

Effects of Dietary Supplementation with a Lactic Acid Bacteria and Yeast Composite during Late Gestation on Sow Reproductive Performance, Plasma Lipid Metabolism, and Antioxidant Capacity: Postprint

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

Abstract

This study was conducted to investigate the effects of dietary supplementation with a compound probiotic of lactic acid bacteria and yeast in late gestation on reproductive performance, plasma lipid metabolism, and antioxidant capacity of sows, and to determine the optimal supplementation level of the compound probiotic in the diet of late-gestation sows. Forty-eight third-parity “Large × Landrace” crossbred sows with similar body condition on day 80 of gestation were randomly allocated into 4 groups, with 12 replicates per group and 1 sow per replicate. The control group was fed a basal diet, while groups , , and were fed the basal diet supplemented with 150, 300, and 450 mL/d of compound probiotic fermentation broth of lactic acid bacteria and yeast, respectively. The preliminary period was 5 days, and the formal experimental period was 37 days. The formal experiment commenced on day 85 of gestation and concluded on day 7 postpartum, during which the compound probiotic fermentation broth was not supplemented in the diet for 7 days postpartum. The results showed that, compared with the control group: 1) The litter birth weight of piglets in group was significantly increased ($P < 0.05$), and the birth weight of piglets in groups , , and was significantly increased ($P < 0.05$). 2) The plasma total cholesterol (TC) and high-density lipoprotein cholesterol (HDL-C) concentrations of farrowing sows in groups and were significantly increased ($P < 0.05$), and the plasma triglyceride (TG) concentration in group was significantly increased ($P < 0.05$). 3) The plasma malondialdehyde (MDA) concentration of farrowing sows in groups and was significantly decreased ($P < 0.05$). It was concluded that under the conditions of this experiment, the optimal supplementation level of the compound probiotic fermentation broth was 300 mL/d from the perspective of reproductive performance and plasma lipid metabolism; whereas from the

perspective of plasma antioxidant capacity and economic benefits, the optimal supplementation level was 150 mL/d.

Full Text

Effects of Dietary Compound Bacteria of Lactobacillus and Yeast in Late Pregnancy on Reproductive Performance, Plasma Lipid Metabolism and Antioxidant Capacity of Sows

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Abstract

This study was conducted to investigate the effects of dietary compound bacteria of Lactobacillus and yeast in late pregnancy on reproductive performance, plasma lipid metabolism, and antioxidant capacity of sows, and to determine the optimal supplementation level. Forty-eight “Large White × Landrace” hybrid sows in their third parity with similar body condition at day 80 of gestation were randomly allocated into four groups with 12 replicates per group and one sow per replicate. Sows in the control group were fed a basal diet, while those in groups I, II, and III received the basal diet supplemented with 150, 300, and 450 mL/d of Lactobacillus and yeast compound bacteria fermentation broth, respectively. The pre-trial period lasted 5 days, and the formal trial period lasted 37 days from day 85 of gestation to day 7 postpartum, during which no compound bacteria fermentation broth was added to the diets in the first 7 days postpartum. The results showed that compared with the control group: (1) the birth litter weight of piglets in group II was significantly increased ($P < 0.05$), and the individual birth weight of piglets in groups I, II, and III was significantly increased ($P < 0.05$); (2) the plasma total cholesterol (TC) and high-density lipoprotein cholesterol (HDL-C) contents in farrowing sows in groups I and II were significantly increased ($P < 0.05$), and the plasma triglyceride (TG) content in group II was significantly increased ($P < 0.05$); and (3) the plasma malondialdehyde (MDA) content in farrowing sows in groups I and III was significantly decreased ($P < 0.05$). It was concluded that under the conditions of this experiment, the optimal supplementation level of compound bacteria fermentation broth was 300 mL/d for reproductive performance and plasma lipid metabolism, and 150 mL/d for plasma antioxidant capacity and economic benefits.

