Effects of -Glucan on Growth Performance, Carcass Traits, and Meat Quality of Growing-Finishing Pigs: Postprint

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Abstract

This experiment was conducted to investigate the effects of -glucan on growth performance, carcass traits, and meat quality in growing-finishing pigs, aiming to determine its application efficacy and appropriate supplementation level in pig diets. A single-factor experimental design was adopted, selecting 96 healthy "Duroc × Landrace × Yorkshire" pigs weighing approximately 20 kg, which were randomly divided into 4 groups according to body weight and sex ratio, with 6 replicates per group and 4 pigs per replicate. The control group was fed a basal diet, while the experimental groups were supplemented with 50, 100, and 200 mg/kg -glucan in the basal diet, respectively. The experimental period lasted 103 days. The results showed that: 1) Compared with the control group, dietary supplementation with 100 mg/kg -glucan significantly increased average daily gain ($P<0.05$), significantly decreased feed conversion ratio ($P<0.05$), and significantly improved digestibility of dietary dry matter, energy, and crude protein ($P<0.05$); 2) Compared with the control group, dietary supplementation with 100 mg/kg -glucan significantly increased carcass length and muscle pH ($P<0.05$), significantly decreased muscle drip loss ($P<0.05$), significantly improved meat color ($P<0.05$), and simultaneously significantly increased inosine monophosphate content in muscle ($P<0.05$), altering the composition ratio of saturated and monounsaturated fatty acids in pork, thereby improving meat flavor. In conclusion, dietary supplementation with 100 mg/kg -glucan can improve growth performance, enhance nutrient digestibility, increase carcass length, and improve pork quality in growing-finishing pigs.

Full Text

Effects of -Glucan on Growth Performance, Carcass Performance and Meat Quality of Growing-Finishing Pigs

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Abstract: This experiment was conducted to investigate the effects of dietary -glucan on growth performance, carcass performance and meat quality of growing-finishing pigs, aiming to determine the application effect and suitable supplemental level of -glucan in growing-finishing pig diets. A single-factor experimental design was adopted, and a total of 96 healthy Duroc×Landrace×Yorkshire pigs with an initial average body weight of 20 kg were randomly allocated into 4 groups with 6 replicates per group and 4 pigs per replicate. Pigs in the control group were fed a basal diet, while those in the experimental groups were fed the basal diet supplemented with 50, 100 and 200 mg/kg -glucan, respectively. The experiment lasted for 103 days. The results showed as follows: 1) Compared with the control group, dietary supplementation with 100 mg/kg -glucan significantly increased the average daily gain ($P<0.05$), significantly reduced the feed-to-gain ratio ($P<0.05$), and significantly improved the digestibility of dry matter, energy and crude protein ($P<0.05$) of growing-finishing pigs. 2) Compared with the control group, dietary supplementation with 100 mg/kg -glucan significantly increased carcass length and muscle pH ($P<0.05$), significantly reduced muscle drip loss ($P<0.05$), significantly improved meat color ($P<0.05$), significantly increased the inosine monophosphate content in muscle ($P<0.05$), and altered the composition ratio of saturated fatty acids and monounsaturated fatty acids in pork, thereby improving meat flavor. In conclusion, dietary supplementation with 100 mg/kg -glucan can improve growth performance, nutrient digestibility, carcass length and meat quality of growing-finishing pigs.

Keywords: -glucan; growing-finishing pigs; growth performance; carcass performance; meat quality

