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Effects of a traditional Chinese medicine formula supplementation on growth performance, carcass characteristics, meat quality and fatty acid profiles of finishing pigs

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ABSTRACT

This study investigated the effects of a traditional Chinese medicine formula (TCMF) on growth performance, and meat quality and fatty acid profiles of finishing pigs. Ninety 146-day-old Pietrain × Duroc × Landrace × Yorkshire pigs (84.1 ± 0.86 kg BW) were assigned randomly to three treatments with five replicates, six pigs per pen. Control group was fed basal diet and the other two groups were fed basal diet plus different doses of the TCMF (TCMF1: 2.5 g/kg feed; TCMF2: 5 g/kg feed). Growth performance was unaffected by TCMF ($P > 0.05$). Pigs fed the TCMF had higher crude fat content in muscle ($P < 0.05$) and lower level of malondialdehyde ($P < 0.01$) in muscle than those fed with the control diet. The a* values, subjective color scores and marbling scores at TCMF1 dietary treatment were increased ($P < 0.05$), but those at TCMF2 dietary treatment were similar to the control ($P > 0.05$). The concentration of vaccenic acid in *longissimus dorsi* and of total unsaturated fatty acids in abdominal adipose tissue were increased by TCMF1 ($P < 0.05$), while paullinic acid in subcutaneous fat was increased by TCMF2 ($P < 0.05$). In conclusion, TCMF fed to fattening pigs increased crude fat in meat and reduced lipid oxidation of pork meat.

1. Introduction

Traditional Chinese medicine (TCM) uses natural products that have various bioactivities with low/no toxicity, less drug resistance and less residue formation in humans and animals extensively for medical purposes or other applications after a long history of screening according to the TCM theories (Liu et al., 2011; Wang et al., 2007; Zuo et al., 2016). Prescribing a TCM formula that consists of screened herbs at certain doses is most commonly used due to the multifold effects caused by certain herb combinations or herbal interactions (Zhang et al., 2014; Van Vuuren and Viljoen, 2011). The TCM formula used in the present study was composed of nine herbs as described in materials and methods, based on the principles of herbal combination and successful clinical practice (Ung et al., 2007; Zhang et al., 2012). The principles of TCM share a common understanding of animal nutrition, physiology and pathological mechanisms. For example, previous studies have reported the beneficial effects of separate TCM herb, including *Radix Astragali*, *Cortex Eucommiae* and *Rhizoma Atractylodis Macrocephalae*, on growth performance and immune function (Hu et al., 2006; Lee et al., 2009; Xu et al., 2012). Zhang et al. (2013) and Guo and Qi (2015) have indicated that the typical active compounds of *Radix Astragali* and *Cortex Eucommiae* extracts, such as polyphenols, polysaccharides, lignans and flavonoids, have remarkable antioxidant enzyme-stimulating activities and reactive oxygen species (ROS) scavenging activities against various lipid peroxidation systems. Some studies have suggested that the oxidative processes of meat products are closely associated with meat color, fat content in meat, fatty acid content and other meat quality traits (Shan et al., 2009; Zhou et al., 2013). Lipid oxidation of meat products may deteriorate the flavor, cause losses of meat color and nutritional value, and increase fatty acid oxidation and lipid peroxide and carcinogenic substance levels (Huang et al., 2014). Therefore, the prevention of lipid oxidation in feed and meat products is necessary to maintain meat quality and food safety (Kim et al., 2013). The addition of synthetic antioxidants, such as vitamin E, ethoxyquin (EQ), tertiary butylhydroxyquinone (TBHQ), butylated hydroxyanisole (BHA) and propyl gallate (PG), to feed or meat products to retard lipid

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oxidation is generally accepted (Sobotka et al., 2012; Song et al., 2014). However, certain synthetic antioxidants may also have harmful effects (Chan et al., 2012; Blaszczyk and Skolimowski, 2015). Presently, the addition of natural antioxidants, such as gingerols, shogaols, gingerdiol, gingerdione and some related phenolic ketone derivatives in *Rhizoma Zingiberis*, have been used to improve the antioxidant status of animals or meat color (Zhang et al., 2009).

However, thus far, most studies with TCM have focused on the antioxidant effects of *Cortex Eucommiae*, the active components of which are rutin, quercetin and kaempferol, and of *Glabra Glycyrrhiza*, the active components of which are total phenolic and *glycyrrhizic* acids, *e.g.*, on stored meats (Xu et al., 2010a; Jiang et al., 2013). Notably, the effects of TCM formulas on fresh meat in finishing pigs are relatively unknown.

Based on the above discussions, dietary supplementation with a TCM formula could enhance growth performance and meat quality on finishing pigs. We hypothesized that such a treatment could produce pork that exhibited antioxidant properties and improved meat quality. Therefore, this study was conducted to investigate the effects of a new TCM formula on the growth performance, carcass characteristics, meat quality and fatty acid profiles of finishing pigs.

