

## Effects of Chinese Herbal Medicine Residue on Plasma Biochemical Parameters and Antioxidant Capacity in Lactating Sows and Their Piglets (Postprint)

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### Abstract

This study aimed to comparatively investigate the effects of Chinese herbal residues and fermented Chinese herbal residues on plasma biochemical parameters and antioxidant capacity in lactating sows and piglets, providing a basis for their application in sow diet formulations. Sixty crossbred sows with 2-4 parities and similar expected farrowing dates were randomly allocated into 3 groups (n=20). The three groups were supplemented with 2 kg/t rice bran (control group), 2 kg/t Chinese herbal residue preparation (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 d prepartum and concluded at 28 d postpartum. Blood samples were collected from 6 randomly selected sows per group via the ear marginal vein at 1, 7, 14, and 21 d postpartum, and from 6 randomly selected piglets per group via the anterior vena cava at 7, 14, and 21 days of age. Plasma was separated from the collected blood samples for determination of biochemical parameters and antioxidant indices. The results demonstrated that compared with the control group, the Chinese herbal residue group exhibited significantly decreased plasma total protein (TP) and globulin (GLB) contents at 7 d postpartum and GLB content at 14 d postpartum ( $P<0.05$ ), and significantly increased plasma alkaline phosphatase (ALP) and catalase (CAT) activities and total antioxidant capacity (T-AOC) at 1 d postpartum, plasma alanine aminotransferase (ALT) and ALP activities at 7 d, plasma ALT and ALP activities at 14 d, and plasma ALT activity at 21 d ( $P<0.05$ ); the fermented Chinese herbal residue group showed significantly increased plasma aspartate aminotransferase (AST) and CAT activities and T-AOC at 1 d postpartum, and plasma AST and ALP activities at 14 d postpartum ( $P<0.05$ ); the Chinese herbal residue group had

significantly decreased plasma ALP activity and malondialdehyde (MDA) content in 14-day-old piglets ( $P < 0.05$ ), and significantly increased plasma T-AOC in 14-day-old piglets ( $P < 0.05$ ); the fermented Chinese herbal residue group exhibited significantly increased plasma ALP activity and T-AOC in 7-day-old piglets ( $P < 0.05$ ), and significantly decreased plasma MDA content in 14-day-old piglets ( $P < 0.05$ ). These results indicate that dietary supplementation with Chinese herbal residues or fermented Chinese herbal residues in sows can affect the metabolism of lactating sows and their piglets and enhance the antioxidant capacity of the organism.

## Full Text

### Effects of Herb Residues on Plasma Biochemical Parameters and Antioxidant Capacity of Lactating Sows and Their Piglets

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## Abstract

This experiment was conducted to compare the effects of herb residues (HR) and fermented herb residues on plasma biochemical parameters and antioxidant capacity of lactating sows and their piglets, providing a basis for their application in sow dietary formulations. Sixty crossbred sows (parities 2-4) with similar expected delivery dates were randomly allocated to three groups ( $n=20$ ). The basal diet was supplemented with 2 kg/t rice bran (control group), 2 kg/t HR preparation (HR group), or 2 kg/t fermented HR preparation (fermented HR group). Feeding commenced at 21 days prepartum and continued until 28 days postpartum. Blood samples were collected from six randomly selected sows per group via ear vein at 1, 7, 14, and 21 days postpartum, and from six randomly selected piglets per group via anterior vena cava at 7, 14, and 21 days of age. Plasma was separated and analyzed for biochemical parameters and antioxidant indices. The results showed that compared with the control group, HR supplementation significantly decreased plasma total protein (TP) and globulin (GLB) contents in sows at 7 days postpartum and GLB content

