

Effects of Glucose Oxidase on Reproductive Performance and Antioxidant Capacity of Pregnant Dahe Black Pig Sows: Postprint

Authors: You Ruiqi, Guo Rongfu, You Ruhua, Sun Xingda, Ruxiong Wu

Date: 2017-10-10T00:00:00+00:00

Abstract

This experiment aimed to investigate the effects of glucose oxidase (GOD) on the reproductive performance, serum antioxidant indices, and dietary nutrient digestibility in pregnant Dahéwu sows. Sixty healthy multiparous (3-5 parities) pregnant Dahéwu sows were selected and randomly divided into 4 groups, with 15 replicates per group and 1 sow per replicate. The control group was fed a basal diet, while the GOD1, GOD2, and GOD3 groups were fed experimental diets supplemented with 200, 400, and 600 mg/kg GOD in the basal diet, respectively. The experiment started 30 days before parturition and ended when the piglets were weaned. The results showed: 1) Compared with the control group, dietary supplementation with 400 and 600 mg/kg GOD increased the total number of piglets born and number of piglets born alive in pregnant Dahéwu sows ($P > 0.05$); dietary supplementation with 600 mg/kg GOD significantly increased piglet birth weight and 20-day weight ($P < 0.05$). 2) Compared with the control group, dietary supplementation with 600 mg/kg GOD significantly increased serum glutathione peroxidase (GSH-Px) activity and total antioxidant capacity (T-AOC) in pregnant Dahéwu sows and piglets ($P < 0.05$), and significantly decreased serum malondialdehyde (MDA) content ($P < 0.05$). 3) Compared with the control group, dietary supplementation with 600 mg/kg GOD significantly increased the digestibility of crude fat (EE) and phosphorus (P) in the diet of pregnant Dahéwu sows ($P < 0.05$). Under the conditions of this experiment, supplementation of 600 mg/kg GOD in the diet of Dahéwu sows during late gestation (30 days before parturition) improved sow reproductive performance, enhanced antioxidant capacity in sows and piglets, improved sow digestibility of dietary EE and P, and increased dietary utilization efficiency.

Full Text

Effects of Glucose Oxidase on Reproductive Performance and Antioxidant Capacity of Dahe Black Pregnant Sows

**You Ruiqi^{1,2}, Guo Rongfu^{1*}, You Ruhua³, Sun Yingda, Wu Ruxiong **

¹College of Animal Science and Technology, Yunnan Agricultural University, Kunming 650201, China

²Regulatory Office of Veterinary Drugs and Feeds of Qujing, Qujing 655000, China

³Workstation of Livestock Modification of Qujing, Qujing 655000, China
Institute of the Dahe Black Pig of Fuyuan County of Yunnan Province, Fuyuan 655505, China

*Corresponding author, professor, E-mail: rongfug@163.com

Abstract

This experiment was conducted to investigate the effects of glucose oxidase (GOD) on reproductive performance, serum antioxidant indexes, and dietary nutrient digestibility in Dahe black pregnant sows. Sixty healthy multiparous (3–5 parities) Dahe black pregnant sows were randomly allocated into four groups with fifteen replicates per group and one sow per replicate. The control group received a basal diet, while the GOD1, GOD2, and GOD3 groups received the basal diet supplemented with 200, 400, and 600 mg/kg GOD, respectively. The trial began 30 days prepartum and continued until piglet weaning. The results showed: 1) Compared with the control, supplementation with 400 and 600 mg/kg GOD increased litter size and number of piglets born alive ($P > 0.05$), while 600 mg/kg GOD significantly increased piglet birth weight and 20-day weight ($P < 0.05$). 2) Supplementation with 600 mg/kg GOD significantly increased serum glutathione peroxidase (GSH-Px) activity and total antioxidant capacity (T-AOC) while decreasing serum malondialdehyde (MDA) content in both sows and piglets ($P < 0.05$). 3) The 600 mg/kg GOD treatment significantly improved dietary ether extract (EE) and phosphorus (P) digestibility in pregnant sows ($P < 0.05$). Under these experimental conditions, supplementing Dahe black sow diets with 600 mg/kg GOD during late gestation (30 days prepartum) improved reproductive performance, enhanced antioxidant capacity in sows and piglets, and increased EE and P digestibility, thereby improving feed utilization.

