Effects of Dietary Chinese Herbal Medicine Residues and Fermented Chinese Herbal Medicine Residues on Sow Reproductive Performance and Offspring Development: Postprint

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Abstract

This experiment aimed to investigate the effects of microbial fermentation of Chinese herbal residues on reproductive performance of peripartum sows and offspring development, providing a basis for the secondary utilization of Chinese herbal residues. Sixty healthy binary sows with 2-4 parities and similar expected delivery dates at 85 days of gestation were selected and randomly divided into 3 groups with 20 sows per group. The three groups were supplemented with 2 kg/t rice bran (control group), 2 kg/t Chinese herbal residue preparation (composed of Astragalus, Angelica sinensis, Rehmannia glutinosa, and Paeonia lactiflora, etc., Chinese herbal residue group), and 2 kg/t fermented Chinese herbal residue preparation (fermented Chinese herbal residue group) in the basal diet, respectively. Feeding commenced at 21 days prepartum and ended at 28 days postpartum. Backfat thickness of sows was measured at 110 days of gestation and 21 days postpartum, and the total number of piglets born, number of live-born piglets, number of stillbirths, number of mummified fetuses, and postpartum estrus interval of sows were recorded; the litter weight at birth, litter weight gain at 7, 14, and 28 days of age were recorded, and average daily gain was calculated; diarrhea status of piglets was observed daily, and diarrhea rate was calculated. The results showed: Compared with the control group, the fermented Chinese herbal residue group had significantly increased litter weight gain of weaned piglets ($P<0.05$), the Chinese herbal residue group ($P=0.053$) and fermented Chinese herbal residue group ($P=0.075$) showed an increasing trend in diarrhea rate of piglets at 1-14 days of age, and diarrhea rate at 1-21 days of age was significantly increased ($P<0.05$); compared with the Chinese herbal residue group, the fermented Chinese herbal residue group had significantly increased litter weight gain at 7 days of age ($P<0.05$), and average daily

gain showed an increasing trend (P=0.053). In conclusion, dietary supplementation with Chinese herbal residue preparation in peripartum sows caused a certain degree of diarrhea in suckling piglets, but promoted their growth and development, with fermented Chinese herbal residue supplementation showing better effects.

Full Text

Abstract

This study was conducted to determine the effects of dietary supplementation with fermented herb residues during the perinatal period on reproductive performance of sows and growth performance of their offspring, providing a basis for the secondary development and utilization of herb residues. Sixty healthy crossbred sows (parity 2–4) at approximately 85 days of gestation with similar expected farrowing dates were randomly allocated to three groups (n=20 per group). The three groups were fed basal diets supplemented with 2 kg/t rice bran (control group), 2 kg/t herb residue preparation (composed of Astragalus membranaceus, Angelica sinensis, Rehmannia glutinosa, and Paeonia lactiflora; herb residue group), and 2 kg/t fermented herb residue preparation (fermented herb residue group), respectively. Feeding began at 21 days prepartum and continued until 28 days postpartum. Sow backfat thickness was measured on day 110 of gestation and day 21 postpartum. Litter size, number of live-born piglets, number of stillbirths, number of mummified fetuses, and weaning-to-estrus interval were recorded. Litter birth weight and litter weight gain at 7, 14, and 28 days of age were recorded to calculate average daily gain. Diarrhea incidence in piglets was observed daily to calculate diarrhea rate. The results showed that compared with the control group, the fermented herb residue group exhibited significantly increased litter weight gain at weaning (P<0.05), while both the herb residue group (P=0.053) and fermented herb residue group (P=0.075) showed a trend toward increased diarrhea rate during days 1–14, with a significant increase in diarrhea rate during days 1–21 (P<0.05). Compared with the herb residue group, the fermented herb residue group showed significantly increased litter weight gain at 7 days of age (P<0.05) and a trend toward increased average daily gain (P=0.053). These findings suggest that dietary supplementation with herb residues during the perinatal period, while causing a certain degree of diarrhea in suckling piglets, promotes their growth and development, with fermented herb residues showing superior effects.

Keywords: pregnant sows; reproductive performance; suckling piglets; growth and development; fermented herb residues

Introduction

Traditional Chinese medicinal herbs, as functional feed additives, offer advantages including abundant resources, freedom from pollution, and prominent biological functions. Due to limitations in extraction methods and efficiency, herb

residues generated by processing plants retain at least 30% of active ingredients. For instance, residues from Banxia Houpu decoction retain 49.8% of volatile oils, while Astragalus residues contain 72.1% of astragalosides. This demonstrates that developing herb residues as animal feed additives holds substantial value for exploitation and utilization. Furthermore, modern fermentation technology can reduce cellulose content in herb residues, improve their utilization efficiency, and produce functional secondary metabolites such as oligosaccharides during fermentation, making herb residue utilization more efficient and environmentally friendly.

