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Effects of pioglitazone hydrochloride and vitamin E on meat quality, antioxidant status and fatty acid profiles in finishing pigs

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ABSTRACT

To investigate the effects of pioglitazone hydrochloride (PGZ) and vitamin E (VE), 160 Duroc × Landrace × Large White pigs were randomly divided into a 2 × 2 factorial arrangement with 2 levels of PGZ (0 or 15 mg/kg) and 2 levels of VE (0 or 325 mg/kg) for 28 days. Each group had 5 replicates with 8 pigs, half males and half females. Feeding PGZ increased intramuscular fat and VE supplementation decreased cooking loss ($P < 0.05$). Feeding VE increased total polyunsaturated fatty acid (PUFA), C18:2n-6 and C18:3n-3 ($P < 0.05$). For 18:3n-3, the increase in C18:3n-3 due to VE was accentuated when combined with PGZ ($P < 0.001$). Additionally, VE tended to increase superoxide dismutase ($P = 0.079$) and glutathione peroxidase activity ($P = 0.054$). In summary, PGZ and VE had positive effects on pork quality by decreasing cooking loss and increasing intramuscular fat and antioxidant capacity, and may prove useful in improving the healthfulness of fatty acid profiles.

1. Introduction

In recent decades, with the development of the social economy and the improvement of living standards, consumers have demanded higher quality meat products, which must provide eating enjoyment, a healthy balance of nutrients, and be safe and convenient to eat (Henchion, McCarthy, Resconi, & Troy, 2014; Kristensen, Stoier, Wurtz, & Hinrichsen, 2014; Zeng et al., 2016). Muscle fat content and fatty acid composition, which are associated with intrinsic meat quality and play an important role in pork flavor and taste are, therefore, of interest (Moeller et al., 2010).

Pioglitazone hydrochloride (PGZ) is a new type of insulin sensitizer (Cheng et al., 2017; Deng, Meng, Sun, Wang, & Yang, 2017). It has been reported that PGZ regulates a variety of insulin sensitive genes through the activation of peroxisome proliferator activated receptor γ (PPAR γ), affecting blood glucose levels and fat deposition (Jones et al., 2017). As the high affinity ligand of PPAR γ, PGZ also plays an important role in the generation and differentiation of adipocytes (Matsuura et al., 2015). In a previous study we've shown dietary supplementation with PGZ can increase intramuscular fat (IMF) in the *Longissimus thoracis* (LT) muscle, and increase the marbling score in finishing pigs (Chen, Feng, Yang, Shu, Jiang, and Wang, 2013). Consistent with this, other studies have shown that PGZ can increase the number and volume of adipocytes in rodents (Iizuka et al., 2016; Sato et al., 2016). Interestingly, PGZ was also shown to increase unsaturated fatty acid proportions in rodent muscle, mainly by increasing monounsaturated fatty acids (MUFA) (Chabowski, Zendzian-Piotrowska, Nawrocki, & Gorski, 2012). Effects on PGZ on muscle fatty acid composition in pork have, however, not been reported.

Vitamins are widely present in plant-source feed ingredients, and most of them have a specific role in animal growth (Jiang & Xiong, 2016; Kirchhoff, Failing, & Goericke-Pesch, 2017). As a common antioxidant, vitamin E (VE) can protect against stress from transport and help maintain meat quality in pigs (Zou et al., 2017). Furthermore, VE plus polyphenol can help deter lipid oxidation in beef (Gobert et al., 2010), and VE combined with rosemary powder can reduce the lipid oxidation of chilled chicken meat (Rostami et al., 2017).

For the present experiment, we hypothesized feeding PGZ could increase IMF in pork, and reduced oxidative stability which may result from changes in fatty acid composition (i.e. increased unsaturation) could be compensated for by supplementing diets with VE.

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2. Materials and methods

This study was approved by the Animal Care Committee of the South China Agricultural University (Guangzhou, China) and carried out in accordance with the Guidelines for Experimental Animals of the Ministry of Science and Technology (Beijing, China).

2.1. Materials

PGZ was bought from Chengdu Yu Yang High-technology Development Co. Ltd. (Sichuan, China; 99% purity). VE was bought from Zhejiang Xin He Cheng Co., Ltd. (Zhejiang, China; 50% purity).

2.2. Animals and experimental design

A total of 160 Duroc × Landrace × Large White pigs of a similar weight (75.53 ± 0.04 kg) were randomly divided into a 2 × 2 factorial arrangement with 2 supplemental levels of PGZ (0 or 15 mg/kg) and 2 supplemental levels of VE (0 or 325 mg/kg) in basal dietary (containing 75 mg/kg VE). The four treatments included: control (fed a basal dietary containing 75 mg/kg VE), PGZ (fed a basal dietary and 15 mg/kg PGZ), VE (fed a basal dietary and 325 mg/kg VE), and PGZ + VE (fed a basal dietary and 15 mg/kg PGZ and 325 mg/kg VE). Each treatment included 5 replicates and 8 pigs per replicate (half males and half females). After 28 days, the feeding experiment was finished and the slaughter performance and meat quality were evaluated on two hogs closest to the average weight from each replicate for each treatment. The basal diet (Table 1) was formulated to meet NRC (2012) requirements.

