Effects of Dietary Tomato Pomace Supplementation on Growth Performance, Carcass Traits, Meat Quality, and Antioxidant Capacity of Finishing Pigs: Postprint

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Abstract

The objective of this experiment was to investigate the effects of dietary tomato pomace supplementation on growth performance, carcass traits, meat quality, and antioxidant capacity in finishing pigs. A single-factor experimental design was adopted, in which 80 "Duroc × Landrace × Large White" three-way crossbred finishing gilts with an average body weight of (95.20$±$3.95) kg were randomly divided into 4 groups, with 4 replicates per group and 5 pigs per replicate. The control group was fed the basal diet, while the TOP100, TOP200, and TOP300 groups were fed the basal diet supplemented with 100 g/(head · d), 200 g/(head · d), and 300 g/(head · d) of tomato pomace, respectively. The preliminary period lasted 3 days, and the formal experimental period lasted 37 days. The results showed: 1) The average weight gain and daily weight gain in the TOP100 group were extremely significantly higher than those in the other three groups (P<0.01). 2) Compared with the control group, the carcass weight in the TOP200 group was significantly increased (P<0.05); the carcass length in the TOP100 group was significantly decreased (P<0.05); the loin eye area in the TOP100, TOP200, and TOP300 groups increased by 49.11%, 46.82%, and 71.93%, respectively (P<0.05). 3) Compared with the control group, the muscle redness value in the TOP200 group was extremely significantly increased (P<0.01), the muscle cooking loss in the TOP100 group was reduced by 15.17% (P<0.05), and the muscle centrifugal water loss rate in the TOP100 and TOP200 groups was extremely significantly decreased (P<0.01). 4) Compared with the control group, the total antioxidant capacity of liver in the TOP300 group was significantly increased (P<0.05); the malondialdehyde content in liver in the TOP200 group was significantly decreased (P<0.05); the total superoxide dismutase activity in muscle in the TOP300 group was significantly decreased (P<0.05); the malondialdehyde content in muscle in the TOP100, TOP200, and

TOP300 groups was significantly decreased (P<0.05). These results indicate that dietary supplementation with 100 g/(head · d) of tomato pomace can significantly increase the average daily weight gain and reduce the feed conversion ratio, improve carcass traits and meat quality, and enhance the antioxidant capacity of liver and muscle in finishing pigs; furthermore, the supplementation level of tomato pomace in finishing pig diets should not exceed 300 g per head per day.

Full Text

Effects of Tomato Pomace Supplementation on Growth Performance, Carcass Traits, Meat Quality and Antioxidant Capacity of Finishing Pigs

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Abstract

This study investigated the effects of dietary tomato pomace supplementation on growth performance, carcass traits, meat quality, and antioxidant capacity in finishing pigs. Using a single-factor experimental design, eighty "Duroc × Landrace × Yorkshire" crossbred finishing gilts with an average body weight of (95.20$±$3.95) kg were randomly allocated into four groups, with four replicates per group and five pigs per replicate. The control group received a basal diet, while the TOP100, TOP200, and TOP300 groups received the basal diet supplemented with 100 g/(pig·d), 200 g/(pig·d), and 300 g/(pig·d) of tomato pomace, respectively. The experiment consisted of a 3-day pre-feeding period followed by a 37-day formal feeding period. The results showed: (1) The TOP100 group exhibited significantly higher average weight gain and average daily gain compared to the other three groups (P < 0.01). (2) Compared with the control group, the TOP200 group showed significantly increased carcass weight (P < 0.05), the TOP100 group showed significantly decreased carcass length (P < 0.05), and the eye muscle area in the TOP100, TOP200, and TOP300 groups increased by 49.11%, 46.82%, and 71.93%, respectively (P < 0.05). (3) The TOP200 group demonstrated significantly elevated muscle redness (a*) values (P < 0.01), the TOP100 group exhibited a 15.17% reduction in muscle cooking loss (P < 0.05), and both the TOP100 and TOP200 groups showed significantly decreased muscle centrifugal water loss rate (P < 0.01). (4) The TOP300 group had significantly increased liver total antioxidant capacity (P < 0.05), the TOP200 group showed significantly reduced liver malondialdehyde content (P

< 0.05), the TOP300 group exhibited significantly decreased muscle total superoxide dismutase activity ($P < 0.05$), and all three tomato pomace groups displayed significantly reduced muscle malondialdehyde content ($P < 0.05$). These findings indicate that supplementation with 100 g/(pig · d) of tomato pomace can significantly improve average daily gain, reduce feed-to-gain ratio, enhance carcass traits and meat quality, and increase antioxidant capacity in liver and muscle of finishing pigs. Moreover, the daily supplementation level of tomato pomace should not exceed 300 g per pig.