Key words: compound bacteria of Lactobacillus and yeast; pregnant sows; reproductive performance; plasma lipid metabolism; plasma antioxidant capacity

Introduction

Probiotics have emerged as a promising alternative to antibiotics in swine production, demonstrating broad beneficial effects. *Lactobacillus*, a lactic acid-producing bacterium, enhances immunity, improves gastrointestinal microflora balance, provides antioxidant benefits, exhibits anti-tumor and anti-hypertensive properties, and reduces cholesterol levels. Yeast, another widely used probiotic, strengthens immunity, improves gut microflora, regulates metabolism, and serves as a nutritional source. *Lactobacillus* and yeast are both beneficial probiotics for sows that can coexist in the same system, with research showing that *Lactobacillus* metabolites can provide carbon sources for yeast, while nutritional factors produced by yeast fermentation can be utilized by *Lactobacillus*, creating a synergistic metabolic relationship.

Probiotics can improve sow reproductive performance, enhance immunity, and promote growth performance in offspring. Li et al. found that dietary supplementation with a compound probiotic containing *Lactobacillus*, yeast, and *Bacillus subtilis* improved reproductive performance in lean-type sows. Yan et al. reported that adding a compound preparation of phytase, complex enzymes, *Bacillus subtilis*, yeast, and *Lactobacillus* enhanced production performance in late-stage fattening pigs on fermented bedding. Late gestation represents the most rapid period of fetal growth, during which fetal weight increases dramatically. The nutritional status of sows directly affects fetal development, birth weight (both litter and individual), and subsequent lactation performance. Supplementing sow diets with probiotics during late pregnancy can improve gastrointestinal microflora balance, increase feed utilization efficiency, and enhance immunity, though results vary due to differences in experimental conditions. This study aimed to determine the optimal dosage of *Lactobacillus* and yeast compound bacteria for improving reproductive performance, plasma lipid metabolism, and antioxidant capacity in late pregnancy sows, providing a scientific basis for the rational application of probiotics in sow production.

1. Materials and Methods

1.1 Experimental Materials The compound bacteria preparation consisted of *Lactobacillus*, yeast, and their shared culture medium, purchased from Shenzhen Baiaofei Biological Company as a milk-yellow powder with yogurt aroma. After fermentation in a fermenter for 24 hours, it was fed to sows as a biological fermentation broth with a pH of 3.59, containing *Lactobacillus* at 1.0×10^8 CFU/mL and yeast at 8×10^7 CFU/mL.

1.2 Experimental Design The feeding trial was conducted from February to April 2017 at Tianzhong Pig Farm in Luyi County, Henan Province. Forty-eight “Large White \times Landrace” hybrid sows in their third parity with similar body condition at day 80 of gestation were randomly divided into four groups with 12 replicates per group and one sow per replicate. The control group received a basal diet, while groups I, II, and III received the basal diet supplemented

with 150, 300, and 450 mL/d of Lactobacillus and yeast compound bacteria fermentation broth, respectively. The pre-trial period lasted 5 days, and the formal trial period lasted 37 days from day 85 of gestation to day 7 postpartum, during which no compound bacteria fermentation broth was added to the diets in the first 7 days postpartum. The basal diet was formulated according to NRC (2012) nutrient requirements for sows, with composition and nutrient levels shown in Table 1 .

1.3 Management Practices Gestating sows were managed according to conventional farm procedures. During late gestation, sows were housed in large pens and transferred to individual farrowing crates three days before their expected due date. Control and treatment groups were housed in the same gestation barn and farrowing rooms. Feed intake was restricted during late gestation and the first 7 days of lactation, with sows fed 1.8 kg per head per meal twice daily during late gestation. No feed was provided on the day of farrowing, followed by 0.5 kg per head per day on day 1 postpartum, increasing by 0.5 kg daily thereafter, with ad libitum feeding after 7 days. All diets were mixed with water and fed as wet mash, with different doses of compound bacteria fermentation broth added to the treatment groups. Sows had free access to water and were subjected to the same environmental conditions and routine immunization protocols.

1.4 Measurement Indices

1.4.1 Reproductive Performance Reproductive performance indices were recorded for each experimental sow, including total litter size, live litter size, mummy piglets, stillbirths, and individual piglet birth weight. From these data, live litter rate, mummy rate, stillbirth rate, and litter birth weight were calculated.

