymes might stimulate growth of slow-growing pigs around weaning period.

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