Effects of Tea Tree Oil on Growth Performance, Organ Indices, Carcass Traits, and Meat Quality in Finishing Pigs: Postprint

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Abstract

This experiment aimed to investigate the effects of dietary tea tree oil supplementation on growth performance, organ indices, carcass traits, and meat quality of finishing pigs. Sixty-four healthy Duroc × Landrace × Yorkshire crossbred growing-finishing pigs with an initial body weight of (68.13$±$0.46) kg were selected and randomly divided into 4 groups, with 4 replicates per group and 4 pigs per replicate (half barrows and half gilts). The control group was fed a basal diet, while the experimental groups were fed test diets supplemented with 100, 200, and 300 mg/kg tea tree oil in the basal diet, respectively, with a 10-day preliminary period and a 56-day formal experimental period. The results showed: 1) Compared with the control group, the 200 and 300 mg/kg groups had significantly increased final body weight and average daily gain (P<0.05), while the 100 and 200 mg/kg groups had significantly decreased feed-to-gain ratio (P<0.05); 2) Compared with the control group, the 200 and 300 mg/kg groups had significantly increased liver index (P<0.05), and the 300 mg/kg group had significantly increased kidney index (P<0.05); 3) Compared with the control group, the 200 mg/kg group had significantly increased redness value and pH at 24 h of the longissimus dorsi muscle (P<0.05), while the 100 and 200 mg/kg groups had significantly decreased shear force (P<0.05) and significantly increased intramuscular fat content (P<0.05) of the longissimus dorsi muscle. These results indicate that dietary supplementation with different doses of tea tree oil had varying degrees of effects on growth performance, organ indices, and meat quality of finishing pigs, among which supplementation with 200 mg/kg tea tree oil in the basal diet showed better improvement effects on growth performance and meat quality.

Full Text

Effects of Tea Tree Oil on Growth Performance, Organ Indexes, Carcass Characteristics and Meat Quality of Finishing Pigs

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Abstract: This study aimed to investigate the effects of dietary tea tree oil supplementation on growth performance, organ indexes, carcass characteristics, and meat quality of finishing pigs. Sixty-four healthy "Duroc × Landrace × Yorkshire" crossbred finishing pigs with an initial body weight of (68.13$±$0.46) kg were randomly allocated to four groups, each consisting of four replicates with four pigs per replicate (half barrows and half gilts). The control group was fed a basal diet, while the experimental groups were fed the basal diet supplemented with 100, 200, or 300 mg/kg tea tree oil. The experiment included a 10-day adaptation period followed by a 56-day formal feeding period. The results showed that: (1) compared with the control group, the final body weight and average daily gain were significantly increased in the 200 and 300 mg/kg groups ($P<0.05$), while the feed-to-gain ratio was significantly decreased in the 100 and 200 mg/kg groups ($P<0.05$); (2) the liver index was significantly higher in the 200 and 300 mg/kg groups compared to the control group ($P<0.05$), and the kidney index was significantly increased in the 300 mg/kg group ($P<0.05$); (3) the redness value and pH at 24 h postmortem of the longissimus dorsi muscle were significantly increased in the 200 mg/kg group ($P<0.05$), while the shear force was significantly decreased and intramuscular fat content was significantly increased in both the 100 and 200 mg/kg groups ($P<0.05$). These findings indicate that dietary supplementation with different levels of tea tree oil exerts varying effects on growth performance, organ indexes, and meat quality of finishing pigs, with 200 mg/kg being the optimal supplementation level for improving growth performance and meat quality.

Keywords: tea tree oil; finishing pigs; growth performance; organ indexes; meat quality

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Introduction

Essential oils (EO) are aromatic, volatile, oily liquids extracted from flowers, stems, leaves, roots, or fruits of plants through steam distillation [1]. Research has demonstrated that essential oils can promote animal growth, improve feed conversion efficiency, and enhance immune function [2-3]. Tea tree oil (TTO),

as a plant-derived feed additive, is a colorless to pale yellow, light oily liquid obtained from the fresh branches and leaves of *Melaleuca alternifolia*, a small tree belonging to the Myrtaceae family [4]. Tea tree oil possesses antifungal, preservative, antioxidant, antidiarrheal, and growth-promoting properties, making it one of the most effective natural antimicrobial agents discovered to date [5-8]. Nogueria et al. [9] found that terpinen-4-ol, the main component of tea tree oil, can enhance immune function, while both terpinen-4-ol and α-terpineol exhibit anti-inflammatory and antibacterial activities. Ding et al. [10] reported that dietary supplementation with 150 mg/kg tea tree oil significantly improved the condition factor and weight gain rate of tilapia, thereby promoting their growth. Although tea tree oil has been widely applied internationally in medical, food, cosmetic, and chemical industries due to its high economic value, its utilization in China remains limited, with applications primarily confined to daily chemical products. Moreover, the use of tea tree oil as a plant-derived feed additive in animal husbandry has rarely been reported. Therefore, this experiment was conducted to investigate the effects of tea tree oil supplementation in finishing pig diets on growth performance, organ indexes, carcass characteristics, and meat quality, providing scientific evidence for its application in pig production.