2.3. Growth performance

The pigs in each replicate were weighed at the start and finish of the experiment to calculate the average daily gain (ADG). The feed consumption was measured per day to calculate the average daily feed intake (ADFI) and feed conversion rate (FCR, gain to feed ratio).

2.4. Serum biochemical indices

Blood samples were collected on the morning of day 29 from the precaval vein from two pigs of average weight from each treatment for each replicate. Serum was collected after centrifugation at 1000 ×*g* for 10 min and stored at −20 °C. The concentrations of glucose (GLU), total protein (TP), triglyceride (TG), cholesterol (CHO), low density lipoprotein (LDL), high density lipoprotein (HDL) and serum urea nitrogen (SUN) were measured with commercial assay kits (Nanjing Jiancheng Biological Product Co. Ltd., China) according to manufacturers' introductions.

Table 1
The ingredients composition and nutritional levels of the basal dietary (air-dry basis).

Ingredients	Content (%)	Nutritional levels	Content (%)
Corn	58.53	DE, MJ/kg[a]	9.97
Barley	20.00	Crude protein	14.63
Soybean meal	15.90	Crude fiber	2.50
Soybean oil	1.68	Calcium	0.60
Limestone power	0.88	Phosphorus	0.40
Dicalcium phosphate	0.63	Sodium	0.10
L-Lysine sulphate, 70%	0.29	Amino acids, %[b]	
Sodium chloride	0.25	Lysine	0.73
Choline chloride	0.08	Threonine	0.70
Threonine, 98%	0.08	Tryptophan	0.19
Methionine, 98%	0.04	Methionine + Cystine	0.62
Tryptophan, 98%	0.004		
Mildew preventive	0.04		
Premix[c]	1.60		
Total	100.00		

[a] DE = Digestible energy.
[b] Amino acids are indicated as standardized ileal digestible AA.
[c] The premix provides following per kg diet: Vitamin A 3520 IU, Vitamin D_3 380 IU, Vitamin E 75 mg, Vitamin B_2 4.8 mg, Copper 12 mg, Iron 100 mg, Manganese 20 mg, Zinc 92 mg.

2.5. Carcass and meat quality

On day 29, the two barrows closest to the average weight of treatments were selected from each replicate to determine carcass and meat quality. After blood collection, pigs were euthanized by electrical stunning. Then carcasses were chilled at 4 °C for 24 h. Carcass weight, dressing percentage and back fat thickness were evaluated following the Chinese Agriculture Industry Standard NY-T825-2004. For back fat thickness measurement, the carcasses were halved and back fat thicknesses were measured by vernier caliper, and the data was corrected as the average of back fat thickness between the 4th and 5th ribs, the 11th and 12th ribs, and the last rib and first lumbar vertebrae. Then, the LT muscle (central area of the loin, on the right side of the carcass, at the level of the 10th and 12th ribs) was removed and meat quality traits were analyzed following the Chinese Agriculture Industry Standard NY-T2793-2015. Thereafter, a chop (25 mm width) for color, pH and shear force measurements were excised from the LT from between the 10th and 11th ribs, vacuum packed and stored at 4 °C. A chop (25 mm width) for determination of marbling score were taken from the LT between the 11th and 12th ribs, vacuum packed and frozen at −20 °C for IMF content, fatty acid composition and antioxidant ability determination.

2.5.1. Color

Color (chop from between the 10th and 11th ribs) was measured at 45 min post slaughter after 1 h of bloom time using a colorimeter (CR410, MINOLTA, Japan) 50 mm aperture, with illuminant D65-day light and CIE lab color system: L^* (lightness), a^* (red–green) and b^* (yellow–blue).

2.5.2. pH

The pH was measured approximately at 45 min and 24 h post mortem on the same section of the LT using a pH meter (HI99161, HANNA, Italy) equipped with an insertion glass electrode (insert 1 cm). The pH meter was calibrated by set of calibration standards including pH 4.01/6.86/9.18.

2.5.3. Shear force

For shear force determination, the muscle samples were packaged and cooked in a water bath at 70 °C for a period of 30 min and dried using paper towel to remove residual moisture and stored overnight at 4 °C. Then cores (diameter: 1 cm; long: 3 cm) were cut from each chop and measured using a digital muscle tenderness tester (C-LM3B, TENOVO, BeiJin, China). Four cores were taken per chop parallel to the grain and sheared perpendicular to the fiber direction.

2.5.4. Marbling score and IMF content

Marbling was scored following the National Pork Producers Council (NPPC, 1999) guidelines and the IMF was determined using the Soxhlet petroleum-ether extraction procedure (AOAOC, 2000).

2.5.5. Muscle antioxidant ability

The total-antioxidant capacity (T-AOC), malonaldehyde (MDA), catalase (CAT), superoxide dismutase (SOD) and glutathione peroxidase (GSH-P_X) in the LT muscle were measured on the second day after slaughter using commercial kits (Nanjing Jiancheng Biological Product Co. Ltd., China) according to the manufacturer's instructions (Li et al., 2015; Ye, Zhong, Du, Cai, & Pan, 2017).