Keywords: tomato pomace; growth performance; carcass traits; meat quality; antioxidant capacity

Introduction

With rising living standards and health consciousness, consumers increasingly demand higher pork quality, and the regulation of meat quality by phytonutrients in feed has become a focal point in animal nutrition research [1]. As one of Xinjiang' s characteristic agricultural products, tomato production reached approximately 8.4747 million tons in 2014, primarily for ketchup export. Tomato pomace, a byproduct of tomato processing, is rich in protein, mineral elements, and high-quality vegetable oil in tomato seeds, all of which play important roles in animal growth and development [2]. However, with a moisture content of 80%, tomato pomace is prone to acidification and mold, making it difficult to store and severely affecting its palatability and nutritional value. Effective processing of tomato pomace to prevent resource waste and environmental pollution represents an urgent challenge for researchers.

Currently, tomato pomace has limited application in food products [3] and is mainly used as animal feed. Numerous studies have reported on tomato pomace as feed: supplementation with ensiled tomato pomace in beef cattle diets can increase weight gain and reduce feeding costs [4]; feeding fermented tomato pomace can improve the antioxidant performance of Xinjiang brown cattle [5]; and feeding tomato pomace to broiler chickens can extend meat shelf life [6]. These findings demonstrate that tomato pomace is a high-quality feed ingredient, yet research on its application in pig feeding remains scarce. Therefore, this experiment investigated the effects of dietary tomato pomace supplementation on growth performance, carcass quality, meat quality, and antioxidant capacity in finishing pigs, providing scientific evidence and reference for improving pork quality and producing premium pork through dietary manipulation.

1.1 Experimental Materials

The tomato pomace used in this experiment was wet pomace provided by a ketchup factory in Hutubi County, Xinjiang. It was sun-dried to a moisture

content of less than 10% and thoroughly mixed with the basal diet before feeding.

1.2 Experimental Animals and Design

A single-factor experimental design was employed. Eighty "Duroc × Landrace × Yorkshire" crossbred finishing gilts with an average body weight of (95.20$±$3.95) kg were randomly divided into four groups (four replicates per group, five pigs per replicate) and ear-tagged. The control group received the basal diet, while the TOP100, TOP200, and TOP300 groups received the basal diet supplemented with 100 g/(pig · d), 200 g/(pig · d), and 300 g/(pig · d) of tomato pomace, respectively. The experiment included a 3-day pre-feeding period and a 37-day formal feeding period.

1.3 Basal Diet

The basal diet was a corn-soybean meal type formulated according to the NRC (2012) nutrient requirements for finishing pigs. The composition and nutrient levels of the basal diet are presented in Table 1 , and the nutrient levels of tomato pomace and diets for each group are shown in Table 2 .

1.4 Feeding Management

The experiment was conducted at the Xinjiang Tiankang Shihezi Finishing Pig Farm. All groups were maintained under consistent feeding and management conditions with ad libitum access to feed and water. Feed was provided twice daily at 10:00 and 19:00. Feed consumption was recorded daily, and manure was cleaned regularly.

1.5 Measurement Indicators

1.5.1 Growth Performance At the beginning and end of the experiment, the fasting body weight of pigs in each group was measured to calculate total weight gain. Based on total feed consumption during the trial, the average daily feed intake (ADFI), average daily gain (ADG), and feed-to-gain ratio (F/G) were calculated for each group. The feed-to-gain ratio was calculated as total feed consumption divided by total weight gain.

