Effects of Xylooligosaccharides on Growth Performance, Diarrhea Rate, and Serum Biochemical Parameters in Nursery Pigs: Postprint

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Date: 2018-12-24T00:00:00+00:00

Abstract

This experiment aimed to investigate the effects of xylo-oligosaccharides (XOS) on growth performance, diarrhea rate, and serum biochemical indices in nursery pigs, and to determine the optimal supplementation level. Seventy-two healthy Duroc × Landrace × Yorkshire (DLY) piglets at (35±1) days of age with similar parity were selected and randomly allocated into 4 groups with 3 replicates per group and 6 piglets per replicate. The control group was fed a basal diet, while experimental groups I, II, and III were fed experimental diets supplemented with 100, 200, and 400 mg/kg XOS in the basal diet, respectively, for a 28-day experimental period. The results showed: 1) The final body weight, average daily gain (ADG), and average daily feed intake (ADFI) of piglets in experimental group II were significantly higher than those in the other groups ($P<0.05$); the feed-to-gain ratio (F/G) of piglets in experimental groups I and II was significantly lower than that in the control group and experimental group III ($P<0.05$), with experimental group II showing the best effect. 2) Compared with the control group, the diarrhea rate of piglets in all experimental groups was extremely significantly reduced ($P<0.01$), with experimental group II showing the best effect. 3) Compared with the control group, the contents of total protein (TP), albumin (ALB), globulin (GLB), and the albumin/globulin ratio (ALB/GLB) in serum of all experimental groups showed no significant changes ($P>0.05$); the glucose content and activities of amylase and alkaline phosphatase in serum of experimental group II were significantly higher than those of the control group ($P<0.05$); the contents of urea nitrogen and total cholesterol in serum of all experimental groups were significantly lower than those of the control group ($P<0.05$), while the activities of alanine aminotransferase and aspartate aminotransferase in serum showed an increasing trend compared with the control group, but the differences were not significant ($P>0.05$). It can be concluded that dietary supplementation with appropriate amounts of XOS can

improve the growth performance of nursery pigs, reduce diarrhea rate, and improve some serum biochemical indices. Under the conditions of this experiment, supplementation of 200 mg/kg XOS in nursery pig diets was optimal.

Full Text

Effects of Xylo-Oligosaccharide on Growth Performance, Diarrhea Rate and Serum Biochemical Indices of Nursery Piglets

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Abstract: This experiment was conducted to investigate the effects of xylo-oligosaccharide (XOS) on growth performance, diarrhea rate, and serum biochemical indices of nursery piglets, and to determine the optimal supplemental dose. Seventy-two healthy Duroc×Landrace×Yorkshire piglets at (35±1) days of age with similar parity were randomly allocated to four groups with three replicates per group and six piglets per replicate. The control group was fed a basal diet, while experimental groups I, II, and III were fed the basal diet supplemented with 100, 200, and 400 mg/kg XOS, respectively. The trial lasted for 28 days. The results showed: 1) The final body weight, average daily gain (ADG), and average daily feed intake (ADFI) of piglets in group II were significantly higher than those in other groups ($P<0.05$). The feed-to-gain ratio (F/G) of groups I and II was significantly lower than that of the control group and group III ($P<0.05$), with group II showing the best effect. 2) Compared with the control group, the diarrhea rate of piglets in all experimental groups was extremely significantly reduced ($P<0.01$), with group II demonstrating the best effect. 3) Compared with the control group, the contents of serum total protein (TP), albumin (ALB), globulin (GLB), and the ALB/GLB ratio showed no significant changes ($P>0.05$). The glucose content and activities of amylase and alkaline phosphatase in serum of group II were significantly higher than those of the control group ($P<0.05$). The contents of urea nitrogen and total cholesterol in serum of all experimental groups were significantly lower than those of the control group ($P<0.05$), while the activities of alanine aminotransferase and aspartate aminotransferase tended to increase compared with the control group, though the differences were not significant ($P>0.05$). In conclusion, dietary supplementation with appropriate amounts of XOS can improve the growth performance, reduce diarrhea rate, and improve certain serum biochemical indices of nursery piglets. Under the conditions of this experiment, 200 mg/kg XOS was the optimal supplemental dose for nursery piglets.

Keywords: xylo-oligosaccharide; nursery piglets; growth performance; diarrhea rate; serum biochemical indices

Weaned piglets are susceptible to stress due to their immature physiological functions, which can be triggered by weaning, diet changes, and environmental fluctuations. This stress often leads to imbalanced gastrointestinal microbiota, decreased immunity, and consequently, intestinal diseases such as diarrhea and edema, with severe cases resulting in death and substantial economic losses for producers. Due to concerns about antibiotic residues and resistance, many countries have restricted antibiotic use in animal feed, prompting researchers to seek green feed additives that are pollution-free and leave no residues.