Materials and Methods

1.1 Experimental Material The tea tree oil used in this experiment was provided by Wuxi Chenfang Biotechnology Co., Ltd., with the following main specifications: terpinen-4-ol >60%, *p*-cymene 5%-10%, eucalyptol 2%-10%, α-terpineol >3%, α-terpinene <10%, and α-pinene <0.5%.

1.2 Experimental Design and Diets A total of 64 healthy "Duroc × Landrace × Yorkshire" crossbred finishing pigs with an initial body weight of (68.13$±$0.46) kg were used in a single-factor experimental design. The pigs were randomly divided into four groups, each comprising four replicates with four pigs per replicate (half barrows and half gilts), with no significant differences in initial body weight among groups (P>0.05). The control group was fed a basal diet formulated as a powdered complete feed according to the nutrient requirements for finishing pigs specified in NRC (1998). The composition and nutrient levels of the basal diet are presented in Table 1 . The experimental groups were fed the basal diet supplemented with 100, 200, or 300 mg/kg tea tree oil.

1.3 Feeding Management and Slaughter The experiment was conducted at Taicang Jinzhu Pig Farm. The pig house was thoroughly disinfected before the trial. During the experiment, pigs were allowed ad libitum access to feed, which was provided twice daily at 07:00 and 16:30 in amounts that ensured slight residual feed in the trough. All groups were maintained under identical feeding and management conditions. Daily feed intake was recorded, and pigs had free access to water. Ear tags were applied during the trial. The experiment consisted of a 10-day adaptation period followed by a 56-day formal feeding period.

At the end of the feeding trial, three replicates were randomly selected from each group, and two pigs were randomly chosen from each replicate, totaling 24 pigs, which were slaughtered after a 24-hour fasting period (with free access to water).

1.4 Measurement Indicators 1.4.1 Growth Performance

Pigs were weighed after a 24-hour fasting period (with free access to water) on days 1 and 56 of the experiment. Feed consumption was recorded by replicate to calculate average daily gain (ADG), average daily feed intake (ADFI), and feed-to-gain ratio (F/G).

1.4.2 Organ Indexes

At the end of the experiment, three replicates were randomly selected from each group, and two pigs were randomly chosen from each replicate, totaling 24 pigs. After recording live weight, the pigs were slaughtered and dissected to remove the heart, liver, spleen, lungs, kidneys, and pancreas. The organs were weighed after surface blood was absorbed with filter paper. Organ indexes were calculated using the following formula:

Organ index (g/kg) = organ weight (g) / live body weight (kg).

1.4.3 Meat Quality Indicators

After slaughter, meat color was measured within 45 minutes according to the methods described in *Swine Production Science*. Portions of the longissimus dorsi muscle were collected and stored at 4 °C for determination of pH at 24 h postmortem (pH_{24}), drip loss (at 24 and 48 h), shear force, water loss rate, and cooking loss. Additional muscle samples were stored at -20 °C for intramuscular fat content measurement. The pH_{24} was measured using a portable pH meter (OPTP-STAR, Meetest, Germany). Meat color was evaluated using a colorimeter (CR-300, Minolta, Japan) to determine lightness (L*), redness (a*)*, and yellowness (b*) values. Shear force was measured using a C-LM-3B digital muscle tenderness meter (College of Engineering, Northeast Agricultural University). Drip loss was determined according to the method specified in NY/T 821-2004 section 6.3.1.1, water loss rate according to NY/T 821-2004 section 6.3.1.2, and intramuscular fat content according to the method in GB/T 5009.6-2003.

1.5 Data Processing and Statistical Analysis Experimental data were organized using Excel 2010 and analyzed using SPSS 22.0 statistical software. Linear and quadratic regression analyses were performed for ADG and F/G. Growth performance, organ indexes, and meat quality indicators were analyzed using one-way ANOVA, followed by LSD multiple comparisons. Results are expressed as means ± standard error, with $P<0.05$ considered statistically significant.

