Effects of Compound Probiotic Fermentation Broth on Production Performance, Serum Biochemical Parameters, and Immune Indices in Lactating Sows (Postprint)

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Abstract

This study was conducted to investigate the effects of dietary supplementation with compound probiotic fermentation liquid on production performance, serum biochemical parameters, and immune indices in lactating sows. Sixty Landrace sows at 108 days of gestation were randomly allocated into 4 groups, with 15 replicates per group and one sow per replicate. The control group was fed a basal diet, while three experimental groups received the basal diet supplemented with 200, 300, or 400 mL/d of compound probiotic fermentation liquid, respectively, until day 21 of lactation. The results showed: 1) The average daily feed intake of sows in the 300 mL/d compound probiotic fermentation liquid group was significantly higher than that of the control group ($P < 0.05$), and the litter weaning weight and average daily gain of piglets were extremely significantly higher than those of the control group ($P < 0.01$). 2) The serum glucose (GLU) content in the 300 mL/d compound probiotic fermentation liquid group was significantly higher than that of the control group ($P < 0.05$), and the serum triiodothyronine (T3) content was extremely significantly higher than that of the control group ($P < 0.01$). 3) The serum contents of immunoglobulin A (IgA), immunoglobulin G (IgG), immunoglobulin M (IgM), interleukin-2 (IL-2), and interleukin-6 (IL-6) in the 300 mL/d compound probiotic fermentation liquid group were all extremely significantly higher than those of the control group ($P < 0.01$). Based on the comprehensive results of this experiment, it is concluded that dietary supplementation with 300 mL/d of compound probiotic fermentation liquid can effectively improve the production performance, serum biochemical parameters, and immune indices of lactating sows.

Full Text

Effects of Compound Probiotics Fermentation Broth on Performance, Serum Biochemical and Immune Indexes of Lactating Sows

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Abstract: This trial was conducted to investigate the effects of dietary supplementation with compound probiotics fermentation broth on the performance, serum biochemical parameters, and immune indexes of lactating sows. Sixty Large White sows at 108 days of gestation were randomly allocated to four groups with 15 replicates per group and one sow per replicate. The control group received a basal diet, while three experimental groups received the basal diet supplemented with 200, 300, or 400 mL/d of compound probiotics fermentation broth, respectively, from the start of the trial through 21 days of lactation. The results showed: 1) The average daily feed intake of sows in the 300 mL/d group was significantly higher than that of the control group ($P<0.05$), while the weaning litter weight and average daily gain of piglets were extremely significantly higher than those of the control group ($P<0.01$). 2) The serum glucose (GLU) content in the 300 mL/d group was significantly higher than that of the control group ($P<0.05$), and the serum triiodothyronine (T3) content was extremely significantly higher than that of the control group ($P<0.01$). 3) The serum contents of immunoglobulin A (IgA), immunoglobulin G (IgG), immunoglobulin M (IgM), interleukin-2 (IL-2), and interleukin-6 (IL-6) in the 300 mL/d group were all extremely significantly higher than those of the control group ($P<0.01$). Based on these results, it is concluded that supplementation with 300 mL/d of compound probiotics fermentation broth can effectively improve the performance, serum biochemical parameters, and immune indexes of lactating sows.

Keywords: compound probiotics fermentation broth; lactating sows; performance; serum biochemical indexes; serum immune indexes

The nutritional status of lactating sows directly impacts the growth and immune performance of their offspring as well as their own breeding longevity [1]. The indiscriminate use of antibiotics and chemical drugs eliminates not only pathogenic bacteria but also beneficial microbes, leaving sow intestines in a sub-healthy state [2]. Consequently, nutrition and intestinal health have become critically important in lactating sow production. Lactobacillus and yeast, as probiotics naturally present in animals, contribute to intestinal health by preventing digestive diseases while promoting growth [3].

Microecological preparations composed primarily of beneficial bacteria have been studied in swine production. Yin et al. [4] reported that supplementing lactating and weaned piglet diets with 0.10% and 0.05% microecological preparation, respectively, stabilized gastrointestinal microflora and significantly reduced diarrhea rates and mortality, with effects superior to antibiotics. Chen et al. [5] found that adding microecological preparations to lactating sow and piglet diets increased average feed intake during lactation, reduced constipation incidence, and improved daily gain and survival rate of suckling piglets. Chu et al. [6] demonstrated that feeding 250–300 mL/d of Lactobacillus solution to late-gestation and lactating sows improved growth performance, health status, serum antioxidant indexes, and fecal microbial counts. While lactating sows represent a crucial link in pig production, probiotics have been more extensively studied in livestock and piglets than in sows, and the optimal application method and dosage for lactating sow performance remain to be elucidated. Therefore, this study investigated the effects of feeding compound probiotics fermentation broth mixed with wet mash on lactating sow performance, serum biochemical parameters, and immune indexes to provide a basis for the rational application of beneficial bacteria in sow production.