Xylo-oligosaccharide (XOS), as a functional oligosaccharide, exhibits excellent characteristics including good acid and thermal stability and low effective dosage requirements [1-3], and has been widely applied in piglet diets. Research indicates that XOS is barely degraded by digestive enzymes in animals and can directly reach the hindgut, where it selectively promotes the proliferation of bifidobacteria and produces large amounts of organic acids, thereby inhibiting harmful bacteria and maintaining intestinal microecological balance [4-5]. This functionality is 10–20 times more effective than other oligosaccharides. Furthermore, XOS fermentation can inhibit protein decomposition in the hindgut [6], reducing the production of phenols and ammonia, thus avoiding damage to colonic DNA by toxic substances [7] and decreasing the incidence of hindgut lesions. Currently, research on XOS application has been primarily limited to piglets within 35 days of age, with few reports on its effects during the nursery stage. Therefore, this experiment aimed to investigate the effects of different dietary XOS supplementation levels on growth performance, diarrhea rate, and certain serum biochemical indices of nursery piglets, providing a scientific basis for the rational application of XOS in nursery pig diets.

1.1 Test Materials

The XOS used in this experiment was provided by Shandong Longlive Biotechnology Co., Ltd., with xylobiose, xylotriose, and xylotetraose as the main functional components and an effective content of 35%.

1.2 Experimental Design and Diet Composition

Seventy-two Duroc×Landrace×Yorkshire piglets at (35±1) days of age with an average body weight of (9.81±0.42) kg were randomly divided into four groups with three replicates per group and six piglets per replicate (half male and half female). There were no significant differences in initial body weight among groups ($P>0.05$). The control group was fed a basal diet, while experimental groups I, II, and III were fed the basal diet supplemented with 100, 200, and 400 mg/kg XOS, respectively. The experimental period lasted 28 days.

The basal diet was formulated according to the nutrient requirements for piglets in NRC (2012), with feed ingredient values referenced from the Chinese Feed Database (2010). The composition and nutrient levels of the basal diet are shown in Table 1 .

1.3 Animal Management

The animal trial was conducted at Guangxi Bailin Pig Farm. Experimental pigs were housed in semi-open nursery pens with consistent microenvironments across groups. Pigs had free access to feed and water, and were managed and immunized according to conventional farm operation protocols. Growth, feed intake, and diarrhea conditions were observed twice daily (morning and afternoon), and daily feed intake and number of diarrheic pigs were recorded.

1.4 Measurement Indicators and Methods

1.4.1 Growth Performance Feed was withheld for 10 hours before weighing at the beginning and end of the experiment. The initial and final body weight of each replicate were measured to calculate average daily gain (ADG) per piglet. Feed consumption and residual feed for each replicate were recorded during the trial to calculate average daily feed intake (ADFI) and feed-to-gain ratio (F/G) per piglet.

1.4.2 Diarrhea Rate The number of diarrheic piglets in each replicate was observed daily at 09:30 and 17:30. Diarrhea was defined as feces that were pasty or watery and visibly adhered to the piglet' s anus.

Diarrhea rate (%) = 100 × total diarrheic piglet occurrences / (number of piglets × experimental days).

1.4.3 Serum Biochemical Indices At the end of the experiment, two piglets with similar body condition were randomly selected from each replicate and blood was collected from the anterior vena cava. After standing at room temperature for 25 minutes, serum was separated by centrifugation at 3,000 r/min for 10 minutes and stored at -20°C for analysis. An automatic biochemical analyzer was used to determine serum contents of total protein (TP), albumin (ALB), globulin (GLB), glucose (GLU), urea nitrogen (UN), and total cholesterol (TC), as well as activities of amylase (AMY), alkaline phosphatase (ALP), alanine aminotransferase (ALT), and aspartate aminotransferase (AST). The ALB/GLB ratio was also calculated. All assays were performed strictly according to the kit instructions (provided by Beijing Leadman Biochemical Technology Co., Ltd.).

1.5 Statistical Analysis

Experimental data were initially processed using Excel 2007 and then analyzed using the ANOVA procedure in SPSS 19.0. Duncan' s multiple comparison test was applied to data with significant differences ($P<0.05$). Data are expressed as "mean ± standard deviation" .

2 Results and Analysis

Effects of XOS on Growth Performance and Diarrhea Rate of Nursery Piglets

As shown in Table 2 , there were no significant differences in initial body weight among groups (P>0.05). At the end of the experiment, the final body weight, ADG, and ADFI of piglets in group II were significantly higher than those in other groups (P<0.05). The F/G of groups I and II was significantly lower than that of the control group and group III (P<0.05), with group II showing the best effect.

