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Original Research Article

Effect of dietary supplementation with sugar cane extract on meat quality and oxidative stability in finishing pigs

Yangchun Xia [a], Yansen Li [a], Xiangxing Shen [a], Massami Mizu [b], Toma Furuta [b], Chunmei Li [a, *]

[a] College of Animal Science and Technology, Nanjing Agricultural University, Nanjing 210095, China
[b] Product Development Division, Mitsui Sugar Co., Ltd., Tokyo 103-8423, Japan

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ABSTRACT

The aim of the present study was to investigate the effect of dietary supplementation with sugar cane extract (SCE) on meat quality and oxidative stability of *Longissimus dorsi* muscle in finishing pigs. Eighteen barrows (Duroc × Landrace × *Jiaxing* Black), with an average initial body weight of 62.1 ± 5.0 kg, were randomly allotted to 1 of 3 diets with 6 replicates per treatment for 42 days. The diets comprised a normal diet and the normal diets supplemented with 5 and 25 g/kg SCE. The results showed that SCE supplementation did not affect final body weight of finishing pigs. Dietary SCE supplementation significantly increased ($P < 0.05$) *Longissimus dorsi* muscle $pH_{24\ h}$, and tended to reduce ($P < 0.1$) and significantly decreased ($P < 0.05$) shear force, drip loss, myofiber cross sectional area and lactate dehydrogenase activity at 5 and 25 g/kg, respectively. Meanwhile, dietary SCE treatments significantly decreased ($P < 0.05$) malonaldehyde content and total superoxide dismutase activity in *Longissimus dorsi* muscle, and tended to reduce ($P < 0.1$) malonaldehyde content in serum. Altogether, these data indicate that SCE is an effective feed additive to improve pork meat quality, and the underlying mechanism may be partly due to the improved oxidative stability induced by dietary SCE supplementation.

1. Introduction

With the development of meat industry, considerable attention has been paid to the improvement of meat quality parameters. Meat producers consistently produce safe, healthy and tasty meat for consumers, accompanied by eliminating deteriorative phenomenon that negatively affects meat quality. As a major cause of meat deterioration (Asghar et al., 1988), lipid oxidation can produce toxic compounds, such as fatty acid peroxides, cholesterol hydroperoxide and peroxy radicals (Grün et al., 2006) that adversely influence muscle oxidative stability. What is more, muscle oxidative stability is related to many aspects of meat quality that are represented by postmortem pH, color, water holding capacity, etc. It is generally believed that lipid oxidation can be inhibited by synthetic and natural antioxidants. However, the resistance to food additives of synthetic substances has increased due to safety and health concern (Karre et al., 2013). Therefore, there is now considerable appreciation of enhancing pork quality through antioxidant properties of natural occurring substances, such as natural plant extract (Rossi et al., 2013).

The sugar cane (*Saccharum officinarum* L.), one of the major sources of sugar, is a widely cultivated plant throughout the whole world. Sugar cane and its derived products have displayed a wide range of biological activities, including antioxidant, anti-inflammatory, antiatherosclerotic, immune-stimulation, DNA damage protecting activity (El-Abasy et al., 2002; Chung et al., 2011). Sugar cane extract (SCE), a natural byproduct in sugar cane industry, has been found the antioxidant property that is due to the presence of high content of phenolic compounds, primarily, sinapic acid, chlorogenic acid, apigenin derivatives, and tricin derivatives in sugar cane juice (Duarte-Almeida et al., 2006). These natural

* Corresponding author.
E-mail addresses: chunmeili@njau.edu.cn, lichunmei74@gmail.com (C. Li).

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bioactive compounds, present in vegetables, beans, fruits, are generally regarded as safe chemicals exhibiting low toxicity. To the best of our knowledge, although phenolic entities in sugar cane could act as antioxidants, no relevant study was observed for effects of SCE on meat quality. On this basis, we hypothesized that dietary supplementation with SCE may change meat quality characteristics through influencing antioxidative status in finishing pigs.

The aim of the present study is to evaluate the effect of dietary SCE supplementation on meat quality parameters and oxidative stability of *Longissimus dorsi* (LD) muscle in Duroc × Landrace × *Jiaxing* Black crossbred pigs.

2. Materials and methods

2.1. Material

Sugar cane extract was produced and kindly provided by Shin Mitsui Sugar Co., Ltd. (Tokyo, Japan). The original material for SCE production was the sugar cane juice from the raw sugar manufacturing process. After removing most of the sugar components including glucose, fructose and sucrose from sugar cane juice, the residue was dried and adsorbed to bread crumb to produce SCE, according to the production manual. The nutrient content and phenolic content of SCE are presented in Table 1.

2.2. Animals and experimental design

All procedures were approved by the Institutional Animal Care and Use Committee of Nanjing Agricultural University. Eighteen barrows (Duroc × Landrace × *Jiaxing* Black) with an average initial body weight of 62.1 ± 5.0 kg (means ± SD) were randomly divided into 3 groups with 6 duplicates of 1 each as follows: a control group was fed a normal diet (basal diet, Table 2) and the other 2 groups were fed the normal diet supplemented with 5 and 25 g/kg SCE dietary for 42 days. Pigs were housed in individual pens and allowed *ad libitum* access to feed and water.