Results

2.1 Effects of Tea Tree Oil on Growth Performance of Finishing Pigs As shown in Table 2 , no significant differences were observed in initial body weight among groups (P>0.05), and ADFI did not differ significantly between the experimental and control groups (P>0.05). The final body weight of pigs in the 200 and 300 mg/kg groups increased by 4.83% and 4.61%, respectively, compared with the control group (P<0.05). The ADG in both the 200 and 300 mg/kg groups increased by 11.24% compared with the control group (P<0.05). The F/G in the 100 and 200 mg/kg groups decreased by 9.52% and 8.12%, respectively, compared with the control group (P<0.05). Figure 1 [Figure 1: see original paper] presents the quadratic regression curve between tea tree oil supplementation level (x) and ADG (y), with the regression equation $y = 830.171 + 0.88x - 0.002x^2$ ($R^2 = 0.412$, $P = 0.032$), indicating a significant correlation ($P = 0.032 < 0.05$). Figure 2 [Figure 2: see original paper] shows the regression curve between tea tree oil supplementation level (x) and F/G (y), with the equation $y = 3.553 - 0.004x + 9.375 \times 10^{-6}x^2$ ($R^2 = 0.533$, $P = 0.007$), demonstrating a highly significant correlation ($P = 0.007 < 0.01$). The quadratic regression analysis revealed that both ADG and F/G exhibited quadratic responses to increasing tea tree oil levels, with ADG showing an initial increase followed by a decrease and peaking at 200 mg/kg, while F/G showed an initial decrease followed by an increase, reaching its minimum at 200 mg/kg.

2.2 Effects of Tea Tree Oil on Organ Indexes of Finishing Pigs As presented in Table 3 , no significant differences were observed among groups in heart, spleen, lung, or pancreas indexes (P>0.05). However, the liver index in the 200 and 300 mg/kg groups increased by 12.69% and 23.85%, respectively, compared with the control group (P<0.05). The kidney index in the 300 mg/kg group increased by 17.5% compared with the control group (P<0.05).

2.3 Effects of Tea Tree Oil on Carcass Characteristics and Meat Quality of Finishing Pigs As shown in Table 4 , no significant differences were detected among groups in carcass straight length, carcass oblique length, loin eye area, water loss rate, lightness value, yellowness value, or drip loss (at 24 and 48 h) of the longissimus dorsi muscle (P>0.05). Compared with the control group, the redness value of the longissimus dorsi muscle in the 200 mg/kg group increased by 25.95% (P<0.05), and pH_{24} increased by 1.56% (P<0.05). The shear force of the longissimus dorsi muscle in the 100 and 200 mg/kg groups decreased by 13.12% and 11.35%, respectively (P<0.05). Cooking loss in the 100 and 300 mg/kg groups decreased by 14.56% and 5.36%, respectively, compared with the control group (P<0.05). The intramuscular fat content of the longissimus dorsi muscle in the 100 and 200 mg/kg groups increased by 14.29% compared with the control group (P<0.05).

Discussion

3.1 Effects of Tea Tree Oil on Growth Performance of Finishing Pigs Essential oils are natural aromatic volatile oils extracted from plants. When added to feed, they can selectively inhibit bacteria, reduce nutrient loss, stimulate feed intake, improve intestinal microecological balance, and enhance digestive enzyme activity in livestock, thereby facilitating nutrient absorption and promoting animal growth [11-12]. Zhou [13] reported that dietary essential oil supplementation in pig production can increase final body weight by 10% and improve feed conversion efficiency by 3%. Wang et al. [14] found that essential oils improved feed intake in finishing pigs, with ADG significantly increasing at supplementation levels of 200–300 mg/kg and an optimal level of 200 mg/kg. Li et al. [15] observed that plant extract supplementation significantly increased ADG and decreased F/G in growing pigs. In the present study, the final body weight of finishing pigs in the 200 and 300 mg/kg groups significantly increased by 4.82% and 4.61%, respectively, and ADG increased by 11.24% compared with the control group, consistent with previous findings. Zhou et al. [16] reported that a compound meat quality improver composed of tea polyphenols and oregano oil at 450 mg/kg significantly improved feed utilization in growing-finishing pigs. Similarly, our results showed that F/G was significantly reduced in the 100 and 200 mg/kg groups, indicating improved feed utilization, which aligns with the findings of Zhou et al. [16].