1.5.2 Carcass Traits After the feeding trial, six pigs with body weights close to the group average were randomly selected from each group for slaughter. Pigs were fasted for 24 hours before slaughter with free access to water, and live weight was recorded before slaughter. After exsanguination, scalding, and dehairing, the head, feet, and tail were removed before evisceration. Carcass weight was measured after removing internal organs (retaining leaf fat and kidneys). The carcass was then split vertically along the dorsal midline from tail to neck, and the left side was used to determine carcass length, backfat thickness,

loin eye area, and other carcass parameters according to the Technical Specification for Carcass Trait Measurement of Lean-type Pigs (NY/T 825-2004).

1.5.3 Meat Quality Determination **1.5.3.1 Meat Color:** At 45 minutes post-mortem, the cross-section of the longissimus dorsi muscle was placed on a colorimeter to measure lightness (L*), redness (a*), and yellowness (b*) values. Measurements were repeated three times by rotating the sample cup, and average values were recorded.

1.5.3.2 pH: At 45 minutes post-mortem, an incision was made on the longissimus dorsi muscle surface and pH_{45} was measured using a portable pH meter. pH_{24} was measured 24 hours later. Each sample was measured three times consecutively, and the average was calculated.

1.5.3.3 Cooking Loss: Approximately 50 g of longissimus dorsi muscle was weighed (W1), and connective tissue, fascia, and fat were removed. The sample was heated in a water bath at 80°C until the core temperature reached 70°C, then removed and weighed (W2) after cooling to 0–4°C. Cooking loss (%) = 100 × (W1-W2)/W1.

1.5.3.4 Centrifugal Water Loss Rate: Determined according to the method of Guo et al. [7].

1.5.3.5 Shear Force: Measured according to the Method for Determination of Meat Tenderness—Shear Force Determination (NY/T 1180-2006).

1.5.3.6 Nutrient Content: Longissimus dorsi samples were analyzed for crude protein content by the Kjeldahl method (GB 5009.5-2016), crude fat content by Soxhlet extraction (GB 5009.6-2016), dry matter content by drying at 105°C (GB 5009.3-2016), and crude ash content by burning at 550°C (GB 5009.4-2016).

1.5.4 Antioxidant Indices in Liver and Muscle Total superoxide dismutase (T-SOD) activity, glutathione (GSH) activity, malondialdehyde (MDA) content, and total antioxidant capacity (T-AOC) were determined in liver and muscle samples. Sampling and pretreatment followed the method of Chao et al. [8], and measurements were conducted according to the instructions of assay kits from Nanjing Jiancheng Bioengineering Institute.

1.6 Statistical Analysis

Experimental data were organized using Excel 2007 and analyzed using SPSS 17.0 software. One-way ANOVA was performed on the four groups, and LSD multiple comparisons were conducted between groups. Differences were considered significant at $P < 0.05$ and highly significant at $P < 0.01$.

Results

2.1 Effects of Tomato Pomace on Growth Performance of Finishing Pigs

As shown in Table 3 , the TOP300 group had significantly lower final body weight compared to the other three groups ($P < 0.01$), representing a 5.9% decrease from the control group. The TOP100 group showed significantly increased average weight gain and average daily gain compared to the control group ($P < 0.01$). All four groups exhibited similar trends in average weight gain and average daily gain, following the order: TOP100 > TOP200 > control > TOP300. The TOP100 and TOP200 groups had significantly higher average daily feed intake than the other two groups ($P < 0.01$). The TOP300 group showed significantly higher feed-to-gain ratio than the other groups ($P < 0.05$), while no significant differences were observed among the other groups ($P > 0.05$). The feed-to-gain ratio in the TOP100 group was 11.03% lower than that in the control group.

2.2 Effects of Tomato Pomace on Carcass Traits of Finishing Pigs

As presented in Table 4 , the TOP200 group showed significantly increased carcass weight compared to the control group ($P < 0.05$), while other groups showed no significant changes ($P > 0.05$). The TOP200 group also differed significantly from the other two treatment groups ($P < 0.05$). The TOP100 group exhibited significantly reduced carcass length compared to the control group ($P < 0.05$). All three tomato pomace groups demonstrated significantly larger loin eye area than the control group ($P < 0.05$), with increases of 49.11%, 46.82%, and 71.93% for TOP100, TOP200, and TOP300 groups, respectively. Hip fat thickness in the TOP300 group increased by 13.98% compared to the control group, though the difference was not significant ($P > 0.05$). Dietary tomato pomace supplementation had no significant effects on dressing percentage, shoulder fat thickness, waist fat thickness, or average backfat thickness ($P > 0.05$).

