Effects of Safflower Oil on Growth Performance, Lipid Metabolism Indices, and Fatty Acid Composition in Longissimus Dorsi Muscle of Finishing Pigs (Postprint)

Authors: Han Yuxin, Bian Lianquan, Liu Xianjun, Chen Jing, Chao Du

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Abstract

This study aimed to investigate the effects of dietary safflower oil supplementation on growth performance, lipid metabolism indices, and fatty acid composition in the longissimus dorsi muscle of finishing pigs. A single-factor completely randomized design was utilized, with 60 "Duroc × Landrace × Large White" crossbred finishing pigs (average body weight: (60.00±6.00) kg) randomly assigned to 4 groups, each comprising 3 replicates of 5 pigs. The four groups were fed experimental diets containing 1.20% soybean oil (control), 0.80% soybean oil + 0.40% safflower oil (0.40% safflower oil group), 0.40% soybean oil + 0.80% safflower oil (0.80% safflower oil group), and 1.20% safflower oil (1.20% safflower oil group), respectively. The trial lasted 70 days. The results indicated: 1) Compared with the control, safflower oil supplementation groups tended to have higher average daily gain and lower average daily feed intake and feed conversion ratio, but these differences were not significant ($P>0.05$). 2) Compared with the control, total cholesterol (TC) content in the longissimus dorsi muscle was significantly reduced in the 0.80% and 1.20% safflower oil groups ($P<0.05$); low-density lipoprotein (LDL) content in the longissimus dorsi muscle was highly significantly reduced in the 0.80% safflower oil group ($P<0.01$). 3) Compared with the control, contents of palmitic acid, linoleic acid, arachidonic acid, linolenic acid, and essential fatty acids in the longissimus dorsi muscle tended to increase in safflower oil supplementation groups, though differences were not significant ($P>0.05$). In conclusion, dietary safflower oil supplementation can improve growth performance, promote lipid metabolism, and elevate unsaturated fatty acid content in muscle of finishing pigs.

Full Text

Effects of Safflower Oil on Growth Performance, Lipid Metabolism Indices, and Fatty Acid Composition of Longissimus dorsi in Finishing Pigs

Han Yuxin, Bian Lianquan, Liu Xianjun*, Chen Jing, Du Chao
College of Animal Science and Veterinary Medicine, Shenyang Agricultural University, Shenyang 110866, China

Abstract: This experiment was conducted to investigate the effects of dietary safflower oil supplementation on growth performance and lipid metabolism indices and fatty acid composition of longissimus dorsi in finishing pigs. Using a single-factor completely randomized design, sixty "Duroc × Landrace × Yorkshire" crossbred finishing pigs with an average body weight of (60.00±6.00) kg were randomly allocated to 4 groups, with 3 replicates per group and 5 pigs per replicate. The four groups were fed experimental diets containing 1.20% soybean oil (control group), 0.80% soybean oil + 0.40% safflower oil (0.40% safflower oil group), 0.40% soybean oil + 0.80% safflower oil (0.80% safflower oil group), and 1.20% safflower oil (1.20% safflower oil group), respectively. The experimental period lasted 70 days. The results showed that: 1) Compared with the control group, the average daily gain of finishing pigs in all safflower oil supplementation groups showed an increasing trend, while average daily feed intake and feed-to-gain ratio showed decreasing trends, though none of these differences were statistically significant ($P>0.05$). 2) Compared with the control group, the total cholesterol (TC) content in longissimus dorsi of finishing pigs in the 0.80% and 1.20% safflower oil groups was significantly decreased ($P<0.05$), and the low-density lipoprotein (LDL) content in longissimus dorsi of the 0.80% safflower oil group was extremely significantly decreased ($P<0.01$). 3) Compared with the control group, the contents of palmitic acid, linoleic acid, arachidonic acid, linolenic acid, and essential fatty acids in longissimus dorsi of finishing pigs in all safflower oil supplementation groups showed increasing trends, but the differences were not significant ($P>0.05$). In conclusion, dietary safflower oil supplementation can improve the growth performance and lipid metabolism of finishing pigs and increase the content of unsaturated fatty acids in muscle.