Recent studies have shown that Chinese medicinal herbs can promote growth and enhance health in livestock and poultry. For example, active components such as volatile oils in medicinal herbs can increase volatile fatty acid concentrations in lamb rumen and improve feed conversion ratio in beef cattle. Acanthopanax senticosus extracts can enhance digestive metabolism, alleviate weaning stress, improve immunity, and promote growth in piglets. Dietary supplementation with Qingwen Baidu herb residues can improve production performance in lactating rex rabbits and reduce feeding costs. Supplementation with Codonopsis and Astragalus residues can improve mutton quality. Sow nutrition and health directly affect reproductive performance and longevity, as well as piglet growth and health. Adding functional feed additives to sow diets can promote maternal growth and improve reproductive performance. However, research on using herb residues in sow diets remains limited. Therefore, this study selected a compound herb residue composed of Astragalus membranaceus, Angelica sinensis, Rehmannia glutinosa, and Paeonia lactiflora, processed it through microbial fermentation to produce a fermented herb residue product, and investigated its effects on perinatal sow reproductive performance and offspring development to provide a basis for its application in sow production.

1.1 Preparation of Fermented Herb Residues

The herb residues used in this study were provided by Hunan Shengyakai Biotechnology Co., Ltd. Water-extracted herb residues were sterilized at 121°C for 30 minutes, then mixed at a ratio of 4:2:2:2 (dry weight basis) for Astragalus membranaceus:Angelica sinensis:Rehmannia glutinosa:Paeonia lactiflora, with moisture content controlled at 40–60%. A composite microbial inoculum (containing *Bacillus subtilis*, yeast, lactic acid bacteria, and *Clostridium butyricum*, viable count 2×10^{1} CFU/g) was added at 0.4%, and the mixture was fermented for one week at temperatures above 25°C with 1–2 turnings per day. After fermentation, the product was dried under reduced pressure, vacuum-dried, pulverized, and passed through a 40-mesh sieve, yielding a brown powder. Analysis showed that the herb residue preparation contained gross energy 17.12 MJ/kg, dry matter 95.82%, crude protein 11.57%, crude fiber 7.71%, and ether extract 5.6%, while the fermented herb residue preparation contained gross energy 16.42 MJ/kg, dry matter 96.81%, crude protein 16.91%, crude fiber 5.67%, and ether extract 3.96%.

1.2 Experimental Animals, Grouping, and Management

The animal feeding trial was conducted from July to September 2015 at the Animal Experimental Base of the Institute of Subtropical Agriculture, Chinese Academy of Sciences, located at Yong' an Branch of Hunan Xinwufeng Co., Ltd. Sixty healthy crossbred sows (parity 2–4) at 85 days of gestation with similar expected farrowing dates were randomly allocated to three groups (n=20 per group) and housed individually. The three groups received basal diets supplemented with 2 kg/t rice bran (control group), 2 kg/t herb residue preparation (herb residue group), and 2 kg/t fermented herb residue preparation (fermented herb residue group), respectively. The supplementation levels were determined based on preliminary trials by the manufacturer. Feeding began at 21 days prepartum and continued until 28 days postpartum. During the trial, experimental pigs were fed, watered, and vaccinated according to routine farm management procedures. The composition and nutrient levels of the basal diets are shown in Table 1 .

Table 1 Composition and nutrient levels of basal diets (air-dry basis), %

Item	Gestating sow diet	Lactating sow diet
Ingredients		
Corn	62.00	58.00
Wheat bran	24.00	8.00
Wheat flour	0	5.00
Soybean oil	0	2.50
Soybean meal	10.00	22.00
Enzymatic protein powder	0	1.50
Imported fish meal	0	0.50
Lysine	0.10	0.20
Threonine	0.03	0.06
Valine	0.02	0.04
Antimildew agent	0.05	0.05
Pregnant sow compound premix[1]	3.80	0
Lactating sow compound premix[2]	0	4.50
Total	**100.00**	**100.00**
Nutrient levels[3]		
Digestible energy (MJ/kg)	12.55	13.50
Dry matter	87.50	88.20
Ether extract	2.60	4.80
Crude fiber	5.20	3.40
Crude protein	13.80	17.50
Crude ash	4.20	5.10
Lysine	0.78	1.05
Methionine	0.24	0.32
Threonine	0.52	0.68

[1] Provided per kilogram of diet: VA 10,000 IU, VD 2,500 IU, VE 100 IU, VK 2 mg, VB 10 mg, VB 1 mg, VB 50 g, choline chloride 1,500 mg, Fe 80 mg, Cu 20 mg, Zn 100 mg, Mn 45 mg, I 0.7 mg, Se 0.25 mg.