1.1 Experimental Materials

The compound probiotics fermentation broth was prepared using probiotic powder purchased from Shenzhen Baiaofei Co., Ltd., with Lactobacillus and yeast and their metabolites as the main components. The broth was produced through a 24-hour fermentation process using the company' s automatic fermentation tank system. The final product had a pH of 3.59, containing 1.0$\times10^{8}$ CFU/mL of Lactobacillus and 8$\times10^{7}$ CFU/mL of yeast.

1.2 Experimental Animals and Diets

Experimental sows were selected from Luyi Tianzhong Pig Farm in Henan Province. All were second-parity Large White sows with similar body weight, expected farrowing dates, and health status. The trial period spanned from 108 days of gestation to 21 days of lactation. Basal diets for late gestation and lactation were formulated according to NRC (2012) nutrient requirements for sows, with composition and nutrient levels shown in Table 1 .

1.3 Experimental Design

Sows were transferred to farrowing crates seven days before their expected farrowing date. All animals were housed in the same double-row farrowing building under the care of the same stockperson, with individual crates on slatted elevated floors equipped with automatic drinkers and iron feeders. The facility had good ventilation, and the environment was kept clean and dry with temperatures maintained at 20–25°C. Sixty sows were randomly assigned to four groups (n=15 per group). During feeding, appropriate water was added to the basal diet to create wet mash; for sows requiring fermentation broth, the specified dose was mixed into the wet mash. The control group received only wet mash, while experimental groups I, II, and III received wet mash supplemented with 200, 300, and 400 mL/d of fermentation broth, respectively. Feed allowances were as follows: 2-3 kg/d from 7 days pre-farrowing, 1-2 kg/d from 3-1 days pre-farrowing, no feed on farrowing day, 2 kg/d on day 2 of lactation, 3 kg/d on day 3, and ad libitum feeding at 4.5-7.0 kg/d from day 4 until weaning at 21 days. Sows were fed three times daily with free access to water. Management and immunization protocols followed standard farm practices.

1.4.1 Performance Measurements

Piglet performance was assessed by recording initial litter weight at birth and weaning litter weight at 21 days to calculate average daily gain. Average daily feed intake of lactating sows was recorded daily. Estrus interval was monitored for six days post-weaning, with observations recorded.

1.4.2 Serum Biochemical and Immune Index Measurements

At 07:00 on day 2 post-trial completion, eight sows with similar body condition were randomly selected from each group. Blood samples (10 mL) were collected via ear vein into procoagulant vacuum tubes, allowed to clot for 15 minutes, then centrifuged at 3,000 rpm for 20 minutes. Serum was harvested and stored at -20°C for analysis. Routine serum biochemical parameters including glucose (GLU), urea nitrogen (UN), total protein (TP), albumin (ALB), and albumin/globulin ratio (A/G) were measured using an automatic biochemical analyzer. Serum hormone indices (growth hormone [GH], triiodothyronine [T3], thyroxine [T4]) and immune indices (immunoglobulin A [IgA], immunoglobulin G [IgG], immunoglobulin M [IgM], interleukin-2 [IL-2], interleukin-6 [IL-6]) were determined by enzyme-linked immunosorbent assay using kits purchased from Beijing Huaying Biotechnology Research Institute.

1.5 Data Processing

Experimental data were initially processed using Excel 2012, followed by one-way ANOVA using SPSS 22.0 software. Multiple comparisons among groups were performed using LSD method. Results are expressed as "mean ± standard deviation." Differences were considered significant at $P<0.05$ and extremely significant at $P<0.01$.

2.1 Effects of Compound Probiotics Fermentation Broth on Lactating Sow Performance

As shown in Table 2 , the average daily feed intake of sows in the 300 and 400 mL/d groups increased by 9.75% and 9.03% compared with the control group, respectively ($P<0.05$). Weaning litter weight increased by 4.02%, 12.69%, and 9.90% compared with the control group ($P<0.01$). Average daily gain of piglets in all experimental groups was extremely significantly higher than that of the control group (P<0.01). No significant differences were observed among groups in initial litter weight or post-weaning estrus interval (P>0.05).

2.2 Effects of Compound Probiotics Fermentation Broth on Serum Biochemical Indexes

Table 3 shows that serum GLU content in the 300 and 400 mL/d groups was significantly higher than that of the control group (P<0.05). Serum T3 content in the 300 mL/d group was extremely significantly higher than that of the control group (P<0.01), while the 200 and 400 mL/d groups showed significantly higher T3 levels (P<0.05). Dietary supplementation with compound probiotics fermentation broth had no significant effects on serum UN, TP, ALB, GH, T4, or A/G (P>0.05).

2.3 Effects of Compound Probiotics Fermentation Broth on Serum Immune Indexes

As presented in Table 4 , serum IgA, IgG, and IgM contents in all experimental groups were extremely significantly higher than those of the control group (P<0.01). Serum IL-2 content in the 300 mL/d group was extremely significantly higher than that of the control group (P<0.01), while the 200 and 400 mL/d groups showed significantly higher IL-2 levels (P<0.05). Serum IL-6 content in the 300 mL/d group was extremely significantly higher than that of the control group (P<0.01), and the 400 mL/d group showed significantly higher IL-6 levels (P<0.05).