The diarrhea rate of piglets in all experimental groups was extremely significantly lower than that of the control group (P<0.01), with reductions of 38.16%, 58.99%, and 46.04% in groups I, II, and III, respectively, compared with the control group. Group II had the lowest diarrhea rate.

Table 2 Effects of XOS on Growth Performance and Diarrhea Rate of Nursery Piglets

Items	Control	Group I	Group II	Group III
IBW/kg	9.98±0.59	9.53±0.41	10.10±0.40	9.65±0.31
FBW/kg	18.75±2.72b	18.53±2.01b	20.20±1.93a	18.62±3.06b
ADG/(g/d)	314.78±3.13b	323.14±4.11b	362.15±2.16a	320.22±5.18b
ADFI/(g/d)	604.25±9.43b	575.47±10.17c	629.39±8.64a	601.25±7.09b
F/G	1.93±0.03a	1.78±0.05b	1.74±0.03b	1.87±0.05a
Diarrhea rate/%	0.137A	0.086Ba	0.054Bb	0.075Ba

In the same row, values with different small letter superscripts indicate significant difference (P<0.05), and with different capital letter superscripts indicate extremely significant difference (P<0.01), while with the same or no letter superscripts indicate no significant difference (P>0.05). The same as below.

Effects of XOS on Serum Biochemical Indices of Nursery Piglets

As shown in Table 3 , compared with the control group, serum TP content in groups I, II, and III increased by 1.08%, 1.67%, and 0.58%, respectively, but the differences were not significant (P>0.05). There were no significant differences in serum ALB and GLB contents or ALB/GLB ratio among groups (P>0.05). Serum GLU content in group II was significantly higher than that in other groups (P<0.05). Serum UN and TC contents in all experimental groups were significantly lower than those in the control group (P<0.05).

Table 3 Effects of XOS on Serum Biochemical Indices of Nursery Piglets

Items	Control	Group I	Group II	Group III
TP/(g/L)	92.53±8.81	93.57±7.91	94.10±4.14	93.06±8.10
ALB/(g/L)	57.15±9.12	58.84±6.89	58.21±4.93	57.93±7.36
GLB/(g/L)	35.36±4.75	34.72±5.11	35.91±3.25	35.12±6.01
ALB/GLB	1.62±0.14	1.68±0.64	1.64±0.49	1.64±0.32
GLU/(mmol/L)	4.46±0.41b	4.55±0.12b	4.84±0.43a	4.48±0.56b
UN/(mmol/L)	5.16±1.16a	4.83±0.60b	4.65±0.72b	4.76±0.82b
TC/(mmol/L)	2.94±0.65a	2.75±0.53b	2.75±0.23b	2.74±0.12b

Effects of XOS on Serum Enzyme Activities of Nursery Piglets

As shown in Table 4 , serum AMY activity in groups I and II was significantly higher than that in other groups (P<0.05). Serum ALP activity in groups II and III was significantly higher than that in the control group (P<0.05), with increases of 21.39% and 18.69% compared with the control group, respectively. There were no significant differences in serum ALT and AST activities among groups (P>0.05).

Table 4 Effects of XOS on Serum Enzyme Activities of Nursery Piglets

Items	Control	Group I	Group II	Group III
ALP/(U/L)	654.22±64.02b	751.02±22.02a	749.94±18.28a	706.64±57.17b
AMY/(U/L)	226.92±43.17b	245.47±24.18b	275.47±43.02a	269.30±15.62a
ALT/(U/L)	10.84±7.53	12.28±8.69	11.08±9.63	11.56±5.51
AST/(U/L)	14.64±5.85	16.38±6.46	15.49±8.14	15.16±4.68

3 Discussion

Effects of XOS on Growth Performance and Diarrhea Rate of Nursery Piglets

The pathogenesis of piglet diarrhea is complex. While suckling piglets typically suffer from infectious diarrhea, nursery piglet diarrhea is mainly caused by non-infectious factors such as weaning, diet changes, dietary antigen allergies, and stress, with nutritional stress being the most significant. Research indicates that the primary cause of post-weaning diarrhea is not *E. coli*, but rather intestinal damage, decreased gastrointestinal enzyme activity, and disrupted intestinal microecology caused by stress [8]. Both domestic and international studies have found that appropriate dietary XOS supplementation can improve nutrient conversion efficiency, increase growth rate, and reduce diarrhea rate in weaned piglets. Lin et al. [9] and Zhao et al. [10] added 0.02% XOS to experimental diets and found that XOS could alleviate diarrhea in 28-day-old weaned piglets and significantly increase ADG while decreasing ADFI. Tan et al. [11] supplemented 250 g/t XOS in 21-day-old weaned piglet diets and found

that XOS could improve ADFI and ADG to some extent and alleviate diarrhea caused by weaning stress.