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Introduction

In swine production, antibiotics have been widely used as animal feed additives to reduce and control bacterial diseases and promote animal growth. However, this practice has also led to serious problems including drug resistance, veterinary drug residues, unsafe animal products, and environmental pollution [1]. Therefore, seeking green and safe alternatives to antibiotics represents an effective approach to addressing these negative impacts. -glucan is a functional polysaccharide widely distributed in fungi, bacteria, and cereal grains (such as oats, rye, and barley), primarily existing as a structural component of cell walls. It possesses multiple biological activities and functions, including immune regulation, anti-infection, and blood glucose modulation [2-4]. -glucan typically has -1,3-glycosidic bonds as its main chain and -1,6-glycosidic bonds as side chains. The special bond connection pattern and presence of intramolecular hydrogen bonds create a helical molecular structure, making its unique configuration readily accepted by the immune system. Previous studies have primarily used -glucan extracted from yeast cell walls, which contains multiple polysaccharide components and has low purity. In contrast, the -glucan used in this experiment is a novel type produced through microbial fermentation with sucrose as substrate, with a molecular weight of 200 kDa and effective content 90%. Due to its high water solubility and purity, and its structure dominated by -1,3 glycosidic bonds, it may possess unique physiological functions. Studies have shown that -glucan can improve growth performance of weaned piglets and broilers, with these effects related to promoting intestinal health and enhancing immune function [5-7]. However, most research has focused on young animals and short-term feeding effects, while long-term feeding effects require further investigation. Therefore, this study used growing-finishing pigs as experimental subjects and this novel -glucan as research material to examine the effects of different supplemental levels on growth performance, carcass performance and meat quality, aiming to explore the feeding effects of -glucan in growing-finishing pigs and provide experimental basis for determining its optimal dosage.

Materials and Methods

1.1 Experimental Design and Diets

This experiment adopted a single-factor design. A total of 96 healthy Duroc×Landrace×Yorkshire pigs weighing approximately 20 kg were randomly divided into 4 groups according to body weight and sex ratio, with 6 replicates per group and 4 pigs per replicate (3 barrows and 1 gilt). The basal diet (control group) was a corn-soybean meal type diet formulated according to NRC (2012). The experimental groups were fed the basal diet supplemented with 50, 100 and 200 mg/kg -glucan (effective content 90%), respectively. The experiment lasted for 103 days and was divided into three phases: 25–50 kg, 51-75 kg and 76–110 kg. The composition and nutrient levels of the basal diet are shown in Table 1 .

1.2 Feeding Management

The experiment was conducted at Danling Pig Farm in Meishan, Sichuan. The trial was divided into three phases: 35 days for the 25–50 kg phase, 28 days for the 51–75 kg phase, and 40 days for the 76–110 kg phase, totaling 103 days. Pigs were fed at 08:00, 14:00 and 20:00 daily. Temperature and humidity were strictly controlled throughout the experiment. Pens were cleaned daily, and pigs had free access to feed and water. Daily feed intake, wastage and leftovers were recorded, and pigs were weighed at the end of each phase. At the end of each phase, one pig with body weight close to the average was selected from each replicate for blood collection via anterior vena cava puncture; blood was centrifuged to prepare serum for analysis. At the end of the experiment, one pig with body weight close to the average was selected from each replicate for slaughter. Longissimus dorsi muscle samples were collected; one portion was stored at 4°C for shear force determination, other portions were used for measuring cooking loss, drip loss, muscle pH and meat color, and the remaining muscle samples were stored at -20°C for determination of inosine monophosphate (IMP) and fatty acid (FA) contents.

1.4.1 Growth Performance

Average daily gain (ADG) was calculated as (final weight - initial weight)/number of days, with pigs weighed at the beginning and end of each phase after fasting. Average daily feed intake (ADFI) was calculated as total feed intake/number of days for each replicate. Feed-to-gain ratio (F/G) was calculated as ADFI/ADG.

1.4.2 Nutrient Digestibility

Feces were collected for 5 consecutive days at the end of each experimental phase using the incomplete collection method. Each day, 200 g of representative fecal samples were collected from different locations in each pen, mixed with 10 mL of 10% sulfuric acid, stirred evenly, and stored at 4°C pending analysis. Before analysis, fecal samples were dried to semi-dryness and ground. Moisture, crude protein content and energy in diets and feces were determined according to Zhang Liying [8] *Feed Analysis and Feed Quality Detection Technology*. Nutrient digestibility was calculated using the endogenous indicator (4 mol/L HCl insoluble ash) method according to the following formula:

Nutrient digestibility (%) = 100 - (HCl insoluble ash content in diet × nutrient content in feces)/(HCl insoluble ash content in feces × nutrient content in diet) × 100.