3.1 Effects on Lactating Sow Performance

Feed intake represents a critical factor limiting sow performance and genetic potential expression [7]. Research findings on probiotic effects on lactating sow feed intake have been inconsistent. Yin [8] reported that dietary supplementation with plant Lactobacillus during mid-to-late gestation and lactation did not promote feed intake during lactation. Conversely, Tang et al. [9] found that supplementing diets with different doses of Lactobacillus-yeast composite significantly affected feed intake in sows from day 90 of gestation to 10 days post-farrowing. In the current study, the 300 mL/d group exhibited a 9.75% increase in average daily feed intake compared with the control group. This improvement likely occurs because Lactobacillus and yeast reduce intestinal pH, balance the gut environment, and enhance digestive enzyme activity, thereby improving nutrient metabolism and absorption. Piglet growth and development depend heavily on milk quality; sows producing high-quality milk raise heavier piglets at weaning with faster growth rates and stronger immunity, reducing time to market weight and generating economic benefits. Li et al. [10] reported that microecological preparation supplementation improved sow litter weight, average piglet weight, and weaning litter weight. Long [11] demonstrated that dietary Saccharomyces boulardii supplementation during gestation and lactation significantly increased lactation feed intake and improved piglet average daily gain, average litter gain, and weaning litter weight. In this trial, the 300 mL/d group showed an 18.17% increase in 21-day milk yield, with weaning litter weight and piglet average daily gain being extremely significantly higher than the control group. The dosage of compound probiotics fermentation broth critically influences efficacy. The 300 mL/d level produced higher 21-day milk yield than both 200 and 400 mL/d levels, possibly because lower doses fail to provide sufficient viable bacteria for optimal probiotic function, while excessive doses may disrupt microbial balance and compromise effectiveness [12].

3.2 Effects on Serum Biochemical Indexes

Serum biochemical parameters reflect physiological status and overall metabolic condition, with abnormalities indicating health status, adaptability, and performance potential. Glucose serves as the direct energy source for all cellular life activities and correlates with daily gain and dietary nutrient levels [12]. Within normal ranges, elevated serum glucose enhances immunity and reduces stress. In this study, serum GLU content in the 300 and 400 mL/d groups was significantly higher than the control group. Serum glucose level reflects carbohydrate digestion and absorption efficiency; increased GLU stimulates insulin secretion, which influences cell membrane transport, promoting amino acid and glucose uptake and enhancing protein and glycogen synthesis [14]. Thyroid hormones, including T3 and T4, broadly regulate metabolism and promote animal growth. T3, the primary active thyroid secretion, exhibits greater physiological effects and faster action than T4 [15]. Leung et al. [16] demonstrated that thyrotropin-releasing hormone administration increased plasma T3 and T4 in broilers. King et al. [17] confirmed that T3 and T4 are essential for animal growth and development, with appropriate exogenous thyroid hormones promoting livestock growth. The current finding that serum T3 content in the 300 mL/d group was extremely significantly higher than the control group aligns with these previous studies.

3.3 Effects on Serum Immune Indexes

Serum immunoglobulins constitute the primary components of humoral immunity. IgG, IgM, and IgA provide immune defense by binding antigens and protecting against antigen-induced damage [18]. IgG represents the most abundant immunoglobulin (~75% of total) and effectively prevents infectious diseases while enhancing immune function, making it a direct indicator of immunity [19]. Wei et al. [20] reported that NS composite Lactobacillus preparation supplementation during gestation and lactation significantly increased sow serum immunoglobulin content, confirming that Lactobacillus enhances immunity during the reproductive phase. The current study' s observation that all experimental groups showed extremely significantly higher serum IgA, IgG, and IgM contents than the control group corroborates these findings. IL-2 is an essential cytokine for mobilizing immune defense against infection and tumors, promoting proliferation and differentiation of T lymphocytes, B lymphocytes, and natural killer

(NK) cells while stimulating interferon and tumor necrosis factor secretion to enhance disease resistance [21]. IL-6 is a multifunctional factor that stimulates B lymphocyte maturation and IgG secretion, maintaining homeostasis. Upon pathogen invasion, phagocytes release IL-6, which enters the liver via bloodstream and triggers mannose-binding protein production, initiating multi-level immune responses [22]. Therefore, both IL-2 and IL-6 effectively reflect immune function. In this trial, serum IL-2 and IL-6 contents in the 300 mL/d group were significantly or extremely significantly higher than the control group, likely because beneficial bacteria occupied most colonization sites in the sow digestive tract, directly affecting host immune systems, inducing intestinal immunity, increasing immunoglobulin secretion, and enhancing macrophage and NK cell activity to improve overall immune performance.

Conclusion

Dietary supplementation with compound probiotics fermentation broth improved lactating sow performance, serum biochemical parameters, and immune indexes to varying degrees. The most pronounced improvements occurred in average daily feed intake, 21-day milk yield, weaning litter weight, piglet average daily gain, and serum contents of GLU, T3, IgG, IgM, IgA, IL-2, and IL-6. Compound probiotics fermentation broth effectively enhances these indices, with an optimal supplementation level of 300 mL/d.

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