Keywords: finishing pigs; safflower oil; growth performance; lipid metabolism; fatty acid composition

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Introduction

Lipids are indispensable components in livestock and poultry diets. The addition of oils to diets has a history of over 50 years abroad, and successful experiences have also been accumulated in China in recent years. Oils have high utilization efficiency and low heat increment, which can reduce the heat

burden on animals, improve diet appearance and palatability, increase dietary energy levels, and promote animal growth after supplementation [1].

Safflower oil, also known as safflower seed oil, is a functional healthy oil extracted from safflower seeds [2-3]. It belongs to the category of drying oils, appears yellow in color, and contains various fatty acids such as oleic acid, palmitic acid, stearic acid, linolenic acid, and linoleic acid, as well as nutrients like vitamin E and flavonoids [4]. Safflower oil is rich in unsaturated fatty acids and is classified as a polyunsaturated fatty acid (PUFA) oil, playing important roles in preventing obesity, anti-aging, reducing blood lipids, preventing cardiovascular and cerebrovascular diseases, and healthcare [5-6].

Saturated and unsaturated fatty acids in pig diets can be directly absorbed through the digestive tract and used for body fat synthesis. The content of unsaturated fatty acids in carcass varies significantly depending on the type of fat added to the diet, providing the possibility of producing pork products rich in unsaturated fatty acids through dietary regulation of carcass fatty acid composition [7]. This experiment investigated the effects of adding different levels of safflower oil to finishing pig diets on growth performance and lipid metabolism indices and fatty acid composition of longissimus dorsi, providing a basis for further research on producing meat products rich in unsaturated fatty acids.

1.1 Experimental Design and Animals

This experiment adopted a single-factor randomized design. Sixty "Duroc × Landrace × Yorkshire" crossbred finishing pigs with an average body weight of (60.00±6.00) kg were randomly divided into 4 groups, with 3 replicates per group and 5 pigs per replicate. The four groups were fed diets containing 1.20% soybean oil (control group), 0.80% soybean oil + 0.40% safflower oil (0.40% safflower oil group), 0.40% soybean oil + 0.80% safflower oil (0.80% safflower oil group), and 1.20% safflower oil (1.20% safflower oil group), respectively.

1.2 Feeding Management and Experimental Diets

The experiment was conducted at the pig farm of Liaoning Guomei Agriculture and Animal Husbandry Group Green Breeding Co., Ltd. Pigs were raised on solid floors with natural ventilation and provided ad libitum access to feed and water. Immunization and deworming procedures followed the routine practices of the farm. Experimental diets were formulated according to NRC (1998) and the "Feeding Standard of Swine," combined with production practices. The composition and nutrient levels of experimental diets are shown in Table 1 . The experimental period lasted 70 days. After the feeding trial, one pig with similar body weight was randomly selected from each replicate, slaughtered after 12 hours of fasting (with free access to water), and samples of longissimus dorsi between the 6th and 7th ribs were collected, freeze-dried, and stored at -20°C for later analysis.

1.3 Experimental Materials

The safflower oil used in this experiment was provided by COFCO Xinjiang Tayuan Safflower Co., Ltd., and the soybean oil was provided by Yihai Kerry Food Co., Ltd. The fatty acid composition of lipid sources and diets is shown in Table 2 .

1.4.1 Growth Performance

During the experiment, daily feed intake of each pig was accurately recorded. Body weight of each pig was measured after fasting at the beginning and end of the experiment to calculate average daily feed intake (ADFI), average daily gain (ADG), and feed-to-gain ratio (F/G) using the following formulas:

Average daily gain = (average final body weight - average initial body weight) / number of experimental days;
Average daily feed intake = total feed intake per group / (number of experimental days × number of pigs per group);
Feed-to-gain ratio = average daily feed intake / average daily gain.

