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Effects of oregano essential oil or quercetin supplementation on body weight loss, carcass characteristics, meat quality and antioxidant status in finishing pigs under transport stress

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ABSTRACT

This study compared the effects of dietary oregano essential oil (OEO), quercetin or vitamin E (vit E), on the live body weight loss, carcass characteristics, meat quality and antioxidant status of pigs after transportation. A total of 340 finishing pigs (Large White × Landrace) with an initial body weight of 74 kg (±4.0 kg) were randomly assigned to one of four treatment groups (five replicate pens per treatment, 17 pigs per pen). Pigs consumed the basal diet (control) or the basal diet supplemented with 200 mg vit E/kg (positive control), 25 mg OEO/kg or 25 mg quercetin/kg for 4 weeks. After this period, 144 pigs (36 pigs per treatment) were transported for 5 h before slaughter. Compared with the control group, the OEO or quercetin groups had a higher average daily gain ($P < 0.05$), and the OEO group also had a lower feed intake/gain ($P < 0.05$). The live body weight loss was less in the OEO group after 5 h transportation ($P < 0.05$) than in the control group. The hot carcass weight and dressing percentage were higher in the OEO group after 5 h of transportation ($P < 0.05$) than in the control group. After slaughter, the pH value at 45-min postmortem and Opto-star value (meat color) at 24-h postmortem increased in the vit E, OEO or quercetin groups ($P < 0.05$) compared with the control group. The vit E or quercetin groups also exhibited higher 24-h postmortem pH values ($P < 0.05$) than the control group. The *Longissimus thoracis et lumborum* muscle of pigs from the OEO or quercetin groups produced lower 24-h drip loss values ($P < 0.05$) than that of pigs from the control group. Compared with the control group, the OEO or quercetin groups had reduced levels of TBARS (thiobarbituric acid reactive substances) and ROS (reactive oxygen species) in serum, muscle and liver ($P < 0.05$), while the vit E group had reduced levels in serum only ($P < 0.05$). The OEO or quercetin groups also had increased levels of Gpx (glutathione peroxidase) and T-SOD (total superoxide dismutase) activity in serum and liver compared with the control group ($P < 0.05$). Conversely, there were no differences between the vit E and control groups in Gpx or T-SOD activities. In conclusion, supplementation with dietary OEO or quercetin may be superior to supplementation with dietary vit E in alleviating the negative effects of transportation on pigs by improving the pigs' antioxidant status.

1. Introduction

Pigs are exposed to different stressors when transported to the slaughter house, increasing the risk of reduced welfare for the animals and economic losses related to carcass damage, inferior meat quality and even mortality (Tarrant, 1989; Peeters et al., 2004). During transportation, reactive oxygen species (ROS) levels can increase dramatically and any imbalance between production of these molecules and their safe disposal may culminate in oxidative stress (Young et al., 2005; Archile-Contreras and Purslow, 2011; Onmaz et al., 2011). Oxidation by free radicals is the primary mechanism for quality deterioration in foods, especially in meat products (Kanner, 1994). It causes undesirable changes in flavor, color, texture and nutritive value and may induce the production of toxic compounds in meat (Gray et al., 1996), reducing consumer's acceptability. Therefore, the oxidative status of pigs at the time of slaughter is critical for meat quality (Jensen et al., 1997; Jensen et al., 1998).

Vitamin E (vit E) is a well-known chain-breaking antioxidant, which is able to protect biological membranes against lipid

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peroxidation (Buckley et al., 1995). Vit E has been shown to reduce transport stress and improve meat quality in finishing pigs (Peeters et al., 2004, 2005). Plant extracts have been studied as alternative feed additives in recent years. Plant extracts comprise a wide variety of herbs, spices and derived products (Yanishlieva-Maslarova et al., 2001). Among plant extracts, oregano essential oil (OEO) and quercetin have been found to possess significant antioxidant effects *in vitro* and *in vivo* (Kulisic et al., 2004; Alía et al., 2006; Rezaei-Sadabady et al., 2015; Wei et al., 2015). OEO and quercetin can also increase the activities of antioxidant enzymes in the tissues of pigs (Zhang et al., 2015) and rats (Kahraman et al., 2003; Wei et al., 2015). Overall, these findings indicate that OEO and quercetin may be viable alternatives to vit E as feed additives to prevent meat deterioration induced by the accumulation of ROS.

This study aims to evaluate the effects of OEO and quercetin on weight loss, carcass characteristics, meat quality and antioxidant status in pigs after transportation. The effects of dietary OEO and quercetin on growth performance were also determined.

2. Materials and methods

All animal handling protocols were approved by the Huazhong Agricultural University Animal Care and Use Committee (ref. SCXK20080004).

