Effects of Dietary Apple Pectin Oligosaccharide Supplementation on Carcass Traits, Meat Quality, and Major Colonic Microbiota in Late-Stage Finishing Pigs (Postprint)

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Abstract

This study aimed to investigate the effects of dietary supplementation with apple pectin oligosaccharides (APOS) on carcass traits, meat quality, and major colonic microbiota in late-finishing pigs. Thirty-six healthy castrated male Duroc × Landrace × Large White pigs with an average body weight of approximately 80 kg were randomly assigned to 3 treatments based on similar body weight, with 6 replicates per treatment and 2 pigs per replicate. Each treatment group was fed a basal diet supplemented with 0, 200, or 400 mg/kg APOS for a 28-day experimental period. The results showed that dietary APOS supplementation did not significantly affect the growth performance of finishing pigs ($P>0.05$). Dietary APOS supplementation increased the loin eye area ($P<0.05$) and intramuscular fat content ($P=0.07$), and decreased muscle drip loss ($P=0.06$) and cooking loss ($P<0.05$) in finishing pigs to varying degrees. Furthermore, dietary APOS supplementation increased the total bacterial count in colonic digesta of finishing pigs ($P=0.07$) and significantly increased the volatile fatty acid content in colonic digesta ($P<0.05$). In conclusion, supplementation of 200 or 400 mg/kg APOS in the diet had no effect on growth performance of finishing pigs, but improved carcass traits and meat quality to varying degrees, and modulated the major colonic microbiota and volatile fatty acid production.

Full Text

Effects of Dietary Apple Pectic Oligosaccharide Supplementation on Carcass Traits, Meat Quality and Main Colonic Microflora of Finishing Pigs

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Abstract

This study aimed to investigate the effects of dietary apple pectic oligosaccharide (APOS) supplementation on carcass traits, meat quality, and main colonic microflora in finishing pigs. Thirty-six healthy crossbred (Duroc×Landrace×Yorkshire) finishing pigs with an average initial body weight of approximately 80 kg were randomly allocated to three treatments according to the principle of similar body weight, with six replicates per treatment and two pigs per replicate. Pigs in the three treatments were fed basal diets supplemented with 0, 200, and 400 mg/kg APOS, respectively. The experimental period lasted for 28 days. The results showed that dietary APOS supplementation did not significantly affect the growth performance of finishing pigs ($P>0.05$). Dietary APOS supplementation increased the loin-eye area ($P<0.05$) and intramuscular fat content ($P=0.07$), and reduced the drip loss ($P=0.06$) and cooking loss ($P<0.05$) of muscles in finishing pigs to varying degrees. In addition, dietary APOS supplementation tended to increase the total bacteria count in colonic digesta ($P=0.07$) and significantly increased the content of volatile fatty acids in colonic digesta of finishing pigs ($P<0.05$). In conclusion, dietary supplementation with 200 or 400 mg/kg APOS had no effect on growth performance but improved carcass traits and meat quality to varying degrees, and regulated the main colonic microflora and volatile fatty acid production in finishing pigs.

Key words: apple pectic oligosaccharide; finishing pigs; carcass traits; meat quality; main colonic microflora

Introduction

As an important component of oligosaccharides, functional oligosaccharides are linear or branched carbohydrate compounds formed by 2–10 monosaccharide molecules linked via glycosidic bonds, which themselves are essentially resistant to degradation by gastric acid and digestive enzymes and cannot be absorbed by the intestine. Numerous studies have found that dietary supplementation with appropriate doses of functional oligosaccharides can enhance immune function, promote mineral absorption, improve digestive tract microflora structure, and exert antioxidant and anti-tumor effects, thereby promoting growth and maintaining health [1-4]. Consequently, most functional oligosaccharides developed as feed additives are primarily applied to promote growth and health in young animals as alternatives to feed antibiotics. Recent related studies have also found that dietary functional oligosaccharides can regulate glucose and lipid metabolism and modulate meat quality in livestock and poultry [5-6].

Pectic oligosaccharide is a type of functional oligosaccharide, mainly produced by enzymatic hydrolysis of natural pectin from plant fruits, roots, stems, and leaves, with main components being galacturonic acid and pectin disaccharides and trisaccharides formed with other monosaccharides [7]. In recent years, apart from studies on the effects of pectic oligosaccharides on antioxidant capacity and intestinal microbial composition, research by Li Tuoping' s team at Liaoning University on hawthorn pectic oligosaccharides has shown that dietary supplementation with hawthorn pectic oligosaccharides, especially in high-fat diets, can regulate lipid metabolism in mice [8-10]. Therefore, it can be speculated that dietary pectic oligosaccharide supplementation may regulate carcass traits and meat quality in pigs, though relevant studies have not been reported. Thus, the objective of this study was to investigate the effects of dietary apple pectic oligosaccharide (APOS) supplementation in finishing pigs on carcass traits, meat quality, and intestinal microecology, providing experimental support for the application of pectic oligosaccharides in improving pork quality in production.