Keywords: Dahe black pigs; glucose oxidase; reproductive performance; antioxidant capacity; nutrient digestibility

Currently, sows in European and American countries produce 25–28 weaned piglets annually, with advanced pig-producing nations like Denmark achieving

over 30 piglets per sow per year. In contrast, the average level in China is approximately 17 piglets. As the world's largest pork producer and consumer, improving annual sow productivity is a key objective for China's modern swine industry. During late gestation, rapid fetal growth elevates maternal metabolic rates, generating excessive free radicals that increase metabolic burden. This oxidative stress impairs mammary cell nutrient absorption, promotes inflammatory factor production, reduces immunoglobulin content in colostrum and milk, and consequently hinders suckling piglet growth, resulting in economic losses. While dietary antibiotics during late gestation can reduce inflammatory factors and enhance immunoglobulin levels to improve nutrient digestibility, their frequent use leads to antimicrobial resistance and food safety concerns due to drug residues. Glucose oxidase (GOD) represents a novel functional feed additive that is green, non-polluting, and residue-free, with demonstrated antioxidant properties. Its potential to alleviate oxidative stress, improve intestinal health, enhance nutrient digestion and utilization, and boost sow performance warrants investigation. Although GOD research has primarily focused on poultry, limited studies exist in pigs, and no reports have examined its effects on reproductive performance and antioxidant capacity in Dahe black sows. This study utilized Dahe black pregnant sows to evaluate the effects of dietary GOD supplementation at varying levels on reproductive performance, serum antioxidant indexes, and nutrient digestibility during late gestation (30 days prepartum), thereby exploring GOD's efficacy and providing a scientific basis for its practical application in swine production.

1.1 Experimental Material

The GOD used in this experiment was produced by Ningxia Xiasheng Industrial Group, with enzyme activity 2,800 U/g (defined as the amount of enzyme required to release 1 mol of product per minute from excess substrate at 37°C and pH 5.5).

1.2 Experimental Design

Sixty healthy multiparous (3-5 parities) Dahe black pregnant sows were randomly divided into four groups with fifteen replicates per group and one sow per replicate. The control group received a basal diet, while the GOD1, GOD2, and GOD3 groups received the basal diet supplemented with 200, 400, and 600 mg/kg GOD, respectively. The trial began 30 days prepartum and continued until piglet weaning. Fecal samples were collected continuously for four days starting 11 days prepartum. Ear vein blood (8-10 mL) was collected at farrowing completion, and anterior vena cava blood (8 mL) was collected from piglets at 3 days of age. Serum was separated and stored at -20°C.

1.3 Experimental Diets

The basal diet for pregnant sows was formulated according to NRC (2012) recommendations and Dahe black pig production practices. The composition and

nutrient levels of the basal diet are presented in Table 1 . Experimental diets were prepared by supplementing the basal diet with 200, 400, and 600 mg/kg GOD according to the experimental design.

Table 1 Composition and nutrient levels of the basal diet (air-dry basis) %

Note: 1) The premix provided the following per kg of diet: VA 18,000 IU, VD 3,000 IU, VE 92 mg, VK 4 mg, biotin 0.47 mg, folic acid 3.9 mg, nicotinic acid 50 mg, D-pantothenate 30 mg, choline 0.5 mg, Cu 30 mg, Fe 102 mg, Zn 103.5 mg, Mn 38 mg, Se 0.25 mg. 2) DE was a calculated value, while others were measured values.

1.4 Feeding Management

Strict adherence to standardized feeding management protocols for commercial pig farms was maintained. Normal immunization and deworming procedures were implemented during the trial period, with regular disinfection of pens. Pregnant sows were housed individually (one sow per pen). GOD supplementation began 30 days prepartum with timed, quantitative feeding.

1.5 Measurement Indicators

1.5.1 Sow Reproductive Performance Reproductive performance was evaluated by recording litter size and number of piglets born alive. Piglet birth weight, 20-day weight, and 35-day weight were measured accurately.

1.5.2 Serum Antioxidant Indexes Serum malondialdehyde (MDA) content was determined by thiobarbituric acid (TBA) assay, while total superoxide dismutase (T-SOD) activity, glutathione peroxidase (GSH-Px) activity, and total antioxidant capacity (T-AOC) were measured by colorimetric methods. All assay kits were purchased from Nanjing Jiancheng Bioengineering Institute.

