Effects of Fermented Mulberry Leaf Powder on Growth Performance, Meat Quality, and Serum Biochemical Indices of Ningxiang Flower Pigs (Postprint)

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Abstract

Fermented mulberry powder feed; Ningxiang pig; growth performance; meat quality; serum biochemical indices

Full Text

Effects of Fermented Feed Mulberry Powder on Growth Performance, Meat Quality and Serum Biochemical Indexes of Ningxiang Pigs

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Abstract: This study investigated the effects of fermented feed mulberry powder on growth performance, meat quality, and serum biochemical indexes of Ningxiang pigs. Ninety Ningxiang pigs with an average body weight of approximately 30 kg were randomly allocated into five groups, with three replicates (pens) per group and six pigs per replicate. The control group received a basal diet, while groups I, II, III, and IV received diets supplemented with 9%, 12%, and 15% fermented feed mulberry powder, and 9% unfermented feed mulberry powder, respectively. The trial consisted of two phases: a growing phase (days

1–50) and a finishing phase (days 51–75). The results showed: (1) The feed-to-gain ratio of group I was significantly lower than that of the control and group IV during days 1–50 ($P < 0.05$). (2) Compared with the control, the average backfat thickness of pigs in groups I, II, III, and IV was significantly reduced ($P < 0.05$). (3) Serum total cholesterol levels in groups I, II, III, and IV were significantly lower than the control ($P < 0.05$), and serum total protein content in group I on day 50 was significantly higher than in group IV ($P < 0.05$). In conclusion, fermentation enhances the feeding value of mulberry powder by reducing anti-nutritional factors and improving palatability. Supplementation with 9% fermented feed mulberry powder improved growth performance by reducing the feed-to-gain ratio, while all mulberry-supplemented diets decreased backfat thickness and serum cholesterol, thereby improving meat quality.

Keywords: fermented feed mulberry powder; Ningxiang pigs; growth performance; meat quality; serum biochemical indexes

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With increasing scarcity of conventional feed ingredients, the development and utilization of mulberry resources have attracted growing attention from the livestock industry. Through artificial selection and breeding, Chinese researchers have developed a novel stress-resistant variety known as feed mulberry, which exhibits strong adaptability, high yield, and rich nutritional content, offering substantial development potential. Feed mulberry contains abundant protein, fatty acids, vitamins, and balanced amino acid profiles. Previous studies have identified various bioactive compounds in feed mulberry, primarily including flavonoids (kuwanon, kuwanol), steroids, and alkaloids, which possess hypotensive, hypoglycemic, antibacterial, and anti-inflammatory properties. However, feed mulberry also contains anti-nutritional factors such as tannins and lectins, along with astringent flavors that reduce palatability and feed intake when added at high doses, limiting its application in animal diets. Research has demonstrated that fermentation effectively reduces or eliminates these anti-nutritional factors while degrading crude fiber and large-molecular proteins, thereby enhancing feed value. Ningxiang pig, one of China' s four famous indigenous breeds, is characterized by its tolerance to roughage, tender meat quality, and relatively low lean meat percentage. To better utilize feed mulberry resources, this study employed fermentation technology to improve mulberry powder quality and evaluated its effects on growth performance, meat quality, and serum biochemical indexes of Ningxiang pigs, providing a theoretical basis for practical application.

1.1 Experimental Materials

Feed mulberry powder was provided by the Sericulture Science Institute of Hunan. Laboratory analysis revealed the following nutritional composition: crude protein 22.96%, crude fat 6.26%, crude fiber 9.18%, crude ash 13.90%, calcium 4.37%, and phosphorus 0.46%. A mixed microbial inoculum containing *Lacto-*

bacillus, *Saccharomyces*, and *Bacillus subtilis* at a 2:1:1 ratio (3×10 CFU/g viable count) was used for solid-state fermentation via a complete fermentation process, where different proportions of mulberry powder were added to the diet before fermentation. Fermentation equipment and experimental diets were provided by Hunan Ningxiang Xiangxiang Biotechnology Co., Ltd.