1.4.3 Carcass Performance and Meat Quality

Carcass weight, carcass length, backfat thickness and slaughter rate were measured and calculated at the slaughter site. Eye muscle area, muscle pH, meat color, cooking loss, drip loss and shear force were determined using the following methods. Eye muscle area was measured at the thoracolumbar junction by measuring the width and height of the eye muscle with vernier calipers and calculated as: eye muscle area (cm^2) = eye muscle height (cm) × eye muscle width (cm) × 0.7. Muscle pH was measured at 45 min and 24 h post-slaughter in the longissimus dorsi using a pH-STAR (SFK-Technology, Denmark). Meat color was evaluated using a CR-400 (MINOLTA) colorimeter on the cross-section of the longissimus dorsi at the last thoracic and first lumbar vertebrae junction.

Drip loss was measured using a sample from the 2nd–3rd lumbar vertebrae. After removing fat attached to the epimysium, the muscle was cut into 2 cm thick slices, trimmed into 5 cm × 3 cm rectangles and weighed. The sample was then hooked at one end with the muscle fibers oriented vertically upward, placed in an inflated plastic bag without contacting the bag wall, sealed, and hung in a 4°C refrigerator for 24 h before being weighed again. Drip loss (%) = (pre-storage weight - post-storage weight)/pre-storage weight × 100. Cooking loss was determined by weighing the sample (pre-cooking weight, W1), steaming it on a grid in an aluminum pot for 30 min, then cooling it in a draft-free shaded area for 15 min before re-weighing (post-cooking weight, W2). Cooking loss (%) = (W1 - W2)/W1 × 100. Muscle tenderness (shear force) was measured using the internationally recognized Warner-Bratzler shear force (WBSF) method. Specifically, a 2.54 cm thick slice of pork collected in the laboratory was heated in a water bath until the core temperature reached 71°C. Using a 1.27 cm diameter corer, at least three cores were taken from the sample along the muscle fiber direction, and each core' s shear force was measured using a Texture Analyser. The average value was calculated as the sample' s shear force value.

1.4.4 Muscle IMP and FA Content

Muscle IMP content was determined by high-performance liquid chromatography. Muscle FA content was determined according to GB/T 5009.6—2003 *Determination of Fat in Foods* and GB/T 17376—2008 *Preparation of Methyl Esters of Animal and Vegetable Oils and Fats* for fat extraction and transesterification methylation, followed by gas chromatography-mass spectrometry analysis.

1.5 Statistical Analysis

All data were analyzed using SPSS 17.0 software. Differences were tested for significance using one-way ANOVA, and multiple comparisons were performed using the LSD method. Results are expressed as mean ± SEM, with P<0.05 as the significance threshold.

Results and Analysis

2.1 Effects of -Glucan on Growth Performance of Growing-Finishing Pigs

As shown in Table 2 , compared with the control group, dietary supplementation with 100 mg/kg -glucan significantly increased ADG (P<0.05) and significantly reduced F/G (P<0.05) during the 51–75 kg phase. During the 76–110 kg phase, 100 mg/kg -glucan significantly increased ADG (P<0.05), while both 50 and 100 mg/kg -glucan significantly reduced F/G (P<0.05). No significant differences were observed between other groups and the control group (P>0.05). Over the entire period (25–110 kg), dietary supplementation with 100 mg/kg -glucan significantly increased ADG (P<0.05) and significantly reduced F/G (P<0.05) of growing-finishing pigs, while other groups showed no significant differences compared with the control group (P>0.05).

2.2 Effects of -Glucan on Nutrient Digestibility of Growing-Finishing Pigs

As shown in Table 3 , during the 25–50 kg phase, dietary -glucan supplementation had no significant effects on dry matter, energy or crude protein digestibility (P>0.05). During the 51–75 kg phase, 100 mg/kg -glucan significantly improved dry matter, energy and crude protein digestibility (P<0.05). During the 76–110 kg phase, 50 and 100 mg/kg -glucan significantly improved dry matter and energy digestibility (P<0.05), but crude protein digestibility was not significantly affected (P>0.05).

2.3 Effects of -Glucan on Carcass Performance of Growing-Finishing Pigs

As shown in Table 4 , carcass length in the 100 and 200 mg/kg -glucan groups was significantly higher than in the control group (P<0.05). Although the 50 mg/kg -glucan group showed numerically higher carcass length than the control group, the difference was not significant (P>0.05). The 100 mg/kg -glucan group exhibited significantly higher carcass length than the 50 mg/kg group (P<0.05), but no significant difference was observed between the 100 and 200 mg/kg groups (P>0.05).