at 14 days postpartum ( $P < 0.05$ ), while significantly increasing plasma alkaline phosphatase (ALP) and catalase (CAT) activities and total antioxidant capacity (T-AOC) at 1 day postpartum, plasma alanine aminotransferase (ALT) and ALP activities at 7 days postpartum, plasma ALT and ALP activities at 14 days postpartum, and plasma ALT activity at 21 days postpartum ( $P < 0.05$ ). Fermented HR supplementation significantly increased plasma aspartate aminotransferase (AST) and CAT activities and T-AOC in sows at 1 day postpartum, as well as plasma AST and ALP activities at 14 days postpartum ( $P < 0.05$ ). In piglets, HR supplementation significantly decreased plasma ALP activity and malondialdehyde (MDA) content at 14 days of age ( $P < 0.05$ ) while significantly increasing plasma T-AOC ( $P < 0.05$ ). Fermented HR supplementation significantly increased plasma ALP activity and T-AOC at 7 days of age ( $P < 0.05$ ) and significantly decreased plasma MDA content at 14 days of age ( $P < 0.05$ ). These results indicate that dietary supplementation with HR or fermented HR can affect metabolism and enhance antioxidant capacity in lactating sows and their offspring.

**Keywords:** herb residues; fermentation; pregnant sow; piglet; biochemical parameters; antioxidant capacity

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With the rapid development of China's traditional Chinese medicine processing industry, approximately 30-50 million tons of herb residues (including plant extraction waste) are generated annually. Improper disposal leads to spoilage and odor, causing resource waste and environmental pollution. Due to limitations in extraction techniques and efficiency, herb residues retain numerous bioactive compounds and nutrients. For example, 49.8% of volatile oils remain in Banxia Houpu decoction residues, and 72.1% of astragalosides persist in Astragalus residues. Additionally, herb residues contain proteins, cellulose, reducing sugars, and inorganic salts. Modern fermentation processes can reduce cellulose content and produce functional secondary metabolites such as oligosaccharides, conferring special biological functions. Recent studies demonstrate that Chinese herbal preparations promote growth, enhance immunity, and improve antioxidant capacity in livestock. Fermented Schisandra residues can improve immune function in piglets, while fermented preparations containing Rehmannia, hawthorn, tangerine peel, malt, and licorice can increase intestinal absorption area and nutrient digestibility, regulate blood lipid concentration, and enhance antioxidant capacity, thereby improving growth performance in weaned piglets. Fermented herb residues containing Astragalus, Angelica, Leonurus, and honeysuckle can increase litter size, number of live-born piglets, and average daily weight gain of nursing piglets. However, although numerous studies have investigated Chinese herbal applications in animal production, research on fermented herb residues in sow diets remains limited. Our previous research found that dietary supplementation with fermented herb residues composed of Astragalus, Angelica, Rehmannia, and Paeonia did not affect litter size (control:  $9.74 \pm 0.52$ ; HR group:  $10.17 \pm 0.55$ ; fermented HR group:  $9.55 \pm 0.61$ ) or litter

birth weight (control:  $15.36 \pm 0.80$  kg; HR group:  $15.43 \pm 0.85$  kg; fermented HR group:  $16.87 \pm 0.94$  kg), but significantly increased litter weight gain at weaning (control:  $39.90 \pm 1.62$  kg; HR group:  $42.88 \pm 2.36$  kg; fermented HR group:  $45.84 \pm 2.59$  kg). Therefore, this study further investigated the effects of HR and fermented HR on plasma biochemical parameters and antioxidant capacity of lactating sows and their piglets to provide a basis for dietary application.

## 1. Materials and Methods

### 1.1 Preparation and Composition of Herb Residues

The herb residues were provided by Hunan Shengyakai Biotechnology Co., Ltd. Water-extracted herb residues were sterilized at  $121^{\circ}\text{C}$  for 30 minutes, then mixed at a ratio of Astragalus:Angelica:Rehmannia:Paeonia of 4:2:2:2 (air-dry basis) with moisture content controlled at 40-60%. A composite microbial inoculum (containing *Bacillus subtilis*, yeast, lactic acid bacteria, and *Clostridium butyricum*, viable count  $2 \times 10^1$  CFU/g) was added at 0.4% and fermented at  $25^{\circ}\text{C}$  for one week with 1-2 daily turnings. The fermented product was dried under vacuum, ground to an average particle size of 0.38 mm, yielding a brown powder. Analysis showed the HR preparation contained 17.12 MJ/kg gross energy, 95.82% dry matter (DM), 11.57% crude protein (CP), 7.71% crude fiber (CF), and 5.6% ether extract (EE), while the fermented HR preparation contained 16.42 MJ/kg gross energy, 96.81% DM, 16.91% CP, 5.67% CF, and 3.96% EE.