1.2 Experimental Design

Ninety Ningxiang pigs averaging approximately 30 kg body weight were randomly divided into five groups with three replicates (pens) per group and six pigs per replicate. The control group received a basal diet, while groups I, II, III, and IV received diets supplemented with 9%, 12%, and 15% fermented feed mulberry powder, and 9% unfermented feed mulberry powder, respectively. The trial was conducted from July to September 2016 at Hunan Ningxiang Dalong Animal Husbandry Technology Co., Ltd., and comprised two phases: a growing phase (days 1–50) and a finishing phase (days 51–75). Diet composition and nutrient levels are presented in Table 1 and Table 2 .

1.3 Feeding Management and Sample Collection

Pigs were managed according to standard farm procedures. Following a 3-day adaptation period, the formal trial lasted 75 days with ad libitum access to feed and water. On days 50 and 75, after 12-hour fasting, one pig per replicate was randomly selected for jugular vein blood collection (10 mL × 2). Serum was harvested after centrifugation at 3,000 rpm for 10 minutes and stored at -20°C for subsequent analysis. On day 75, after 16-hour fasting, one pig per replicate was weighed and slaughtered for carcass evaluation. The left carcass was split, and the *longissimus dorsi* muscle at the last rib was sampled for meat quality analysis.

1.4 Measurement Indicators and Methods

1.4.1 Growth Performance

Body weight was recorded on days 1, 50, and 75 after 16-hour fasting. Feed consumption per replicate was monitored to calculate average daily gain (ADG), average daily feed intake (ADFI), and feed-to-gain ratio (F/G).

1.4.2 Meat Quality

Post-slaughter measurements included average backfat thickness and carcass weight. The *longissimus dorsi* muscle at the last rib was used to determine pH at 45 minutes and 24 hours postmortem (pH , pH), loin eye area, drip loss, shear force, water loss rate, meat color, and marbling score.

1.4.3 Serum Biochemical Indexes

Serum glucose, triglycerides, urea nitrogen, total cholesterol, and total protein were measured using a Mindray Chemistry Analyzer BS-2000. All assay kits were purchased from Nanjing Jiancheng Bioengineering Institute.

1.5 Data Statistics and Analysis

Data were processed using Excel 2007 and SPSS 20.0 software, presented as "mean ± standard deviation." Inter-group comparisons were performed using one-way ANOVA, while t-tests were conducted between the 9% fermented and 9% unfermented mulberry powder groups. Significance was declared at $P < 0.05$.

2.1 Effects of Fermented Feed Mulberry Powder on Growth Performance

As shown in Table 3 , the feed-to-gain ratio of group I during days 1–50 was significantly reduced by 17.95% compared with the control ($P < 0.05$) and by 15.79% compared with group IV ($P < 0.05$). No significant differences were observed among groups in ADFI, ADG, or F/G during other phases ($P > 0.05$).

2.2 Effects of Fermented Feed Mulberry Powder on Meat Quality

Table 4 shows that compared with the control, average backfat thickness was significantly reduced by 14.72%, 14.98%, 19.27%, and 15.61% in groups I, II, III, and IV, respectively ($P < 0.05$). No significant differences were detected among groups in loin eye area, drip loss, pH, meat color, or shear force ($P > 0.05$). Groups I, II, III, and IV exhibited higher pH and marbling scores and lower water loss rates than the control, though these differences were not statistically significant ($P > 0.05$).

2.3 Effects of Fermented Feed Mulberry Powder on Serum Biochemical Indexes

On day 50, serum total cholesterol levels in groups I, II, III, and IV were significantly reduced by 10.89%, 17.49%, 18.15%, and 8.25%, respectively, compared with the control ($P < 0.05$). Serum total protein content in group I was significantly higher than in group IV ($P < 0.05$). Serum glucose, triglyceride, and urea nitrogen levels were lower in all treatment groups than in the control, but differences were not significant ($P > 0.05$). On day 75, serum total cholesterol remained significantly lower in groups I, II, III, and IV (reductions of 13.86%, 17.16%, 24.42%, and 12.54%, respectively; $P < 0.05$). Serum total protein was higher in all treatment groups, while glucose, triglycerides, and urea nitrogen were lower than the control, though without significant differences ($P > 0.05$).