2.1. Animals, diets and treatments

A total of 340 finishing pigs (Large White × Landrace) were selected from the same farm (Wuhan Chinapork Co. Ltd, Wuhan, China), based on body weight (BW), structural soundness, and health status of the pigs. All pigs (74 ± 4 kg BW) were individually ear-tagged, weighed, and randomly assigned to four dietary treatments from blocks designed to balance initial BW across treatments. Each treatment had five replicate pens of 17 pigs per pen. The treatments were: Control, basal diet; Positive control, basal diet supplemented with 200 mg vit E/kg; OEO, basal diet supplemented with 25 mg OEO/kg; and Quercetin, basal diet supplemented with 25 mg quercetin/kg. Pigs had *ad libitum* access to feed and water throughout the 4-week feeding experiment. The pig pens were kept in an environmentally controlled building with a temperature between 15 and 25 °C. The weights of feed allocated and left in the feeders were recorded daily. The BW of each pig was recorded at the beginning and end of the experiment. At the end of the 4-week feeding experiment, the average daily gain (ADG), average daily feed intake (ADFI), and feed/gain ratio (F/G) were calculated for each pen. The composition of the control diet is shown in Table 1. Vit E was purchased from New Weipu Additive Co., Ltd. (Zhejiang, China). Quercetin (98% extract from *Sophora japonica L*) was purchased from YuanCheng Biotechnology Co., Ltd. (Wuhan, China). The OEO was in the form of a powder called Phytogen (Meritech Bioengineering Co. Ltd., Guangzhou, China) that contains 5% OEO of Greek *Origanum vulgare* subsp. *hirtum* and 95% natural feed-grade inert carrier.

Table 1
Composition and analysis of the basal diet.

Composition (g kg^{-1})	Basal diet[a]
Wheat	380
Corn, grains	464
Soybean meal (46%)	89.0
Monocalcium phosphate	14.0
Limestone	7.00
Mycetes adsorbent	1.50
Antimildew agent	0.50
Salt	3.50
Soybean oil	20.0
Ethoxyquin	0.25
Probiotics	0.20
Y402 premix[b]	20.0
Analysis[c]	
Dry matter – DM (g)	868
Metabolizable energy (MJ kg^{-1})	13.2
Crude protein – CP (g)	139
Crude fiber (g)	28.0
Ash (g)	36.0
Fat (g)	43.0
Calcium (g)	6.00
Phosphorus (g)	6.00

[a] The control group was fed with the above basal diet, whereas the oregano essential oil, quercetin and vitamin E groups consumed the basal diet supplemented with 200 mg kg^{-1} vitamin E, 25 mg kg^{-1} oregano essential oil and 25 mg kg^{-1} quercetin, respectively.

[b] Provided per kg of diet (as-fed basis): 210 mg Fe, 28 mg Cu, 170 mg Zn, 80 mg Mn, 0.15 mg Se, 0.6 mg I, 7000 IU of vitamin A, 800 IU of vitamin D3, 30 IU of vitamin E, 1 mg of vitamin K3, 1 mg of vitamin B1, 3 mg of vitamin B2, 2 mg of vitamin B6, 0.002 mg of vitamin B12, 1.72 g lysine, 0.35 g methionine, 0.5 g threonine, 400 FTU phytase and 15 g choline.

[c] Metabolizable energy was calculated from data provided by the Feed Database in China (1999).

2.2. Transport procedures and transport weight loss evaluation

On the day before slaughter, feed was withdrawn 12 h before transport, but water was available at all times. On the day of slaughter, 36 pigs per treatment (total of 144 pigs) were selected for transport. Pigs were selected based on final BW, with those weighing closest to 100 kg chosen. Pigs were transported for 5 h (from 9:00 to 14:00) in an open truck along a route that included ordinary roads, highways, and bumpy roads. The ambient temperature during transport ranged from 20 to 30 °C and truck speed ranged from 60 to 90 km/h. The trucks used to transport the pigs had three levels, each containing eight pens (length × width × height:190 × 112.5 × 120 cm). Pigs were loaded into the pens with stocking densities of six pigs per pen or 281 kg/m^2. Each pen contained pigs of one diet treatment only. To account for the effect of pen position in the truck on the pigs' welfare and stress response, pigs from the four treatments were randomly assigned to two of the eight pens on each truck level. Pigs were weighed per vehicle pen immediately before being transported (farm gate weight) and again immediately before slaughter. The loss in body weight during transport and holding was expressed as percentage shrinkage. Body weight loss (% shrinkage) was calculated as [1 − (scale weight after transport/scale weight before transport)] × 100.

2.3. Carcass evaluation

After weighing, the 12 pigs from each treatment group (control, vit E, quercetin or OEO, two pigs per vehicle pen) with final BW closest to 100 kg were selected for slaughter for carcass and meat quality evaluation. Pigs were slaughtered quickly by severance of the jugular veins after electrical stunning (75 V, 1.5 A, 3–4 s) on a single day to avoid interference arising from lairage time and treatment during lairage. Following evisceration, the leaf fat was removed, carcasses were split down the midline, and hot carcass weights were recorded. Measurements were taken with a metal ruler of the following: carcass straight length (measured from the cranial tip of the aitch bone to the cranial edge of the first rib adjacent to the thoracic vertebra), carcass slanting length