2.4 Effects of -Glucan on Meat Quality of Growing-Finishing Pigs

As shown in Table 5 , dietary -glucan supplementation affected pork pH, with the 100 mg/kg -glucan group showing significantly higher pH at 45 min post-slaughter (pH45min) than the control group (P<0.05), while the 50 and 200 mg/kg groups showed no significant differences (P>0.05). Compared with the control group, 100 mg/kg -glucan significantly reduced drip loss (P<0.05), indicating enhanced water-holding capacity, though 50 and 200 mg/kg -glucan had no significant effects on drip loss (P>0.05). Dietary -glucan supplementation did not affect 45 min meat color lightness (L*) value (P>0.05), but significantly affected redness (a*)* and yellowness (b*) values at 45 min (P<0.05). Specifically, the 100 mg/kg -glucan group showed significantly higher a* value at 45 min than the control group (P<0.05), while the 50 and 200 mg/kg groups showed no significant differences (P>0.05). -glucan supplementation significantly reduced the b* value at 45 min (P<0.05), though no significant differences were observed among treatment groups (P>0.05). No significant effects were found on meat color at 24 h post-slaughter (P>0.05).

2.5 Effects of -Glucan on Muscle IMP and FA Content of Growing-Finishing Pigs

IMP is the primary material basis for meat umami flavor. As shown in Table 6 , muscle IMP content was significantly increased when -glucan was supplemented at 50–100 mg/kg compared with the control group ($P<0.05$). Compared with the control group, -glucan supplementation did not significantly affect caprylic acid, lauric acid, myristic acid, palmitic acid, stearic acid or oleic acid contents in muscle ($P>0.05$). Different -glucan levels increased palmitoleic acid content, with an 11.98% increase at 50 mg/kg supplementation, though the difference was not significant ($P>0.05$). At 100 mg/kg -glucan, heptadecanoic acid, linoleic acid and arachidic acid contents were significantly increased by 47.3%, 14.4% and 34.4%, respectively ($P<0.05$). Additionally, dietary -glucan supplementation significantly increased cis-11-gadoleic acid and eicosadienoic acid contents ($P<0.05$).

Discussion

3.1 Effects of -Glucan on Growth Performance of Growing-Finishing Pigs

The results of this experiment indicate that dietary supplementation with 100 mg/kg -glucan significantly improved the growth performance of growing-finishing pigs from 25 to 110 kg. Wang Huitian et al. [9] reported that dietary supplementation with 1,000, 1,500 and 2,000 mg/kg yeast cell wall polysaccharides significantly increased ADG and reduced F/G in 22–42 day-old broilers. An Shangze et al. [10] found that 0.1% -glucan supplementation effectively increased ADG and improved intestinal structure in piglets. Dritz et al. [11] reported that -glucan significantly increased ADG and reduced mortality in weanling pigs. -glucan extracted from yeast is a natural immune enhancer, and appropriate supplementation can reduce various stress responses, improve non-specific immunity and health status, thereby enhancing production performance [12]. In this experiment, ADFI and ADG of growing-finishing pigs showed a trend of increasing first and then decreasing with increasing -glucan dosage, possibly because low-dose -glucan acts as an immune regulator to modulate immune responses, while long-term consumption of high-dose -glucan may interfere with intestinal absorption of other nutrients, and 200 mg/kg -glucan may over-activate the immune system of growing-finishing pigs, thereby reducing growth performance. Research has shown that the molecular weight, spatial structure, degree of branching on the main chain, and number of functional groups of glucan can all affect its biological functions [13]. The glucan used in this experiment is a straight-chain linear macromolecule formed by D-glucose connected through -1,3 bonds, existing in a triple-helix conformation that is closely related to immune activity, thereby improving the health status and growth performance of growing-finishing pigs.