3.1 Effects on Growth Performance

Feed mulberry is rich in protein, carbohydrates, vitamins, minerals, and natural bioactive compounds, making it an excellent livestock feed ingredient. Recent studies have increasingly explored its use in animal diets. Song et al. found that 10% mulberry leaf powder supplementation did not affect finishing pig performance, but 15% supplementation significantly reduced ADG and impaired

production. Similarly, Chen et al. reported that mulberry stem and leaf powder up to 16% did not affect rabbit performance, but levels exceeding 24% reduced ADG. The presence of anti-nutritional factors like tannins and lectins in feed mulberry decreases palatability and feed intake, which explains why group IV (9% unfermented) had a higher feed-to-gain ratio than group I (9% fermented), consistent with Yang' s findings in finishing pigs. Zhang et al. observed that 15% fermented mulberry powder in late-finishing diets significantly improved ADG and shortened the growth period. Our study demonstrated that 9% fermented mulberry powder significantly reduced the feed-to-gain ratio during days 1-50, indicating that fermentation effectively reduces anti-nutritional factors, improves palatability, and enhances growth performance in Ningxiang pigs.

3.2 Effects on Meat Quality

Ningxiang pigs are renowned for tender meat but have high body fat and low lean meat percentages. This study found that mulberry powder supplementation significantly reduced average backfat thickness, with greater effects at higher inclusion levels, likely due to active compounds influencing lipid metabolism, consistent with Yang' s research. Post-slaughter muscle pH is a critical meat quality indicator reflecting acidity. After slaughter, anaerobic glycolysis of muscle glycogen and fat produces lactic acid, causing pH decline and protein denaturation; thus, slowing this process helps reduce pale, soft, exudative (PSE) and dark, firm, dry (DFD) pork. Jia et al. reported that mulberry supplementation in sheep diets slowed postmortem pH decline, positively affecting meat freshness. Guo et al. found that fresh mulberry leaves in finishing pig diets increased high-density lipoprotein, inosinic acid, linoleic acid, vitamin E, lysine, and total amino acids in the *longissimus dorsi* while reducing cholesterol and stearic acid, thereby improving pork nutritional value and quality. Intramuscular fat is a key indicator of meat quality and flavor, and marbling score positively correlates with intramuscular fat content. In this study, mulberry-supplemented groups showed increased marbling scores and reduced water loss rates compared with the control, aligning with Liu et al.' s findings in finishing pigs fed mulberry branch and leaf powder. Overall, feed mulberry powder effectively reduced backfat thickness and improved meat quality and flavor in Ningxiang pigs.

3.3 Effects on Serum Biochemical Indexes

Flavonoids are major bioactive compounds in feed mulberry. Research indicates that flavonoids promote vasodilation, increase arterial blood flow, and reduce blood pressure and lipids. Wang found that mulberry leaf powder significantly decreased serum triglycerides and cholesterol in Qingyuan geese. Song et al. reported that 10% mulberry leaf powder in finishing pig diets reduced serum triglycerides and regulated lipid metabolism. Our results showed that serum total cholesterol was significantly lower in all mulberry-supplemented groups, with greater reductions at higher inclusion levels, likely attributable to flavonoids and

other bioactive compounds regulating lipid metabolism, consistent with Huang' s findings in bearded chickens fed mulberry powder. Serum urea nitrogen, the end product of protein catabolism and amino acid metabolism, inversely correlates with dietary protein utilization efficiency. Chang et al. observed that increasing mulberry powder levels in broiler diets gradually reduced plasma urea nitrogen. Serum total protein reflects protein absorption and metabolism; increased levels within the normal range indicate enhanced protein anabolism. Our finding that group I had significantly higher serum total protein than group IV on day 50 suggests that fermentation degrades large-molecular proteins, facilitating protein digestion and absorption, though the underlying mechanisms require further investigation.

4 Conclusion

1. Fermentation reduces anti-nutritional factors and improves palatability of feed mulberry powder. Supplementation with 9% fermented mulberry powder significantly decreased the feed-to-gain ratio during days 1–50, thereby enhancing growth performance in Ningxiang pigs.
2. Dietary inclusion of feed mulberry powder regulated lipid metabolism, significantly reducing average backfat thickness and serum total cholesterol content in Ningxiang pigs.

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