2. Materials and methods

2.1. Preparation of the TCM formula

The TCM formula powders were supplied by Nong Zhi Dao Co., Ltd., Guangzhou, China. The TCM formula contained the following: 25% of *Radix Astragali* (root), 20% of *Radix Glycyrrhizae* (root), 15% of *Cortex Eucommiae* Leaf (bark and leaf), 10% of *Rhizoma Atractylodis Macrocephalae* (rootstalk), 10% of *Rhizoma Zingiberis* (rootstalk), 10% of *Fructus Crataegi* (fruit), 5% of *Fructus Rosae Laevigatae* (fruit), 3% of *Fructus Ligustri Lucidi* (fruit) and 2% of *Pericarpium Citri Reticulatae* (pericarp). The TCM herbs in the formula were dried, crushed, sifted through a 60-mesh screen and stored at room temperature before use. The *Radix Glycyrrhizae*, *Rhizoma Zingiberis*, *Fructus Crataegi*, and *Pericarpium Citri Reticulatae* used in the formula are generally recognized as safe according to the USA legislation of USP (2014). The TCM formula was dried in an air circulatory tray drier (DHG-9240A, Hengke, Shanghai, China) at 60 °C for 48 h to analyse the dry matter. A total of 10 g TCM formula was extracted with 50% ethanol at 60 °C for 2 h with 3 times repetition for extraction rate assessment according to Inbaraj et al. (2010). The active substances of TCM formula were analyzed according to the method described by Liu et al. (2013) using ultra-fast liquid chromatography combined with quadrupole-time-of-flight mass spectrometry (UFLC/Q-TOF-MS, Agilent, Santa Clara, USA). The active ingredients of TCM formula were separated on a ZORBAX SHHB-C18 column (150 mm × 2.1 mm, 3.5 μm, Agilent, Santa Clara, USA) at 0.3 mL/min flow rate with diode array detector (Agilent, Santa Clara, USA). Two solvents were used for elution: solvent A was methanol (Merck, Darmstadt, Germany) and solvent B was 0.1% (v/v) methanoic acid (Merck, Darmstadt, Germany). Mass spectrometry system (Agilent, Santa Clara, USA) was equipped with electrospray ion source. The analytical results are presented in Table 1. The overall TCM formula was confirmed to be safe by an acute toxicity test with rats (up to 40 times the human recommended level 0.5 g/kg/d BW) (unpublished data) according to the method of Mu et al. (2011).

2.2. Experimental design, animals and diets

A total of 90 146-day-old castrated Pietrain × Duroc × Landrace × Yorkshire (PDLY) finishing pigs with an average initial body weight (BW) of 84.1 ± 0.86 kg were allotted to pens (6 pigs per pen) based on initial BW to make homogenous the pigs' BW within each pen in a completely randomized design experiment with 3 treatments and 5 replicate pens per treatment. The pens were randomly assigned to one of the following treatments: Control (basal diet), TCMF1 (basal diet plus 2.5 g/kg TCM formula) and TCMF2 (basal diet plus 5 g/kg TCM formula). The TCMF inclusion levels in diets were defined based on China Criteria (GB/T 19424, 2003) and the additive level of *Radix Astragali* reported by Ho and Yoonhwa (2002) and Hu et al. (2006). Feed and water were provided to the pigs *ad libitum*. The study lasted for 35 days. The experimental protocol was approved by the Animal Care and Use Committee of South China Agriculture University (certificate number: SCXK (Guangzhou, Guangdong, China) 2013-0002). The experimental diets (Table 2) were formulated in accordance with the NRC (2012) requirement. Amino acids are presented as total. Three samples of each diet from the feed batch were collected according to the China Criteria (GB/T 14699.1/ISO 6497, 2005) for the analysis of fatty acids profile, which are summarized in Table 3.

Table 1
Dry matter, extraction rate and the active substances of traditional Chinese medicine formula (TCMF).

Items	Content
Dry matter (g/kg)	904
Extraction rate (g/kg)	235
Active ingredient (mg/kg)	
Calycosin	216
Liquiritin	187
Eucommiol	182
6-Gingerol	164
Ursolic acid	108
Atractylolide	75.4
Glycyrrhizic acid	56.4
Chlorogenic acid	55.9
Salidroside	53.4
Nobiletin	48.2
Specnuezhenide	24.0

2.3. Sampling and measurements

BW and feed disappearance were recorded for each pen at beginning of the trial (d 146) and at the termination of the test (d 181). The average daily gain (ADG), average daily feed intake (ADFI) and feed: gain (F:G) ratio were calculated.

At the conclusion of the experiment, one pig with BW closest to the average BW of each pen was sacrificed *via* electrical stunning, followed by jugular vein exsanguination (Daza et al., 2012). The live weight from fasted pig, hot carcass weight at slaughter, and organ weights, including the heart, liver, spleen, lung and kidney weights, were recorded (Fernandez-Figares et al., 2008). Using these data, the dressing percentage was also calculated (Lee et al., 2011). The left half of the carcass was used for carcass characteristic analyses. The carcass straight length was measured from the first cervical vertebra cavity to the pubic symphysis midline, and the carcass oblique length was determined between the joint of the first rib and sternum and the pubic symphysis midline (Latorre et al., 2009). The skin thickness was obtained from the sixth to the seventh rib in the dorsal line (Xu et al., 2010b). Backfat depths (BD, skinless) were measured at three points (the first rib, the last rib and the last midline lumbar), and the values of BD were averaged (Lee et al., 2011). The *longissimus dorsi* (*LD*) between the 10th and 11th ribs was dissected to facilitate the determination of the loin cross-sectional area (Mas et al., 2011). The left ham was excised vertically between the last and penultimate lumbar vertebra and was weighed to calculate the percentage of ham (Conde-Aguilera et al., 2011). The carcass lean (CL) percentage was predicted using the equation CL% = 60.8 + 0.011 (backfat depth, mm)^2 + 0.127 (loin depth, mm)-1.176 (backfat depth, mm) (Schinckel et al., 2010). In this equation, the backfat depth was measured over the midline opposite the last rib, and the loin depth measurement was taken between the 10th and 11th ribs (Font-i-Furnols et al., 2012).