Materials and Methods

1.1 Experimental Materials

APOS was provided by the Feed Research Institute of the Chinese Academy of Agricultural Sciences. The product contained more than 30% pectic oligosaccharides (mainly pectin disaccharides, pectin trisaccharides, and galacturonic acid monosaccharides), with corn starch as the excipient.

1.2 Experimental Animals and Design

Thirty-six healthy crossbred (Duroc×Landrace×Yorkshire) barrows with an average initial body weight of approximately 80 kg were selected for the experiment. All pigs were randomly allocated to three treatments according to the principle of similar body weight, with six replicates per treatment and two pigs per replicate. The experimental period lasted for 28 days.

1.3 Experimental Diets

The basal diet was a corn-soybean meal type formulated according to the nutrient requirements for pigs in the 75–135 kg stage as specified in NRC (2012).

The experimental diets were prepared by supplementing the basal diet with 0, 200, and 400 mg/kg APOS, respectively, with the added APOS isoenergetically replacing corn starch in the basal diet. The composition and nutrient levels of the basal diet are shown in Table 1 .

1.4 Feeding Management

The experiment was conducted at the Teaching and Research Farm of the Institute of Animal Nutrition, Sichuan Agricultural University. Prior to the experiment, feed troughs and waterers were cleaned, and pig houses were thoroughly disinfected. During the experimental period, pigs were fed at three fixed times daily (08:30, 13:30, and 18:30) with small amounts added frequently to ensure slight leftovers in the troughs, and had free access to water. The pens were kept ventilated, dry, and sanitary, and feed intake was recorded daily.

1.5 Sample Collection and Measurements

1.5.1 Growth Performance With replicate as the experimental unit, all pigs were weighed after fasting on days 1 and 29 of the experiment, and daily feed intake was recorded to calculate average daily feed intake (ADFI), average daily gain (ADG), and feed-to-gain ratio (F/G).

1.5.2 Sample Collection After weighing on day 29, one pig from each replicate was randomly selected for slaughter to determine carcass traits and meat quality parameters. Simultaneously, colonic digesta was collected and stored at -80 °C.

1.5.3 Carcass Traits Carcass trait measurements and calculations were performed according to the methods described in "Swine Production Science" [11]. After conventional exsanguination slaughter, the head, feet, tail, and viscera (with kidneys and leaf lard retained) were removed. Hot carcass weight, loin-eye height and width, and backfat thickness at three points (the thickest part of the shoulder, the thoracolumbar junction, and the lumbosacral junction) were measured to calculate dressing percentage, loin-eye area, and backfat thickness.

1.5.4 Meat Quality Following the methods described in "Swine Production Science" [11], pH (at 45 min and 24 h postmortem), drip loss, cooking loss, and shear force of the Longissimus dorsi muscle were measured. pH was measured using a portable pH meter (OPTO-STAR, R. Matthaus, Germany). Shear force was determined using a texture analyzer (A-XTplus, Stable MicroSystem, UK). Intramuscular fat (IMF) content was measured according to the GB/T 5009.6–2003 method.

1.5.5 Colonic Microflora and VFA Content The enumeration of main microbial groups (total bacteria, lactobacilli, bifidobacteria, and Escherichia coli) in porcine colonic digesta was performed according to the method of Mao et al. [12]. The determination of VFA (acetate, propionate, and butyrate) content in colonic digesta was conducted according to the method of Diao et al. [13].

1.6 Data Processing and Analysis

Experimental data were initially processed using Excel 2003. All measurements were analyzed with replicate as the statistical unit. One-way ANOVA was performed using SAS 8.1 software, and Duncan' s multiple comparison test was applied when significant differences were detected. $P<0.05$ was set as the criterion for statistical significance, and $P<0.10$ was considered a tendency. Data are expressed as "mean $\pm$ standard error."

Results

2.1 Effects of APOS on Growth Performance

As shown in Table 2 , dietary APOS supplementation had no significant effect on the growth performance of finishing pigs ($P>0.05$).

2.2 Effects of APOS on Carcass Traits

As shown in Table 3 , dietary supplementation with 400 mg/kg APOS significantly increased the loin-eye area of finishing pigs ($P<0.05$). Compared with pigs fed the diet without APOS, carcass weight, dressing percentage, and backfat thickness of pigs fed diets supplemented with 200 and 400 mg/kg APOS showed no significant differences ($P>0.05$).