2.3 Effects of Tomato Pomace on Meat Quality of Finishing Pigs

As shown in Table 5 , the pH_{45} and pH_{24} values of muscle in the three tomato pomace groups were lower than those in the control group, though the differences were not significant ($P > 0.05$). The TOP200 group exhibited significantly higher muscle a* values ($P < 0.01$). Lightness (L*) and yellowness (b*) values increased in all three tomato pomace groups, but differences were not significant ($P > 0.05$). The TOP100 group showed significantly lower muscle cooking loss than the control group ($P < 0.05$), representing a 15.17% reduction. Both the TOP100 and TOP200 groups demonstrated significantly reduced muscle centrifugal water loss rate compared to the control group ($P < 0.01$). Muscle shear force in the TOP100 group decreased by 13.85% compared to the control group, though the difference was not significant ($P > 0.05$). The TOP200 group

showed a 22.73% reduction in muscle crude fat content compared to the control group, but the difference was not significant ($P > 0.05$). Dietary tomato pomace supplementation had no significant effects on muscle dry matter, crude protein, or crude ash content ($P > 0.05$).

2.4 Effects of Tomato Pomace on Antioxidant Indices in Liver and Muscle of Finishing Pigs

As presented in Table 6 , the TOP300 group showed significantly increased liver T-AOC compared to the control group ($P < 0.05$), while the TOP200 group exhibited significantly reduced liver MDA content ($P < 0.05$). Liver GSH content in the TOP300 group increased by 20.62% ($P > 0.05$). Liver T-SOD activity showed varying degrees of increase across groups, but differences were not significant ($P > 0.05$). Muscle T-SOD activity in the TOP300 group was significantly lower than in the other three groups ($P < 0.05$). Muscle MDA content in all three tomato pomace groups was significantly reduced compared to the control group ($P < 0.01$), though no significant differences were observed among the three treatment groups ($P > 0.05$). Muscle GSH content in the TOP200 group increased by 11.4% compared to the control group, but the difference was not significant ($P > 0.05$).

Discussion

3.1 Effects of Tomato Pomace on Growth Performance of Finishing Pigs

Previous studies by Wang et al. [9] demonstrated that dietary tomato pomace supplementation significantly improved average daily gain and feed-to-gain ratio in sheep. Chen et al. [4] reported that tomato pomace supplementation enhanced average daily gain, feed-to-gain ratio, and economic benefits in beef cattle. Huang and Dai [10] found that dietary tomato pomace increased egg production and total egg weight by 2.7% and 4.1%, respectively, in laying hens. The current study indicates that supplementation with 100 g/(pig·d) of tomato pomace significantly improved average daily gain and reduced feed-to-gain ratio in finishing pigs, with 200 g/(pig·d) showing moderate effects, while 300 g/(pig·d) showed no significant difference compared to the control group. This may be attributed to the reduced moisture content and acidity of dried tomato pomace, along with its sweet aroma that enhances palatability and increases feed intake and weight gain. However, as tomato pomace inclusion increased, feeding rate decreased, likely due to its high crude fiber content [11] causing excessive propionic acid production in the stomach and inducing satiety [12], thereby reducing feed intake. Therefore, appropriate supplementation levels are crucial. Further detailed investigation is needed to determine the optimal inclusion level between 100 and 200 g/(pig·d) for practical application in finishing pig diets.

3.2 Effects of Tomato Pomace on Carcass Traits of Finishing Pigs

The present results show that 100 g/(pig · d) tomato pomace significantly reduced carcass length, while the TOP300 group increased dressing percentage and carcass weight by 3.01% and 7.62%, respectively, compared to the control group. These findings suggest that tomato pomace may have some beneficial effects on carcass traits, though the improvements were not substantial, indicating that tomato pomace metabolites do not adversely affect pig growth. Currently, no studies have reported on the effects of tomato pomace on pig carcass traits, though research on other residue feeds is available. Ou et al. [13] demonstrated that 6% cassava residue supplementation had non-significant effects on carcass weight, meat percentage, meat-to-bone ratio, and backfat thickness in Longlin black pigs. Zhang et al. [14] found that fermented peanut hulls had no significant effects on carcass weight, dressing percentage, backfat thickness, or loin eye area in finishing pigs. These results may be explained by the minimal impact of dietary factors on animal body composition and edible portion proportions. Numerous factors influence pig carcass traits, including breed, sex, age, and nutrition level, and due to the high heritability of carcass traits, nutritional level has relatively limited influence [15], which is consistent with our findings.