3.2 Effects of Tea Tree Oil on Organ Indexes of Finishing Pigs Organ indexes are biological indicators that reflect the functional status of an organism and hold significant theoretical and practical importance [17]. The liver is a vital metabolic organ and the largest digestive gland in the digestive system [18], playing crucial roles in oxidation, glycogen storage, synthesis and secretion of proteins, and biotransformation of non-nutritive substances for excretion, thereby providing defense and detoxification functions. In this study, the liver index was significantly higher in the 200 and 300 mg/kg groups compared with the control group, suggesting that tea tree oil promotes liver development and supports healthier animal growth. The kidney is another essential metabolic organ that excretes metabolic waste and harmful substances, maintains water balance through urine production, promotes erythropoiesis, and regulates electrolyte and acid-base balance, playing a critical role in maintaining internal homeostasis [19]. The kidney index was significantly increased in the 300 mg/kg group, with the 100 and 200 mg/kg groups also showing numerical improvements, indicating that dietary tea tree oil supplementation positively influences kidney growth and helps maintain internal environmental stability.

3.3 Effects of Tea Tree Oil on Meat Quality of Finishing Pigs Meat quality is commonly evaluated using indicators such as meat color, pH, intramuscular fat, tenderness, water loss rate, drip loss, cooking loss, and intramuscular fat content, which collectively reflect sensory properties and palatability and influence consumer preferences. Muscle pH directly indicates muscle acidity and

serves as an important indicator of glycolytic rate and meat quality [20]. Post-slaughter, muscle glycogen and fat undergo anaerobic glycolysis, producing large amounts of lactic acid that accumulate and reduce muscle pH until glycolytic enzyme activity is inhibited [21]. The normal pH range at 24 h postmortem is 5.6–6.0; values above 6.0 with dark, dry meat indicate dark, firm, dry (DFD) meat [22]. Conversely, excessively rapid pH decline can cause water loss, protein denaturation, and pale meat color, reducing nutritional value. Therefore, slowing pH decline is beneficial for improving pork quality and flavor. As shown in Table 4, all groups exhibited pH_{24} values within the normal range (5.6–6.0), with the 200 mg/kg group showing a significant increase compared with the control group. Meat color is primarily determined by myoglobin and hemoglobin contents, which are influenced by multiple factors, resulting in color variations from gray-white to dark red [23]. Zhang et al. [24] reported that plant-derived feed additives can improve pork quality by delaying pH decline and increasing redness values. In this study, the redness value was significantly increased in the 100 and 200 mg/kg groups, while lightness and yellowness values showed no significant differences. Gao et al. [25] noted that meat color is related to muscle pH, with higher pH associated with greater redness values, which is consistent with our findings. Water-holding capacity, indicated by drip loss and water loss rate, is a crucial sensory quality parameter that directly affects meat color, aroma, flavor, nutritional content, juiciness, and tenderness [22]. Although no significant differences were observed in drip loss (24 and 48 h) or water loss rate among groups, numerical reductions were evident in all treatment groups. Muscle tenderness, which reflects meat texture and is primarily determined by protein structure characteristics [26], is inversely correlated with shear force. Wang et al. [27] reported that drip loss is correlated with shear force, with lower drip loss associated with lower shear force. Our results showed that shear force was significantly reduced in the 100 and 200 mg/kg groups, indicating improved tenderness, which aligns with Wang et al. [27]. Fat deposition in finishing animals occurs through increased adipocyte volume and weight [28]. The optimal intramuscular fat content is 2.5%–3.0%; levels below 2.5% result in poor flavor and sensory quality, while levels above 3.0% do not further improve palatability [29]. In this study, intramuscular fat content was significantly increased in the 100 and 200 mg/kg groups, enhancing meat flavor and texture. Increased intramuscular fat also indicates greater fat deposition in muscle adipocytes and better nutritional status [30]. Research on tea tree oil effects on pork quality remains limited, and the underlying mechanisms require further investigation.

Conclusions

Based on the results of this study, the following conclusions can be drawn:

1. Dietary supplementation with 200 and 300 mg/kg tea tree oil significantly increased final body weight and average daily gain, while supplementation with 100 and 200 mg/kg significantly reduced the feed-to-gain ratio in finishing pigs.

2. Dietary supplementation with 200 and 300 mg/kg tea tree oil significantly increased the liver index, and 300 mg/kg supplementation significantly increased the kidney index of finishing pigs.

3. Dietary supplementation with 200 mg/kg tea tree oil significantly increased the redness value, pH_{24} , and intramuscular fat content, while significantly decreasing the shear force of longissimus dorsi muscle in finishing pigs.

4. Based on these results, the optimal dietary supplementation level of tea tree oil for finishing pigs is 200 mg/kg.

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