Effects of Bamboo Vinegar Powder on Meat Quality and Flavor of Finishing Pigs (Postprint)

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Abstract

This experiment was conducted to investigate the effects of bamboo vinegar powder on meat quality and flavor in finishing pigs. Forty finishing pigs with similar body weight were selected and randomly divided into 5 groups (with 4 replicates per group and 2 pigs per replicate). The control group (CON) was fed a basal diet, the antibiotic group (ANT) was fed the basal diet + 0.12% compound antibiotics, and the bamboo vinegar powder groups were fed the basal diet + 0.5% (BV5), 1.0% (BV10), and 1.5% (BV15) bamboo vinegar powder, respectively, for a 60-day experimental period. The results showed: 1) The redness value of pork from BV5 and BV10 was higher than that of CON and ANT ($P<0.05$), the shear force of pork from BV10 and BV15 was significantly lower than that of CON ($P<0.05$), and the shear force of pork from bamboo vinegar powder groups was significantly lower than that of ANT ($P<0.05$); 2) The contents of aspartic acid and flavor amino acids in pork from BV10 and BV15 were significantly higher than those in CON and ANT ($P<0.05$), and the glutamic acid content in pork from bamboo vinegar powder groups was significantly higher than that in CON and ANT ($P<0.05$); 3) The inosine monophosphate content in pork from BV5 and BV10 was significantly higher than that in CON and ANT ($P<0.05$), and the inosine monophosphate content in pork from BV15 was significantly higher than that in ANT ($P<0.05$); 4) The palmitic acid content in pork from BV10 and the palmitoleic acid content in pork from BV5 were significantly higher than those in other groups ($P<0.05$), and the octadecenoic acid content in pork from BV10 and BV15 was higher than that in CON ($P<0.05$). In conclusion, bamboo vinegar powder can improve meat quality, enhance pork flavor and nutritional value in finishing pigs, with effects superior to antibiotics, and the recommended supplementation level is 1.0%.

Full Text

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Abstract

This study investigated the effects of bamboo vinegar powder (BVP) on meat quality and flavor in finishing pigs. Forty finishing pigs with similar body weight were randomly allocated to five groups, each consisting of four replicates with two pigs per replicate. The groups were: control (CON) fed a basal diet; antibiotic group (ANT) fed basal diet + 0.12% compound antibiotics; and three BVP groups fed basal diet supplemented with 0.5% (BV5), 1.0% (BV10), or 1.5% (BV15) bamboo vinegar powder. The experimental period lasted 60 days. The results demonstrated: (1) BV5 and BV10 groups exhibited significantly higher meat redness values compared to CON and ANT ($P<0.05$), while BV10 and BV15 groups showed significantly lower shear force values than CON ($P<0.05$). All BVP groups had significantly lower shear force values than ANT ($P<0.05$). (2) BV10 and BV15 groups displayed significantly higher aspartic acid and flavor amino acid contents in meat compared to CON and ANT ($P<0.05$), and all BVP groups showed significantly elevated glutamic acid content relative to CON and ANT ($P<0.05$). (3) BV5 and BV10 groups had significantly higher inosinic acid content in meat than CON and ANT ($P<0.05$), with BV15 also exceeding ANT significantly ($P<0.05$). (4) BV10 showed significantly higher palmitic acid content, while BV5 exhibited significantly higher palmitoleic acid content compared to all other groups ($P<0.05$). Additionally, BV10 and BV15 groups had significantly higher stearyl acid content than CON ($P<0.05$). In conclusion, bamboo vinegar powder improved meat quality, enhanced pork flavor, and increased nutritional value more effectively than antibiotics, with an optimal supplementation level of 1.0%.

Keywords: bamboo vinegar powder; antibiotics; pigs; meat quality; flavor amino acids; fatty acids

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Bamboo vinegar is rich in acids and phenolic compounds, exhibiting strong antibacterial, bactericidal, and antiviral properties while promoting growth, enhancing immunity, and improving antioxidant function. Previous research demonstrated that dietary bamboo vinegar powder supplementation reduced diarrhea rates and feed conversion ratios in finishing pigs, suggesting its potential

as an antibiotic alternative. Bamboo vinegar powder also positively influences meat quality. Phenolic compounds have shown antimicrobial activity and can serve as clarifying agents in beverages and alcoholic products, or as food preservatives and antioxidants that effectively slow post-harvest biochemical activities in fruits and vegetables while improving flavor and color. Kook et al. reported that dietary bamboo vinegar liquid supplementation increased yellowness and redness in porcine longissimus dorsi muscle. Yan et al. found that 0.2% bamboo vinegar supplementation significantly improved meat color and firmness in finishing pigs, likely due to phenolic compounds reacting with lipids and hydroxyl radicals to form stable products. Jang et al. confirmed that phenolic compound supplementation in broiler diets elevated total phenol content in breast muscle. However, no studies have yet reported the effects of bamboo vinegar powder on amino acid and fatty acid profiles in finishing pig meat.