1.4.2 Plasma Lipid Metabolism and Antioxidant Indices Blood samples (10 mL) were collected from the ear vein using heparin sodium anticoagulant vacuum tubes on day 85 of gestation (fasting) and on the day of farrowing. After standing for 30 minutes, plasma was separated by centrifugation at 3,000 r/min for 20 minutes and stored at -20 °C. Plasma lipid metabolism indices, including total cholesterol (TC), triglyceride (TG), high-density lipoprotein cholesterol (HDL-C), and low-density lipoprotein cholesterol (LDL-C), were measured using an automatic biochemical analyzer. Plasma antioxidant indices, including malondialdehyde (MDA) content and superoxide dismutase (SOD) activity, were measured using colorimetric assay kits purchased from Beijing Huaying Biotechnology Research Institute.

1.5 Data Processing Experimental data were initially processed using Excel 2007 software and then subjected to one-way ANOVA using SPSS 19.0. Significant differences were further analyzed using Duncan's multiple comparison test.

Results are expressed as “mean \pm standard deviation,” with $P < 0.05$ indicating significant difference.

2. Results

2.1 Effects on Sow Reproductive Performance As shown in Table 2 , no significant differences were observed among groups in total litter size, live litter size, mummy piglets, stillbirths, live litter rate, mummy rate, or stillbirth rate ($P > 0.05$). Compared with the control group, the birth litter weight of piglets in group II was significantly increased ($P < 0.05$), while groups I and III showed no significant difference ($P > 0.05$). The individual birth weight of piglets in groups I, II, and III was significantly increased compared with the control group ($P < 0.05$).

2.2 Effects on Plasma Lipid Metabolism As shown in Table 3 , no significant differences were found among groups in plasma TC, TG, HDL-C, or LDL-C contents on day 85 of gestation ($P > 0.05$). As shown in Table 4 , no significant difference was observed in plasma LDL-C content among farrowing sows ($P > 0.05$). However, compared with the control group, plasma TC content in groups I and II was significantly increased ($P < 0.05$), while group III showed no significant difference ($P > 0.05$). Plasma TG content in group II was significantly increased ($P < 0.05$), while groups I and III showed no significant difference ($P > 0.05$). Plasma HDL-C content in groups I and II was significantly increased ($P < 0.05$), while group III showed no significant difference ($P > 0.05$).

2.3 Effects on Plasma Antioxidant Capacity As shown in Table 5 , no significant differences were observed among groups in plasma MDA content or SOD activity on day 85 of gestation ($P > 0.05$). Compared with the control group, plasma MDA content in farrowing sows in groups I and III was significantly decreased ($P < 0.05$), while group II showed no significant difference ($P > 0.05$). No significant differences were observed among groups in plasma SOD activity in farrowing sows ($P > 0.05$).

3. Discussion

3.1 Effects on Reproductive Performance Reproductive performance in late gestation sows is primarily reflected in litter size, stillbirths, litter birth weight, individual birth weight, live litter rate, and stillbirth rate. Litter size is associated with sow breed and nutritional status during early gestation, while sow nutrition and health directly affect reproductive performance and offspring development. Dietary probiotic supplementation during late gestation can enhance sow constitution and feed utilization efficiency, thereby improving reproductive performance. However, research results vary, likely due to differences in sow breed, gestation stage, housing environment, management practices, nutritional levels, and probiotic species, quantity, and ratio.

Liu et al. found that supplementing sow diets with a compound probiotic containing *Bacillus*, *Lactobacillus*, and yeast during the 30 days before farrowing significantly increased individual piglet birth weight without affecting litter size. Huo et al. reported that adding microbial agents to sow diets 45 days before farrowing significantly increased litter size, live litter size, and piglet birth weight while reducing stillbirth rate. Fu et al. observed that adding compound bacterial preparation to purebred Landrace sow diets 45 days before farrowing significantly increased litter birth weight and individual birth weight without affecting the number of live-born piglets or survival rate. The present study found that dietary supplementation with *Lactobacillus* and yeast compound bacteria during late gestation significantly increased litter birth weight and individual piglet weight, possibly due to enhanced nutrient absorption and utilization and optimized intestinal environment. However, no significant effects were observed on litter size, live litter size, mummy piglets, stillbirths, live litter rate, mummy rate, or stillbirth rate, consistent with findings by Zhang et al. and Long.