1.5.3 Dietary Nutrient Digestibility National standard methods were used to determine dry matter (DM), crude ash (Ash), ether extract (EE), crude fiber (CF), crude protein (CP), calcium (Ca), and phosphorus (P) contents in feces and diets for calculating nutrient digestibility.

Nutrient digestibility (%) = [(Nutrient intake - Nutrient in feces) / Nutrient intake] × 100.

1.6 Data Analysis

All data were processed using Excel 2007 and analyzed by one-way ANOVA using SPSS 17.0 statistical software. Duncan's multiple range test was used for post-hoc comparisons. Results are expressed as "mean ± standard deviation."

2.1 Effects of GOD on Reproductive Performance of Dahe Black Pregnant Sows

As shown in Table 2 , compared with the control group, GOD1, GOD2, and GOD3 groups exhibited increasing trends in total feed intake during the 30 days prepartum, daily feed intake during the 30 days prepartum, litter size, and number of piglets born alive, though differences were not significant ($P>0.05$). Litter size and number born alive in GOD1, GOD2, and GOD3 groups increased by 0.25, 0.53, 1.12 and 0.25, 0.53, 0.70 piglets, respectively, compared with the control. The GOD3 group showed significantly increased birth weight and 20-day weight compared with the control ($P<0.05$). No significant differences were observed in 35-day weight among all groups ($P>0.05$).

Table 2 Effects of GOD on reproductive performance of Dahe black pregnant sows

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

2.2 Effects of GOD on Serum Antioxidant Indexes of Dahe Black Pregnant Sows

As shown in Table 3 , compared with the control, GOD1, GOD2, and GOD3 groups showed increased serum T-SOD activity in Dahe black pregnant sows, but without significant differences ($P>0.05$). Serum GSH-Px activity in the GOD3 group was significantly higher than in the control ($P<0.05$). Serum T-AOC in the GOD3 group was extremely significantly higher than in the control, GOD1, and GOD2 groups ($P<0.01$). Serum MDA content in the GOD3 group was extremely significantly lower than in the control ($P<0.01$), while GOD1 and GOD2 groups were significantly lower than the control ($P<0.05$).

Table 3 Effects of GOD on antioxidant indexes in serum of Dahe black pregnant sows

As shown in Table 4 , compared with the control, GOD1, GOD2, and GOD3 groups showed increased serum T-SOD activity in piglets, but without significant differences ($P>0.05$). Serum GSH-Px activity in GOD1, GOD2, and GOD3 groups was extremely significantly higher than in the control ($P<0.01$). Serum T-AOC in GOD2 and GOD3 groups was extremely significantly higher than in the control ($P<0.01$), with GOD3 being significantly higher than GOD2 ($P<0.05$). Serum MDA content in the GOD3 group was extremely significantly lower than in the control ($P<0.01$).

Table 4 Effects of GOD on antioxidant indexes in serum of Dahe black piglets

2.3 Effects of GOD on Dietary Nutrient Digestibility of Dahe Black Pregnant Sows

As shown in Table 5, compared with the control, GOD1, GOD2, and GOD3 groups showed increasing trends in dietary DM, Ash, CF, CP, and Ca digestibility in Dahe black pregnant sows, but without significant differences ($P>0.05$). Dietary EE digestibility in GOD2 and GOD3 groups was extremely significantly higher than in the control ($P<0.01$), with GOD3 being significantly higher than GOD2 ($P<0.05$). Dietary P digestibility in the GOD3 group was significantly higher than in the control ($P<0.05$).

Table 5 Effects of GOD on dietary nutrient digestibility of Dahe black pregnant sows %

3.1 Effects of GOD on Reproductive Performance of Dahe Black Pregnant Sows

Research indicates that maternal metabolic capacity increases significantly during late gestation, with the placenta generating more reactive oxygen species (ROS). Excessive ROS can impair gamete fusion, inhibit embryonic development, induce oxidative stress, and compromise reproductive performance, leading to reduced litter size, increased rates of weak and stillborn piglets, and decreased neonatal viability. Functional feed additives can effectively mitigate oxidative stress during late gestation and improve reproductive performance. Luo et al. found that continuous supplementation of α -hydroxy- β -methylbutyrate during late gestation and lactation significantly improved sow reproductive performance and piglet immunity. Tang et al. reported that dietary GOD increased serum triiodothyronine (T3), thyroxine (T4), and growth hormone (GH) levels in piglets, promoting growth and development. Tang Haiou et al. observed that GOD supplementation during late gestation increased litter size and significantly improved litter birth weight. In this study, supplementing Dahe black sow diets with 200, 400, and 600 mg/kg GOD during late gestation increased litter size and number born alive by 0.25, 0.53, 1.12 and 0.25, 0.53, 0.70 piglets, respectively, compared with the control. Supplementation with 600 mg/kg GOD significantly increased piglet birth weight and 20-day weight. These results demonstrate that appropriate GOD supplementation during late gestation promotes embryonic development and neonatal piglet growth in Dahe black sows.