### 1.2 Experimental Animals, Grouping, and Management

The animal trial was conducted from September to November 2015 at the Animal Experimental Base of the Institute of Subtropical Agriculture, Chinese Academy of Sciences, located at Yong'an Branch of Hunan New Wufeng Co., Ltd. Sixty crossbred sows (parities 2-4) at 85 days of gestation with similar expected delivery dates were randomly allocated to three groups ( $n=20$ ) and housed individually. The basal diet was supplemented with 2 kg/t rice bran (control group; rice bran composition: 15.12 MJ/kg gross energy, 94.24% DM, 2.37% CP, 41.01% CF, and 6.6% EE), 2 kg/t HR preparation (HR group), or 2 kg/t fermented HR preparation (fermented HR group). The basal diet was formulated according to NRC (2012) recommendations for pregnant and lactating sows, with composition and nutrient levels shown in Table 1. Supplemental levels were determined based on preliminary results from the manufacturer. Feeding began at 21 days prepartum and continued until 21 days postpartum. Pigs were fed, watered, and immunized according to routine farm management procedures.

### 1.3 Sample Collection and Analysis

Blood samples were collected from six randomly selected sows per group via ear vein at 1, 7, 14, and 21 days postpartum. From piglets, blood was collected

from six randomly selected individuals per group via anterior vena cava at 7, 14, and 21 days of age. Blood was anticoagulated with heparin, centrifuged at 4,000 r/min for 15 minutes, and plasma was stored at -20°C. Plasma TP and GLB contents and activities of AST, ALT, and ALP were measured using a CX4 automatic biochemical analyzer (Beckman) with reagents from Beijing Leadman Biochemistry Co., Ltd. Plasma CAT activity, T-AOC, and MDA content were determined using kits from Nanjing Jiancheng Bioengineering Institute.

#### 1.4 Statistical Analysis

Data are expressed as “mean  $\pm$  standard error.” One-way ANOVA was performed using SPSS 17.0 software, and Duncan’s multiple comparison test was used to compare group means.  $P < 0.05$  indicated significant difference, and  $0.05 > P > 0.10$  indicated a trend.

## 2. Results

### 2.1 Effects of HR and Fermented HR on Plasma Biochemical Parameters of Lactating Sows

As shown in Table 2, compared with the control group, HR supplementation significantly decreased TP and GLB contents at 7 days postpartum and GLB content at 14 days postpartum ( $P < 0.05$ ), while significantly increasing ALT activity at 7, 14, and 21 days postpartum and ALP activity at 1, 7, and 14 days postpartum ( $P < 0.05$ ). Fermented HR supplementation significantly increased AST activity at 1 and 14 days postpartum and ALP activity at 14 days postpartum ( $P < 0.05$ ), with ALP activity at 1 day postpartum showing an increasing trend ( $P = 0.09$ ). Compared with the HR group, the fermented HR group showed significantly higher TP and GLB contents at 7 days postpartum and AST activity at 1 and 14 days postpartum ( $P < 0.05$ ), while ALT activity at 7 and 14 days postpartum and ALP activity at 7 days postpartum were significantly lower ( $P < 0.05$ ).

### 2.2 Effects of HR and Fermented HR on Plasma Antioxidant Indices of Lactating Sows

As shown in Table 3, both HR and fermented HR supplementation significantly increased CAT activity and T-AOC at 1 day postpartum compared with the control group ( $P < 0.05$ ). No significant differences were observed between the HR and fermented HR groups for any indices ( $P > 0.05$ ).