However, few studies have reported the application effects of XOS during the nursery stage. The present experiment demonstrated that the diarrhea rate of piglets in all experimental groups was extremely significantly reduced compared with the control group, and group II showed significantly superior ADG and ADFI with significantly lower F/G than the control group and group III. This may be because XOS can improve gastrointestinal microbial balance, promote the proliferation of beneficial microorganisms, and produce organic acids and digestive enzymes that facilitate nutrient digestion and absorption. Additionally, XOS can enhance the intestinal mucosal microbial defense barrier while promoting the production of physiologically active substances, thereby improving immune function and reducing diarrhea rate in nursery piglets. It has also been reported that XOS can bind to bacterial cell wall surface proteins (such as lectins) in the intestine, blocking bacterial adhesion to intestinal mucosa and thus reducing or eliminating bacterial pathogenicity [12-13].

Effects of XOS on Serum Biochemical Indices of Nursery Piglets

Studies have shown that dietary XOS supplementation can improve nutrient metabolism and immune function in animals. XOS may regulate liver anabolic function, coordinate the synthesis rate and quantity of ALB and GLB, maintain normal plasma osmotic pressure, regulate metabolism and substance transport, and consequently improve animal health status [14].

Serum TP consists of ALB and GLB, primarily synthesized in the liver; therefore, serum TP content can reflect liver function and nutritional status, with higher TP content being beneficial for enhancing metabolic function and immunity [15]. The ALB/GLB ratio serves as an important indicator of specific immune response level, and a decrease in this ratio indicates accelerated immunoglobulin synthesis and enhanced disease resistance. Yang [16] conducted a 20-day feeding trial with (35±2)-day-old weaned piglets and found that dietary supplementation with 200 g/t XOS had no significant effect on serum TP content. In this experiment, serum TP, ALB, and GLB contents and ALB/GLB ratio in all experimental groups showed no significant differences compared with the control group, but all showed improvement, demonstrating that XOS had no adverse effects on nutrient metabolism and immune function in nursery piglets. This result may be due to the relatively well-developed systems of 35-day-old piglets that have adapted to dietary and management conditions, resulting in stronger stress resistance.

Serum GLU content can reflect glucose metabolism status, and appropriate GLU levels can maintain stable physiological functions of tissues and organs and resist adverse environmental stress [17]. Within the normal range, high-producing animals have higher serum GLU content than low-producing animals. Serum UN content is an important indicator of protein synthesis efficiency and amino

acid balance [18], and is negatively correlated with muscle growth or ADG. Serum TC content, as an important indicator of fat metabolism, increases during stress states, leading to decreased fat utilization [19-20]. This experiment found that dietary supplementation with 200 mg/kg XOS significantly increased serum GLU content in nursery piglets, while serum UN and TC contents in all experimental groups were significantly lower than those in the control group, suggesting that appropriate XOS supplementation in nursery pig diets can enhance nutrient digestion and absorption, improve protein biosynthesis efficiency and fat utilization, and consequently reduce adverse stress and improve piglet health status by affecting serum GLU, UN, and TC contents.

Effects of XOS on Serum Enzyme Activities of Nursery Piglets

Alkaline phosphatase (ALP) is mainly distributed in the liver and bones, promoting calcium and phosphorus deposition in bones and metabolic function, and reflecting piglet growth and development status [11]. Serum amylase (AMY) activity reflects the ability to digest and absorb starch, affecting the rate of chemical reactions, growth and health, and adaptability. Increasing ALP and AMY activities has positive effects on ADG. This experiment showed that dietary supplementation with different levels of XOS could increase serum ALP and AMY activities in nursery piglets, with the best effect observed at 200 mg/kg XOS supplementation, which was consistent with the growth performance results.

ALT and AST mainly exist in hepatocyte mitochondria and cytoplasm and are two important aminotransferases. Under normal conditions, their activities in serum are low; however, when animals experience liver damage or acute stress leading to cell damage, ALT and AST are released from cells into the serum, causing increased activities [18]. Therefore, serum ALT and AST activities can reflect hepatocyte damage [21-22]. In this experiment, there were no significant differences in serum ALT and AST activities among groups, indicating that nursery piglets had strong stress resistance and that dietary XOS supplementation had no adverse effects on the liver.

4 Conclusion

Dietary supplementation with appropriate amounts of XOS can improve the growth performance, reduce diarrhea rate, and improve certain serum biochemical indices of nursery piglets. Under the conditions of this experiment, 200 mg/kg XOS was the optimal supplemental dose for nursery piglets.

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