3.2 Effects of GOD on Serum Antioxidant Indexes of Dahe Black Pregnant Sows and Neonatal Piglets

As a functional feed additive, GOD exhibits strong antioxidant properties and can enhance hepatic detoxification capacity. Serum GSH-Px activity, T-SOD activity, T-AOC, and MDA content serve as reliable indicators of antioxidant capacity in pigs. This study demonstrated that supplementing Dahe black sow diets with 200, 400, and 600 mg/kg GOD during late gestation increased maternal serum T-SOD activity, with 600 mg/kg GOD significantly increasing serum

GSH-Px activity and T-AOC while extremely significantly reducing serum MDA content. Maternal nutrition influences oxidative stress in both dam and fetus, with high correlations between plasma antioxidants and oxidative stress markers in maternal and fetal circulation. This study also found that GOD supplementation during late gestation improved not only sow antioxidant capacity but also that of neonatal piglets. Supplementation with 200, 400, and 600 mg/kg GOD extremely significantly increased serum GSH-Px activity in piglets, while 400 and 600 mg/kg GOD extremely significantly increased serum T-AOC, and 600 mg/kg GOD extremely significantly reduced serum MDA content, thereby enhancing neonatal piglet antioxidant capacity. These findings indicate that appropriate GOD supplementation during late gestation in Dahe black sows can increase serum GSH-Px activity and T-AOC while reducing serum MDA content in both sows and piglets, thereby decreasing free radical levels and enhancing antioxidant capacity. However, the underlying mechanisms by which GOD improves antioxidant capacity in Dahe black sows require further investigation.

3.3 Effects of GOD on Dietary Nutrient Digestibility of Dahe Black Pregnant Sows

As an enzyme preparation, GOD catalyzes glucose in the gastrointestinal tract to produce gluconic acid and hydrogen peroxide when added to diets. Gluconic acid acts as an acidifier in the intestinal tract, reducing gastrointestinal chyme pH and activating pepsin activity, while small amounts of hydrogen peroxide function similarly to antibiotics by inhibiting harmful bacteria and promoting beneficial bacterial growth, thereby enhancing immunity and improving intestinal health. GOD can maintain intestinal microecological balance and improve intestinal morphology, consequently enhancing nutrient digestion and absorption. Yu et al. found that dietary GOD improved apparent nutrient digestibility and feed conversion efficiency in laying hens. Tang et al. reported that GOD supplementation improved intestinal health and reduced fecal Salmonella counts in piglets. Studies have also shown that GOD significantly improved dietary energy and nutrient digestibility and enhanced growth performance and health status in piglets. In this study, supplementing Dahe black sow diets with 200, 400, and 600 mg/kg GOD during late gestation showed increasing trends in DM, Ash, CF, CP, and Ca digestibility. Supplementation with 400 and 600 mg/kg GOD extremely significantly improved dietary EE digestibility, while 600 mg/kg GOD significantly improved dietary P digestibility. These results indicate that GOD supplementation enhances nutrient digestibility in pregnant sows, particularly for EE and P.

In conclusion, oxidative stress commonly occurs during late gestation. Appropriate GOD supplementation in Dahe black pregnant sow diets during late gestation can enhance antioxidant capacity, alleviate oxidative stress, and improve reproductive performance. Supplementation with 600 mg/kg GOD increased litter size and number born alive, and significantly improved piglet birth weight

and 20-day weight. The mechanisms underlying GOD' s effects on reproductive performance in Dahe black sows warrant further investigation.

Supplementing Dahe black sow diets with 600 mg/kg GOD during late gestation improved reproductive performance, dietary nutrient digestibility, and antioxidant capacity in both sows and neonatal piglets. Application of GOD represents an effective nutritional strategy for improving antioxidant capacity and reproductive performance in sows.

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