[2] Provided per kilogram of diet: VA 15,000 IU, VD 33,200 IU, VE 50 IU, VK 4 mg, VB 4 mg, VB 10 mg, VB 3 mg, VB 20 g, choline chloride 800 mg, Fe 120 mg, Cu 20 mg, Zn 112 mg, Mn 24 mg, I 0.5 mg, Se 0.4 mg.

[3] Digestible energy was a calculated value, while others were measured values.

1.3 Measurement of Sow Reproductive Performance

Litter size, number of live-born piglets, number of stillbirths, number of mummified fetuses, weaning-to-estrus interval, litter birth weight, and litter weight gain at 7, 14, and 21 days of age were recorded to calculate average daily gain.

1.4 Measurement of Piglet Diarrhea Rate

Diarrhea incidence was observed and recorded daily for each litter to calculate diarrhea rate using the formula: Diarrhea rate = 100 × (total number of diarrheic piglets × diarrhea days) / (total number of suckling piglets × suckling days).

1.5 Measurement of Sow Backfat Thickness

Sow backfat thickness was measured on day 110 of gestation and at weaning on day 21 postpartum to calculate backfat loss during the perinatal period.

1.6 Data Processing and Analysis

Experimental data were preliminarily processed using Excel 2010 and analyzed using SPSS 22.0 software. Except for estrus rate expressed as mean values, all other data were expressed as "mean ± standard error." $P<0.05$ was considered statistically significant, while $0.05 P<0.10$ indicated a trend.

Results

2.1 Effects of Dietary Herb Residue and Fermented Herb Residue Supplementation on Sow Reproductive Performance

As shown in Table 2 , no significant differences were observed among groups in litter size, number of live-born piglets, number of mummified fetuses, number of stillbirths, or litter birth weight ($P>0.05$).

Table 2 Effects of herb residues (HR) and fermented HR on reproductive performance of sows

Item	Control group (n=20)	HR group	Fermented HR group
Litter size	9.74±0.52	10.17±0.55	9.55±0.61
Alive litter size	9.57±0.52	9.83±0.61	9.41±0.60
Mummy size	0.05±0.05	0.19±0.15	0.05±0.05
Dead fetus size	0.13±0.46	0.17±0.08	0.14±0.08
Litter birth weight of piglets (kg)	15.36±0.80	15.43±0.85	16.87±0.94

Data in the same row with different superscripts differ significantly (P<0.05). The same as below.

2.2 Effects of Dietary Herb Residue and Fermented Herb Residue Supplementation on Piglet Growth Performance

As shown in Table 3 , no significant differences were observed in 7-day litter weight gain or average daily gain between the control and herb residue groups (P>0.05). However, compared with the herb residue group, the fermented herb residue group exhibited significantly increased 7-day litter weight gain (P<0.05) and a trend toward increased average daily gain (P=0.053). No significant differences were found among groups in 14-day litter weight gain or average daily gain (P>0.05). Compared with the control group, the fermented herb residue group showed significantly increased litter weight gain at weaning (P<0.05), though no significant differences were observed among groups in average daily gain at weaning (P>0.05).

Table 3 Effects of HR and fermented HR on growth performance of piglets

Item	Control group	HR group	Fermented HR group
Weight gain per litter (kg)			
7 days of age	11.77±0.91ab	10.26±0.79b	12.78±1.06a
14 days of age	28.00±1.39	27.37±1.56	30.48±1.79
Weanling	39.90±1.62b	42.88±2.36ab	45.84±2.59a
Average daily gain (kg)			
7 days of age	1.67±0.11	1.51±0.11	1.81±0.14

Item	Control group	HR group	Fermented HR group
14 days of age	1.15±0.04	1.22±0.06	1.26±0.07
Weanling	2.08±0.08	2.10±0.09	2.24±0.12

2.3 Effects of Dietary Herb Residue and Fermented Herb Residue Supplementation on Piglet Diarrhea Rate

As shown in Table 4 , no significant differences were observed among groups in diarrhea rate during days 1-7 (P>0.05). However, compared with the control group, both the herb residue and fermented herb residue groups exhibited significantly increased diarrhea rates during days 1-14 and 1-21 (P<0.05), with no significant differences between these two treatment groups (P>0.05).

Table 4 Effects of HR and fermented HR on diarrhea rate of piglets, %

Item	Control group	HR group	Fermented HR group
1 to 7 days of age	0.21±0.14	0.27±0.12	0.33±0.17
1 to 14 days of age	0.18±0.08b	1.03±0.29a	0.96±0.34a
1 to 21 days of age	0.18±0.07b	1.31±0.32a	1.22±0.41a

2.4 Effects of Dietary Herb Residue and Fermented Herb Residue Supplementation on Postpartum Recovery of Sows

As shown in Table 5 , no significant effects were observed for herb residue or fermented herb residue supplementation on sow backfat loss, weaning-to-estrus interval, estrus rate during days 1-7, estrus rate during days 8-14, or abnormal estrus rate (P>0.05).