Building upon our previous research demonstrating that dietary bamboo vinegar powder regulates growth performance, intestinal health, and immunity in finishing pigs, this study further investigated its effects on meat quality and muscle nutrient composition to provide a theoretical foundation for developing new non-polluting feed additives.

1.1 Experimental Design

Forty finishing pigs with an initial body weight of 75$±$4 kg were randomly divided into five groups, with four replicates per group and two pigs per replicate. Each pig was individually weighed and recorded. The five treatment groups were: control group (CON) fed a basal diet; antibiotic group (ANT) fed basal diet + 0.12% compound antibiotics; BV5 group fed basal diet + 0.5% bamboo vinegar powder; BV10 group fed basal diet + 1.0% bamboo vinegar powder; and BV15 group fed basal diet + 1.5% bamboo vinegar powder. The basal diet was formulated according to NRC (2012) standards, with composition and nutrient levels shown in . Pigs were fed twice daily at 06:00 and 18:00, with feed intake recorded throughout the 60-day experimental period, which included a 7-day pretrial adaptation phase. All experimental pigs were housed in the same barn, with replicates separated into identical pens under consistent management conditions. No immunizations were administered during the trial, and no mortality occurred. Feed was restricted one day before the trial ended, and all pigs were weighed and slaughtered on the final day. Longissimus dorsi muscle samples were collected for meat quality analysis.

1.2 Experimental Materials

The bamboo vinegar powder used in this study was produced by Jiangyin Zhongli Biotechnology Co., Ltd. through a dextrin spraying process. The production flow involved low-temperature spray drying of refined bamboo vinegar liquid with edible dextrin to produce the powder. The main components of bamboo vinegar powder included ethanol (14.53%), acetic acid (23.08%), acetol (7.86%), phenol (3.64%), 2,6-dimethoxyphenol (3.82%), and butyrolactone

(1.81%), with detailed parameters reported previously by our research team. The compound antibiotic consisted of 10% bacitracin zinc, 10% colistin, 10% roxarsone, and 70% carrier.

1.3 Detection Indicators

One day before the trial concluded, pigs were fasted for 24 hours, then weighed (pre-slaughter live weight) and slaughtered. After bleeding, scalding, and dehairing, carcasses were divided and longissimus dorsi muscles were collected. Surface blood was blotted dry, and meat samples were stored in self-sealing bags with proper labeling for subsequent meat quality and nutrient composition analyses.

1.3.1 Meat Quality Determination Meat color (lightness, redness, and yellowness), pH, shear force, and water loss rate of longissimus dorsi muscle were measured at slaughter using methods described in reference [11].

1.3.2 Muscle Nutrient Composition Inosinic acid content was determined according to reference [12]. Amino acid composition was analyzed following reference [13]. For fatty acid analysis, 1 g of frozen preserved pork was minced and hydrolyzed with 6 mL of 5 mol/L potassium hydroxide methanol solution (containing 0.1% hydroquinone as antioxidant) at 60°C for 2 hours. C21:0 at 1.5 mg/g meat was added as an internal standard before hydrolysis. After hydrolysis, distilled water was added and non-saponifiable lipids were extracted with petroleum ether and discarded. The hydrolysate was acidified with 3 mL of 10 mol/L sulfuric acid and extracted three times with 5 mL petroleum ether each time. Samples were analyzed by gas chromatography using an SGE-FFA capillary column (50 m × 250 m, 0.25 m) with nitrogen as carrier gas at 1.1 mL/min. Hydrogen and air were used as fuel gases at 40 and 450 mL/min, respectively. Split injection was employed at a 50:1 ratio, with injector temperature at 220°C and flame ionization detector (FID) at 250°C. The temperature program started at 45°C for 3 minutes, increased at 13°C/min to 175°C and held for 27 minutes, then increased at 4°C/min to 215°C and held for 5 minutes. Fatty acids were identified by comparing retention times with FAME standards and quantified using internal standard and peak area normalization methods. Total fatty acid content was expressed as mg/g fresh meat, and individual fatty acid contents were expressed as percentages of total fatty acids.

1.4 Statistical Analysis

Experimental data were compiled and processed using Excel 2003, and analysis of variance was performed using the ANOVA module of SAS 9.0. Significance level was set at $P<0.05$ and highly significant level at $P<0.01$.

2.1 Effects of Dietary Bamboo Vinegar Powder Supplementation on Meat Quality of Finishing Pigs

As shown in , dietary bamboo vinegar powder supplementation had no significant effects on meat lightness, yellowness, pH, or water loss rate ($P>0.05$). However, BV5 and BV10 groups exhibited significantly higher redness values compared to CON and ANT ($P<0.05$). BV10 and BV15 groups showed significantly lower shear force values than CON ($P<0.05$), and all BVP groups had significantly lower shear force values than ANT ($P<0.05$).