1.4.2 Lipid Metabolism Indices of Longissimus dorsi

Longissimus dorsi muscle samples were collected, and the contents of total cholesterol (TC), high-density lipoprotein (HDL), low-density lipoprotein (LDL), and very low-density lipoprotein (VLDL) were determined by enzyme-linked immunosorbent assay (ELISA).

1.4.3 Fatty Acid Composition of Longissimus dorsi

Approximately 5 g of longissimus dorsi muscle sample was taken, crushed, and dried. The sample was placed in a 10 mL test tube, and 2 mL of benzene-petroleum ether mixture (1:1) was added and gently shaken to dissolve the lipid. Then 2 mL of 0.4 mol/L KOH-methanol solution was added, shaken well, and left to stand for 15 minutes. Distilled water was slowly added along the tube wall to fill the tube, and after the solution became clear, the supernatant was taken for fatty acid composition analysis using an Agilent GC-7890A gas chromatograph.

1.5 Statistical Analysis

Experimental data were expressed as "mean ± standard deviation." Data were initially processed using Excel 2007 software, and then one-way ANOVA and Duncan' s multiple range test were performed using SPSS 17.0 statistical software. Differences were considered significant at $P<0.05$.

2.1 Effects of Safflower Oil on Growth Performance of Finishing Pigs

As shown in Table 3 , compared with the control group, the average daily gain of finishing pigs in all safflower oil supplementation groups showed an increasing trend, while average daily feed intake and feed-to-gain ratio showed decreasing trends, but none of these differences were statistically significant (P>0.05).

2.2 Effects of Safflower Oil on Lipid Metabolism Indices of Longissimus dorsi in Finishing Pigs

As shown in Table 4 , compared with the control group, the TC content in longissimus dorsi of finishing pigs in the 0.80% and 1.20% safflower oil groups was significantly decreased (P<0.05), and the LDL content in longissimus dorsi of the 0.80% safflower oil group was extremely significantly decreased (P<0.01). The HDL and VLDL contents in longissimus dorsi of all safflower oil supplementation groups showed no significant differences compared with the control group (P>0.05).

2.3 Effects of Safflower Oil on Fatty Acid Composition of Longissimus dorsi in Finishing Pigs

As shown in Table 5 , compared with the control group, the contents of palmitic acid, linoleic acid, arachidonic acid, linolenic acid, and essential fatty acids in longissimus dorsi of finishing pigs in all safflower oil supplementation groups showed increasing trends, but the differences were not significant (P>0.05).

3.1 Effects of Safflower Oil on Growth Performance of Finishing Pigs

Lipids are important energy sources in diets, providing animals with highly concentrated, easily utilizable digestible energy and essential fatty acids, while promoting the absorption and utilization of fat-soluble vitamins [8]. Safflower oil contains more than 70% linoleic acid [9], which is a very important unsaturated fatty acid. Deficiency of linoleic acid in animals affects normal growth and development, and it is also one of the essential fatty acids for humans. Linoleic acid participates in fat decomposition and metabolism, reduces cholesterol content, inhibits arterial thrombosis formation, and improves immunity, thus possessing high nutritional and health values [10].

The results of this experiment showed that compared with the control group, the average daily gain of finishing pigs in all safflower oil supplementation groups showed an increasing trend, while average daily feed intake and feed-to-gain ratio showed decreasing trends, but none of these differences were statistically significant. Jin et al. [11] reported that compared with the control group, dietary safflower oil supplementation had no significant effect on initial and final body weight of growing-finishing pigs, but showed an increasing trend in average daily gain and a decreasing trend in feed-to-gain ratio. This may be because unsaturated fatty acids participate in oxidative metabolism, providing substantial

energy for the body and thereby promoting growth. This conclusion is similar to the results of our experiment, indicating that safflower oil can improve the growth performance of finishing pigs to a certain extent.