3.2 Effects of -Glucan on Nutrient Digestibility of Growing-Finishing Pigs

-glucan is a type of non-starch polysaccharide (NSP) that has been extensively studied. Yin et al. [14] reported that dietary NSP affected apparent ileal digestibility in growing pigs; when dietary NSP content increased from 8.3% to 19.3%, digestibility of dry matter, energy and crude protein decreased from 77.3%, 78.7% and 80.7% to 59.4%, 59.5% and 72.0%, respectively. As an antinutritional factor, -glucan can absorb water and swell in the digestive tract, becoming viscous and significantly interfering with and inhibiting the digestion and utilization of various dietary nutrients [15]. However, some studies have reported that -glucan can improve nutrient digestibility. Hahn et al. [16] found that dietary supplementation with 0.01%, 0.02%, 0.03% and 0.04% glucan in weanling pigs significantly improved digestibility of dry matter, energy, crude protein, ether extract, calcium and phosphorus. Qin Zhibiao [17] reported that -glucan improved the activities of protease, amylase, lipase and cellulase in Nile tilapia, thereby increasing nutrient digestibility. This experiment found that 100 mg/kg -glucan significantly improved digestibility of dry matter, energy and crude protein in growing-finishing pigs, consistent with the above results.

3.3 Effects of -Glucan on Carcass Performance of Growing-Finishing Pigs

Pig carcass traits refer to carcass weight and composition, mainly including carcass weight, average backfat thickness, eye muscle area and slaughter rate [18]. In this experiment, carcass length in the 100 and 200 mg/kg -glucan groups was significantly higher than in the control group, indicating that -glucan can improve growth performance and promote body length growth, thereby affecting carcass length of growing-finishing pigs.

3.4 Effects of -Glucan on Meat Quality of Growing-Finishing Pigs

The muscle pH of live animals is neutral, at which protein molecules carry net negative charges and can bind large amounts of water. After slaughter, lactic acid accumulates in muscle due to glycolysis, causing muscle pH to decline. The rate of pH decline is highly correlated with drip loss and shear force [19]. In this experiment, dietary supplementation with 100 mg/kg -glucan resulted in significantly higher muscle pH at 45 min post-slaughter than the control group, indicating that -glucan can slow the post-slaughter pH decline and enhance muscle water-holding capacity, which led to significantly reduced drip loss in the 100 mg/kg -glucan group compared with the control group.

Meat color is an important indicator for evaluating muscle appearance, primarily affected by hemoglobin (Hb) content, myoglobin (Mb) content, oxidation, and light reflection [20]. In meat color indices, higher a* values and lower b* values are desirable. The results showed that the 100 mg/kg -glucan group had significantly higher a* value at 45 min than the control group, and all treatment groups had significantly lower b* values at 45 min than the control group, consistent with the findings of Cho et al. [21] and Zhang et al. [22].

The primary material basis for meat umami flavor is IMP (inosine monophosphate). After slaughter, muscle tissue stops receiving oxygen, and energy is provided by phosphocreatine and glycolysis for ATP synthesis. As glycolysis stops and phosphocreatine is depleted, ATP synthesis ceases and ATP begins to degrade continuously, generating IMP [23]. This study demonstrated that dietary supplementation with 50-100 mg/kg -glucan significantly increased muscle IMP content. Fatty acid composition forms the basis of meat's characteristic flavor. High contents of saturated fatty acids and monounsaturated fatty acids in pork are associated with higher scores for tenderness, juiciness, flavor and overall acceptability. However, high polyunsaturated fatty acid content can soften carcass fat, increase fat oxidation and rancidity, produce off-flavors, and reduce pork quality. The results showed that the 100 mg/kg -glucan group had significantly increased heptadecanoic acid, linoleic acid and arachidic acid contents by 47.3%, 14.4% and 34.4%, respectively, compared with the control group, along with corresponding increases in cis-11-gadoleic acid and eicosadienoic acid contents. Thus, dietary -glucan supplementation in growing-finishing pigs increased muscle IMP content and altered the ratio of saturated to unsaturated fatty acids, thereby improving meat flavor.

Conclusion

Dietary -glucan supplementation can significantly improve growth performance, nutrient digestibility, carcass length and meat quality of growing-finishing pigs. Under the conditions of this experiment, the optimal supplemental level of -glucan in growing-finishing pig diets is recommended to be 100 mg/kg.

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