2.2 Effects of Dietary Bamboo Vinegar Powder Supplementation on Amino Acid Composition and Inosinic Acid Content in Muscle of Finishing Pigs

As presented in , BV10 and BV15 groups had significantly higher aspartic acid and flavor amino acid contents in meat compared to CON and ANT ($P<0.05$). All BVP groups showed significantly elevated glutamic acid content relative to CON and ANT ($P<0.05$). Additionally, BV10 group had significantly lower histidine content than ANT ($P<0.05$). According to , BV5 and BV10 groups exhibited significantly higher inosinic acid content in meat than CON and ANT ($P<0.05$), while BV15 also showed significantly higher inosinic acid content than ANT ($P<0.05$).

2.3 Effects of Dietary Bamboo Vinegar Powder Supplementation on Fatty Acid Composition in Muscle of Finishing Pigs

As shown in , BV10 group had significantly higher palmitic acid content than all other groups ($P<0.05$), while BV5 group exhibited significantly higher palmitoleic acid content than other groups ($P<0.05$). ANT and all BVP groups showed significantly higher stearic acid content compared to CON ($P<0.05$). BV10 and BV15 groups had significantly higher stearyl acid content than CON ($P<0.05$), and BV5 group displayed significantly higher linolelaidic acid content than CON, ANT, and BV15 ($P<0.05$).

3.1 Effects of Dietary Bamboo Vinegar Powder Supplementation on Meat Quality of Finishing Pigs

Pork eating quality represents one of the most important meat quality attributes for both consumers and producers, typically evaluated through tenderness, color, and water-holding capacity. Meat color is the most critical factor affecting pork appearance quality, as consumers generally associate bright red pork with superior quality. This study found that supplementation with 0.5% and 1.0% bamboo vinegar powder significantly increased meat redness compared to CON and ANT, indicating improved meat color. Meat tenderness reflects muscle texture, with shear force being the most common method for assessing tenderness —lower values indicate more tender meat. The results showed that 1.0% and 1.5% bamboo vinegar powder supplementation significantly reduced shear force

compared to CON, and all BVP groups had significantly lower shear force than ANT, suggesting that bamboo vinegar powder enhances pork tenderness more effectively than antibiotics. Water-holding capacity, measured as water binding capacity, affects juiciness and palatability. Although bamboo vinegar powder groups showed reduced water loss rates compared to CON and ANT, the differences were not statistically significant, indicating a potential improvement in juiciness. Yan et al. reported that 0.2% bamboo vinegar powder supplementation significantly improved meat redness and water-holding capacity, consistent with our findings. Overall, dietary bamboo vinegar powder supplementation at appropriate levels improved meat color, increased tenderness and juiciness, with 1.0% being the optimal inclusion level.

3.2 Effects of Dietary Bamboo Vinegar Powder Supplementation on Inosinic Acid Content and Amino Acid Composition in Muscle of Finishing Pigs

Amino acid content and composition in pork affect both nutritional value and meat quality. Research indicates that pork flavor is primarily determined by aspartic acid, glutamic acid, asparagine, and inosinic acid. No previous studies have reported the effects of bamboo vinegar powder or related products on pork amino acid profiles. This study found that 1.0% and 1.5% bamboo vinegar powder supplementation significantly increased aspartic acid, glutamic acid, inosinic acid, and flavor amino acid contents compared to CON and ANT, suggesting enhanced umami flavor. Additionally, 1.0% bamboo vinegar powder reduced histidine content compared to ANT. Histidine can be converted to histamine via histidine decarboxylase, participating in immune responses, so its reduction does not directly affect meat quality. In conclusion, bamboo vinegar powder supplementation enhances pork umami and flavor, with 1.0% and 1.5% being effective inclusion levels.

3.3 Effects of Dietary Bamboo Vinegar Powder Supplementation on Fatty Acid Composition in Muscle of Finishing Pigs

As a major source of meat protein for human consumption, pork fatty acid content correlates with both meat quality and human fatty acid balance. Nutritional modulation of pork fatty acid composition has attracted widespread research attention. No studies have previously reported bamboo vinegar powder effects on pork fatty acid profiles. This study demonstrated that bamboo vinegar powder supplementation significantly increased palmitic acid, palmitoleic acid, stearic acid, stearyl acid, and linolelaidic acid contents. Research shows that pork tenderness, juiciness, and flavor are associated with saturated and monounsaturated fatty acid contents. Bamboo vinegar powder supplementation increased both saturated and unsaturated fatty acid levels, suggesting improved fatty acid content. Due to experimental constraints and limited sample size, not all fatty acid types were measured, preventing calculation of saturated to unsaturated fatty acid ratios. Nevertheless, these results indicate that bamboo

vinegar powder can modulate pork fatty acid composition. Bamboo vinegar contains organic acids, phenols, ketones, aldehydes, alcohols, and esters, but which specific component regulates amino acid and fatty acid composition and the underlying mechanisms require further investigation.

Conclusions

1. Dietary bamboo vinegar powder supplementation at appropriate levels improved meat color, increased muscle tenderness and juiciness, enhanced flavor amino acid and inosinic acid contents, increased pork umami, and elevated fatty acid content in finishing pigs.
2. Bamboo vinegar powder can partially replace antibiotics for antibiotic-free pork production, with a recommended supplementation level of 1.0%.

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