2.3 Effects of APOS on Meat Quality and IMF Content

As shown in Table 4 , dietary supplementation with 200 and 400 mg/kg APOS significantly reduced the cooking loss of muscles in finishing pigs ($P<0.05$), tended to decrease drip loss ($P=0.06$), and showed a tendency to increase the intramuscular fat content in the Longissimus dorsi muscle ($P=0.07$), but had no significant effect on muscle pH or shear force ($P>0.05$).

2.4 Effects of APOS on Colonic Microflora

As shown in Table 5 , dietary supplementation with 200 and 400 mg/kg APOS tended to increase the total bacteria count in colonic digesta of finishing pigs ($P=0.07$), but had no significant effect on the numbers of lactobacilli, bifidobacteria, or Escherichia coli in colonic digesta ($P>0.05$).

2.5 Effects of APOS on Colonic VFA Content

As shown in Table 6 , dietary APOS supplementation significantly increased the contents of acetate, propionate, butyrate, and total VFA in colonic digesta of finishing pigs ($P<0.05$).

Discussion

As a functional oligosaccharide developed in recent years, the effects of pectic oligosaccharide as a feed additive on animal growth performance have shown some variation in research results. Studies by Li Tuoping' s team at Liaoning University have shown that dietary supplementation with hawthorn-derived pectic oligosaccharide can reduce weight gain induced by high-fat diets in adult Kunming mice [8-10]. In contrast, our previous research on weaned Wistar rats and piglets showed that supplementation with apple-derived pectic oligosaccharide in normal diets could improve the growth performance of weaned rats and piglets [14]. In this study, dietary APOS supplementation in normal finishing pig diets had no significant effect on average daily gain, average daily feed intake, or feed-to-gain ratio. Based on the design and results of these studies, it can be speculated that the effects of dietary pectic oligosaccharide supplementation on growth performance may be related to diet type, composition, and different growth stages of animals.

Loin-eye area, along with muscle drip loss, cooking loss, and intramuscular fat content, are important indicators for evaluating carcass traits and meat quality in pigs [11]. The results of this study showed that dietary APOS supplementation increased the loin-eye area and intramuscular fat content, and decreased the cooking loss and drip loss of muscles in finishing pigs to varying degrees, indicating that dietary APOS supplementation improved carcass traits and meat quality in finishing pigs to some extent.

Although this study found that dietary APOS supplementation could promote intramuscular fat deposition in finishing pigs, it had no significant effect on backfat thickness. Research by Li Tuoping' s team also showed that pectic oligosaccharide supplementation in high-fat diets could regulate lipid metabolism and reduce peripheral fat deposition in rats [8-10]. The different results from these studies on the effects of pectic oligosaccharide on body fat deposition suggest to some extent that animal species, growth stage, and diet type may all be important factors affecting fat deposition, and also reflect that the mechanisms and patterns of intramuscular versus intermuscular fat deposition differ.

In recent years, research on the regulation of physiological functions by intestinal microorganisms has become a hotspot, and numerous studies have shown that gut microbes can affect lipid and protein metabolism in humans and animals [15-17]. Pectic oligosaccharides can significantly improve the composition of intestinal microorganisms in humans and animals [18], and our previous research showed that dietary APOS supplementation significantly increased the numbers of lactobacilli and bifidobacteria, decreased the number of Escherichia coli, and tended to increase total bacteria count in cecal digesta of weaned Wistar rats and piglets [14]. In contrast, this study found that dietary APOS supplementation tended to increase total bacteria count in colonic digesta but had no significant effect on the numbers of lactobacilli, bifidobacteria, or Escherichia coli. These results suggest that the effects of dietary pectic oligosaccharide supplementation on intestinal microbial composition are related to the growth stage and age of animals. Studies on the correlation between intestinal microbial composition and body fat metabolism have also shown that the ratio of Firmicutes to Bacteroidetes in the gut is closely related to body fat metabolism [16-17]. Therefore, it can be speculated that the increased total bacterial count in the gut observed in this study with dietary APOS supplementation may be due to an increase in Firmicutes bacteria, though this speculation requires further verification.

In addition, numerous recent studies have explored the mechanisms by which intestinal microorganisms regulate lipid metabolism in animals and humans. These studies have found that metabolites produced by microbial fermentation in the gut, particularly VFAs, are important pathways for regulating body fat metabolism [16-17,19-20]. Pectic oligosaccharides can also significantly improve VFA production from microbial fermentation in the gut of humans and animals [14,18], and this study obtained similar results, showing that dietary APOS supplementation significantly increased the contents of acetate, propionate, butyrate, and total VFA in colonic digesta. Therefore, changes in intestinal microecology may be the reason why dietary APOS supplementation improves carcass traits and meat quality in finishing pigs.

Conclusion

Dietary supplementation with 200 or 400 mg/kg APOS had no significant effect on the growth performance of finishing pigs but improved carcass traits and meat quality to some extent.

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Note: Figure translations are in progress. See original paper for figures.