3.2 Effects of Safflower Oil on Lipid Metabolism Indices of Longissimus dorsi in Finishing Pigs

Studies have shown that high LDL content can lead to atherosclerosis, while HDL has blood lipid-lowering effects [12]. The results of this experiment, which added different levels of linoleic acid-rich safflower oil to finishing pig diets, showed that compared with the control group, the contents of TC, LDL, and VLDL in longissimus dorsi of finishing pigs in all safflower oil supplementation groups decreased, while HDL content increased. The decrease in LDL content indicates that safflower oil has anti-atherosclerotic and lipid-lowering effects, and the decrease in TC content suggests that safflower oil can promote cholesterol metabolism and transport in the body [13]. Lin et al. [14] reported that high-dose safflower oil could increase the content of high-density lipoprotein cholesterol (HDLC) in rabbit serum. The possible reason is that safflower oil can increase the activity of lecithin cholesterol acyltransferase (LCAT) in rabbits, and the main physiological function of LCAT is to participate in the maturation of nascent HDLC. Since safflower oil can ensure the content of HDLC and facilitate cholesterol excretion, this may be one of the mechanisms by which safflower oil maintains a certain HDLC content, and higher HDLC content has certain functions in preventing cardiovascular diseases.

3.3 Effects of Safflower Oil on Fatty Acid Composition of Longissimus dorsi in Finishing Pigs

Fatty acids are essential substances for human growth and development, providing important energy for the body, and essential fatty acids play very important roles in maintaining normal physiological functions. Fatty acids are divided into saturated fatty acids and unsaturated fatty acids, with unsaturated fatty acids mainly including -3, -6, -7, and -9 series [15]. The -3 series of unsaturated fatty acids mainly includes -linolenic acid, eicosapentaenoic acid, docosapentaenoic acid, and docosahexaenoic acid, while the -6 series mainly includes -linolenic acid and arachidonic acid [16]. Unsaturated fatty acids are a special class of bioactive substances with good health care and therapeutic effects on cardiovascular diseases, as well as benefits for weight loss, skin care, and brain health [17].

Sheng [18] demonstrated that dietary supplementation with safflower oil and conjugated linoleic acid could increase the linoleic acid content in goat milk fat and significantly increase the contents of palmitoleic acid and trans-11-oleic acid. Guo et al. [19] reported that dietary supplementation with evening primrose oil could significantly increase the -6/ -3 ratio in egg yolk and significantly increase the contents of linoleic acid, conjugated linoleic acid, -linolenic acid, and docosahexaenoic acid in egg yolk. The results of this experiment showed

that compared with the control group, the contents of palmitic acid, linoleic acid, arachidonic acid, linolenic acid, and essential fatty acids in longissimus dorsi of finishing pigs in all safflower oil supplementation groups showed increasing trends, but the differences were not significant, which is consistent with the above research results. These results indicate that linoleic acid-rich safflower oil can increase the content of unsaturated fatty acids in finishing pig muscle, providing certain feasibility for producing pork rich in polyunsaturated fatty acids such as linoleic acid, linolenic acid, and docosahexaenoic acid through dietary safflower oil supplementation in finishing pigs. However, this remains in the exploratory stage, and the specific mechanisms require further research.

Conclusions

1. Dietary safflower oil supplementation increased the average daily gain and decreased the average daily feed intake and feed-to-gain ratio of finishing pigs, thereby improving growth performance.
2. Dietary safflower oil supplementation increased the HDL content and significantly decreased the TC and LDL contents in longissimus dorsi of finishing pigs.
3. Dietary safflower oil supplementation increased the contents of palmitic acid, linoleic acid, arachidonic acid, linolenic acid, and essential fatty acids in longissimus dorsi of finishing pigs.

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