### 2.3 Effects of HR and Fermented HR on Plasma Biochemical Parameters of Piglets

As shown in Table 4, HR supplementation significantly decreased ALP activity in piglets at 14 days of age ( $P < 0.05$ ), while fermented HR supplementation significantly increased ALP activity at 7 days of age ( $P < 0.05$ ) and showed a

decreasing trend for ALP activity at 14 days of age ( $P=0.077$ ). Compared with the HR group, fermented HR supplementation significantly increased ALP activity at 7 days of age ( $P<0.05$ ) and showed increasing trends for ALP activity at 14 days ( $P=0.067$ ) and GLB content at 21 days ( $P=0.063$ ).

#### 2.4 Effects of HR and Fermented HR on Plasma Antioxidant Indices of Piglets

As shown in Table 5, HR supplementation significantly decreased MDA content and increased T-AOC in piglets at 14 days of age ( $P<0.05$ ). Fermented HR supplementation significantly decreased MDA content at 14 days of age and increased T-AOC at 7 days of age ( $P<0.05$ ). Compared with the HR group, fermented HR supplementation showed an increasing trend for CAT activity at 14 days of age ( $P=0.086$ ) but significantly decreased T-AOC ( $P<0.05$ ).

### Discussion

Plasma TP content reflects dietary CP level and its utilization efficiency; increased plasma TP indicates greater protein deposition and faster growth. Globulin, secreted by plasma cells transformed from B lymphocytes, reflects immune competence. During lactation, sows require increased nutrients and mobilize body reserves to maintain milk production. In this study, reduced plasma TP and GLB contents at 7 and 14 days postpartum in the HR group may result from decreased dietary CP level and slow recovery of postpartum feed intake, failing to meet physiological demands. However, fermented HR contains beneficial bacteria, bacterial protein, and metabolites that enhance nutrient digestibility, explaining why fermented HR supplementation did not significantly alter plasma TP and GLB compared with the control group.

AST and ALT are crucial transaminases involved in amino acid metabolism and interconversion of proteins, fats, and carbohydrates. Elevated plasma AST and ALT activities in sows and piglets at certain stages following HR or fermented HR supplementation suggest enhanced nitrogen metabolism, which may contribute to increased litter weight gain and improved piglet performance.

ALP, a monophosphate ester hydrolase widely distributed in tissues, is closely associated with absorption, transport, and synthesis of fats, carbohydrates, and proteins, with its activity reflecting animal performance. Previous studies report positive correlations between ALP activity and daily weight gain in pigs, and demonstrate that dietary *Acanthopanax* extracts can increase serum ALP activity, enhance nutrient absorption, and improve performance—effects linked to ALP's role in maintaining intestinal barrier integrity. This study found increased plasma ALP activity in fermented HR group piglets compared with the HR group, which may benefit growth by promoting digestion and absorption of dietary zinc and fats and enhancing calcium and phosphorus deposition.

Oxidative stress occurs when excessive free radicals overwhelm cellular clearance capacity, generating oxidative intermediates that damage organisms. Catalase

is a key antioxidant enzyme that rapidly eliminates hydrogen peroxide, protecting sulfhydryl enzymes and membrane proteins together with glutathione peroxidase (GSH-Px). T-AOC represents a comprehensive antioxidant capacity index, while MDA, an end product of lipid peroxidation, directly reflects the degree of membrane oxidation. Peripartum sows experience dramatic physiological and metabolic changes, consuming large amounts of oxygen and energy that generate abundant free radicals and increase oxidative stress risk. Excessive free radicals can attack oocytes, delay embryo implantation, inhibit embryonic development, reduce litter size and piglet survival, and decrease growth rate and viability of nursing piglets. This study demonstrates that dietary HR or fermented HR supplementation can increase plasma T-AOC and decrease MDA content in sows and piglets, thereby enhancing antioxidant capacity and benefiting health and offspring development. These effects may be attributed to flavonoids in HR that increase tissue GSH-Px activity and reduce MDA content, as well as Rehmannia polysaccharides that enhance serum CAT and GSH-Px activities while decreasing MDA content.

In conclusion, dietary supplementation with HR or fermented HR in sows can regulate metabolism and enhance antioxidant capacity in lactating sows and their piglets.

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