3.2 Effects on Plasma Lipid Metabolism Total cholesterol (TC) is an essential nutrient and important cellular component that serves as a precursor for steroid hormones, vitamin D3, and bile acid synthesis. It maintains leukocyte function and vascular integrity while reducing cancer risk. TC is transported in blood primarily via high-density lipoprotein (HDL) and low-density lipoprotein (LDL). Elevated LDL-C indicates excessive cholesterol in circulation and represents a risk signal for arteriosclerosis, whereas HDL-C clears excess LDL-C from blood vessels and provides vascular protection. Moderately elevated blood lipid levels benefit both mother and fetus during pregnancy. Enhanced fat metabolism in late gestation increases plasma free fatty acids and glycerol, which serve as efficient substrates for maternal glucose synthesis and energy storage. When maternal nutrition is deficient, these metabolites ensure continuous nutrient supply to the fetus while maintaining maternal metabolic balance. However, excessive blood lipids and abnormal lipid metabolism can lead to placental abruption and pregnancy-induced hypertension.

Probiotics exhibit lipid-lowering effects, with research demonstrating that *Lactobacillus* can reduce blood TC content. Several mechanisms have been proposed: (1) absorption theory—*Lactobacillus* degrades cholesterol through cellular uptake, with absorption rates varying under different bile salt concentrations; (2) precipitation theory—bile salt hydrolase produced by *Lactobacillus* alters bile salt structure, causing precipitation with cholesterol for excretion; (3) cell membrane incorporation theory—absorbed cholesterol partially incorporates into cell membranes rather than entering the cytoplasm. The present study found that compared with the control group, plasma TC, TG, and HDL-C contents in group II farrowing sows were significantly increased, while no significant differences were observed in LDL-C content among groups. These results suggest that compound bacteria do not reduce blood lipid levels but promote lipid metabolism and protect vascular integrity. The birth litter weight followed the pattern group II > group I > group III > control group, mirroring the plasma

TG content pattern, supporting the association between higher maternal TG levels and greater fetal weight.

3.3 Effects on Plasma Antioxidant Capacity Oxidative stress occurs when the generation of oxidants exceeds the scavenging capacity of the antioxidant defense system or when antioxidant defense capacity weakens, representing an imbalance between reactive oxygen species generation and degradation. While moderate reactive oxygen levels are essential for normal physiological activities, excessive levels damage normal physiological functions. Malondialdehyde (MDA) and superoxide dismutase (SOD) are primary indicators reflecting oxidative damage and antioxidant defense, respectively. MDA, a degradation product of lipid peroxidation, indirectly reflects free radical content—reduced plasma MDA indicates decreased free radicals and enhanced antioxidant capacity. SOD, a major endogenous antioxidant enzyme, scavenges free radicals, and increased SOD activity indicates enhanced antioxidant defense.

Research has demonstrated that *Lactobacillus* possesses antioxidant activity through various mechanisms: (1) antioxidant enzyme mechanisms involving SOD, catalase, and NADH oxidase/peroxidase; (2) manganese ion mechanisms where high manganese concentrations mimic SOD activity; (3) thiol compound mechanisms where protein and non-protein thiols scavenge hydroxyl radicals; and (4) adaptive mechanisms where environmental stress induces enhanced antioxidant responses. The present study found that dietary supplementation with *Lactobacillus* and yeast compound bacteria during late gestation had no significant effect on plasma SOD activity in farrowing sows, but plasma MDA content in groups I and III was significantly lower than in the control group. These results indicate that compound bacteria can reduce free radical content, decrease oxidant generation, and enhance antioxidant defense system capacity.

4. Conclusion

Dietary supplementation with *Lactobacillus* and yeast compound bacteria during late gestation improved sow reproductive performance, plasma lipid metabolism, and antioxidant capacity, with significant effects on piglet birth litter weight and individual birth weight, as well as plasma TC, TG, HDL-C, and MDA contents in farrowing sows. Under the conditions of this experiment, the optimal supplementation level was 300 mL/d for reproductive performance and plasma lipid metabolism, and 150 mL/d for antioxidant capacity and economic benefits.

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