3.3 Effects of Tomato Pomace on Meat Quality of Finishing Pigs

Muscle pH is a key indicator for evaluating meat quality [16]. Post-mortem anaerobic glycolysis of muscle glycogen and fat produces large amounts of lactic acid, causing pH decline and pale meat color [17]. The current results show that muscle pH values at 45 minutes and 24 hours post-mortem decreased in all groups, with the decline being slower in tomato pomace groups, consistent with previous findings. This slower decline may be attributed to lycopene, a potent antioxidant in tomato pomace that enhances immunity, protects phagocytes from oxidative damage, and clears metabolic products such as lactic acid [18]. Yang et al. [19] reported that mulberry powder could slow post-mortem pH decline in finishing pigs. The lack of significant differences compared to the control group may be due to excessive pre-slaughter transport stress or suboptimal absorption and utilization of lycopene in vivo.

Muscle a* values increased then decreased with tomato pomace supplementation, with the TOP200 group showing a highly significant increase. Lightness (L*) and yellowness (b*) values in tomato pomace groups decreased then increased, but differences were not significant compared to the control group. Tomato pomace contains abundant lutein from lycopene [20], which intensifies red coloration when absorbed by pigs, similar to findings in laying hens [10] and Ba Mei sheep [18]. Centrifugal water loss rate, cooking loss, and shear force are indicators of meat tenderness. Supplementation with 100 and 200 g/(pig · d) tomato pomace significantly reduced muscle centrifugal water loss rate. Shear force decreased then increased with tomato pomace inclusion, indicating that tomato pomace can significantly improve pork tenderness, though nutrient absorption may reach a threshold level. The lack of significant effect on cooking loss may

be due to antioxidants having minimal impact on post-mortem muscle maturation [21]. The 22.73% reduction in muscle crude fat content in the TOP200 group is consistent with Lan et al. [22], suggesting that bioactive components in tomato pomace may reduce triglyceride content without significantly affecting crude protein or ash content. These results demonstrate that 100–200 g/(pig · d) tomato pomace supplementation can improve meat quality in finishing pigs.

3.4 Effects of Tomato Pomace on Antioxidant Capacity of Finishing Pigs

Post-mortem muscle oxidation rate and extent depend on the animal' s antioxidant capacity. T-AOC, T-SOD, GSH, and MDA are indicators that directly or indirectly reflect antioxidant system function during free radical metabolism [23]. In this study, T-SOD activity, T-AOC, and GSH content increased while MDA content decreased in both liver and muscle. Since antioxidant enzymes gradually denature and lose activity after slaughter, non-enzymatic antioxidants play a more important role in preventing muscle oxidation [21]. Tomato pomace is rich in lycopene, which participates in antioxidant processes and regulates endogenous antioxidant enzyme activities [24], exhibiting strong reducing power and free radical scavenging capacity [25]. Research has shown that dietary lycopene enhances antioxidant capacity and immune function in mice [26] and increases antioxidant content in sheep longissimus dorsi muscle, thereby delaying meat color changes [18]. These findings align with our results. The non-significant increases in T-SOD activity, T-AOC, and GSH content may be due to metabolic transformation and loss of antioxidants during deposition in muscle and liver. Overall, dietary tomato pomace supplementation can enhance antioxidant capacity in liver and muscle of finishing pigs.

Conclusion

Dietary supplementation with 100 g/(pig · d) tomato pomace can significantly improve average daily gain, reduce feed-to-gain ratio, enhance carcass traits and meat quality, and increase antioxidant capacity in liver and muscle of finishing pigs. The daily supplementation level of tomato pomace should not exceed 300 g per pig.

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