Table 5 Effects of HR and fermented HR on postpartum recovery of sows

Item	Control group	HR group	Fermented HR group
Backfat loss (mm)	1.68±0.34	1.38±0.88	0.63±0.92
Weaning-to-estrus interval (d)	5.05±0.17	5.25±0.03	4.50±0.17
Estrus rate of 1 to 7 days (%)	-	-	-
Estrus rate of 8 to 14 days (%)	-	-	-
Abnormal estrus rate (%)	-	-	-

Discussion

Currently, China generates 30-50 million tons of herb residues annually (including waste from plant extraction), primarily used as substrates for edible mushroom cultivation and plant seed germination, as well as for production of feed and organic fertilizer, or dried and gasified at high temperatures as fuel. However, high crude fiber content, poor digestibility, and poor palatability limit the

utilization of herb residues in animal production. With increasingly widespread application of fermentation technology, its integration into traditional herbal processing can increase active ingredient content, generate new active components, reduce adverse reactions, and conserve medicinal resources. Similarly, applying microecological fermentation technology to herb residue processing can decompose fiber components, increase nutritional and bioactive components, and enhance the re-utilization value of herb residues.

In this study, dietary supplementation with herb residues and fermented herb residues during the perinatal period did not significantly affect sow reproductive performance or postpartum recovery, but tended to increase litter birth weight, suggesting that herb residue preparations promoted fetal growth and development in utero. Bai et al. reported that feeding Chinese herbal preparations to lactating sows also increased litter birth weight. Yang et al. demonstrated that dietary supplementation with fermented red ginseng residues significantly increased litter size and birth weight in mice. The herb residues used in this study include Astragalus membranaceus (Qi-tonifying and surface-consolidating), Angelica sinensis (blood-activating, blood-nourishing, and menstruation-regulating), Rehmannia glutinosa (Yin-nourishing and blood-enriching), and Paeonia lactiflora (liver-softening and pain-relieving). The increased litter birth weight may result from: (1) pharmacological effects of active ingredients promoting fetal growth; (2) improved gut microecology and metabolism in sows promoting fetal development; and (3) enhanced effects of fermented herb residues due to beneficial bacteria and their metabolites produced during fermentation, which facilitate maternal nutrient digestion and absorption. Lactating sows mobilize body reserves to maintain milk production, but excessive mobilization causes severe weight loss, affecting piglet weight gain and prolonging weaning-to-estrus interval while reducing conception rate. This study showed that dietary herb residue and fermented herb residue supplementation did not significantly affect sow backfat thickness or weaning-to-estrus interval, though fermented herb residues tended to reduce the weaning-to-estrus interval, possibly because active ingredients and abundant beneficial bacteria in fermented herb residues help shorten the interval and improve subsequent reproductive performance.

The results also indicate that dietary herb residue supplementation caused a certain degree of diarrhea in piglets, possibly because the fermented herb residue preparation contained numerous microorganisms and their metabolites that burdened the piglet gut. He et al. reported that dietary supplementation with fermented Schisandra residues could prevent piglet diarrhea and improve digestive absorption. Schisandra, an astringent medicinal herb, has anti-diarrheal, immune-enhancing, hepatoprotective, and antioxidant effects. Therefore, differences in herb residue composition may also contribute to diarrhea incidence, though specific mechanisms require further investigation.

Despite causing some diarrhea, dietary supplementation with herb residues and fermented herb residues promoted piglet growth and development, with

fermented herb residues showing superior effects. This may be because herb residues contain various bioactive substances that regulate sow Qi and blood, improve lactation capacity, and enhance milk production by participating in lactation hormone synthesis and secretion and promoting mammary gland metabolism. Additionally, fermentation destroys cell walls, making active components such as polysaccharides, saponins, and flavonoids more available. The fermented herb residue showed increased protein content (16.91% vs. 11.57%) and reduced crude fiber content (5.67% vs. 7.71%), better meeting the nutritional needs of lactating sows and benefiting piglet growth. Zhu et al. confirmed that high-protein, low-fiber diets benefit sow growth and development. Furthermore, fermented herb residues are rich in beneficial bacteria that reduce intestinal pH, promote digestive juice secretion and intestinal motility, and enhance sow nutrient digestion and absorption, making fermented herb residues more effective for promoting piglet growth.

In conclusion, dietary supplementation with herb residues and fermented herb residues during the perinatal period does not affect sow backfat thickness or postpartum recovery. Although it causes some diarrhea in suckling piglets, it increases litter birth weight and weaning litter weight gain, with fermented herb residues demonstrating superior effects.

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