2.3. Slaughter and sampling

At the completion of the feeding period, all pigs were subjected feed deprivation for 12 h but free drinking including the time during transportation and then slaughtered humanely by bleeding after electrically stunning in a commercial slaughter house (Qinglian Food Co., Ltd., Zhejiang, China). At the same time, blood samples were collected and placed on ice for 1 h, and then, centrifuged at 800 × *g* at 4 °C for 10 min. After centrifugation, the serum from each sample was collected and frozen at −20 °C until analyzed. Immediately after the pigs were killed, LD samples were removed at the level of the last rib in each carcass. For each of these 18 samples, 5 g muscles were frozen in liquid nitrogen for analysis enzyme activity and malondialdehyde (MDA) content, 20 g were stored frozen at −20 °C until chemical composition analysis and 5 g samples for evaluation of histology were fixed in 4% paraformaldehyde solution. The residual muscles refrigerated at 4 °C, were subjected to measurement of pH, color, shear force, cooking loss and drip loss.

Table 1
Nutrient content and phenolic content of sugar cane extract (SCE).

Nutrient content, %	Content	Phenolic compounds[1]	Content
Moisture	5.63	Total phenolic content	89.39
Crude protein	13.65	Sinapic acid	1.16
Crude fat	2.99	Chlorogenic acid	10.70
Crude fiber	1.32	Apigenin	5.68
Ash	16.64	Tricin	7.31
Nitrogen free extracts	59.77	Gallic acid	8.12

[1] Total phenolic content is expressed as mg/g SCE dry matter. Sinapic acid, chlorogenic acid, apigenin, tricin and gallic acid are expressed as mg/100 g SCE dry matter.

Table 2
Feed ingredients and nutrient content of basal diets.

Ingredients, %	Content	Nutrients, %	Content
Corn	77	Digestible energy, MJ/kg	13.90
Soybean meal	18	Crude protein	14.81
Wheat bran	2	Calcium	0.64
Dicalcium phosphate	0.9	Total phosphorus	0.50
Limestone	1	Available phosphorus	0.29
Lysine HCl	0.2	Lysine	0.82
NaCl	0.3	Methionine	0.25
Premix[1]	0.6	Threonine	0.55
Total	100	Tryptophan	0.16

[1] Provided the following per kg diet for finishing pigs: 100 mg of Fe (as ferrous sulfate); 15 mg of Cu (as copper sulfate); 120 mg of Zn (as zinc sulfate); 40 mg of Mn (as manganese sulfate); 0.3 mg of Se (as Na_2SeO_3); 0.25 mg of I (as KI); 13,500 IU of vitamin A; 2,250 IU of vitamin D_3; 24 IU of vitamin E; 6.2 mg of riboflavin; 25 mg of nicotinic acid; 15 mg of pantothenic acid; 1.2 mg of vitamin B_{12}; 0.15 mg of biotin.

2.4. Meat quality measurements

The pH values of the LD muscle was measured at approximately 45 min ($pH_{45\ min}$) and 24 h ($pH_{24\ h}$) postmortem using a pH meter (HI9125 pH meter, HANNA instruments, Italy), as described by Fisher (1995). The pH probe was inserted into the LD muscle directly. Each sample was determined 3 times in different locations and the average value was obtained.

The meat color L^* (lightness), a^* (redness) and b^* (yellowness) were measured at approximately 24 h postmortem using a Colorimeter (CR-10, Konica Minolta, Japan). Measurements were made at 3 different areas of the samples and the average values of L^*, a^* and b^* were recorded.

The pork drip loss was measured as below. Briefly, a muscle section (size 2 cm × 3 cm × 5 cm) was manually trimmed and weighed at about 45 min postmortem, followed by suspending from an iron wire hook within an inflated and sealed plastic bag at 0 to 4 °C for 24 h. After that, the sample was taken out from the plastic, wiped dry on filter paper, and reweighed. Drip loss was expressed as follows: Drip loss (%) = [(Initial weight − Final weight)/Initial weight] × 100. A 2.5 cm thickness sample was weighed accurately and packaged in a plastic bag prior to cooking. Then the sample was immersed in a 72 °C water bath until reaching an internal temperature of 70 °C. After cooling to room temperature, the sample was wiped with filter paper and reweighed. Cooking loss was calculated as follows: Cooking loss (%) = [(Raw weight − Cooked weight)/Raw weight] × 100.

After determining cooking loss, the same muscle was then subjected to measurement of shear force using a muscle tenderness meter (C-LM3, Northeast Agricultural University, China). Briefly, 6 cores (1.27 cm diameter, 3.0 cm length) were removed from each cooked sample along the longitudinal orientation of muscle fiber. Then, the cores were sheared perpendicular to the fiber long axis. Shear force data of each sample were recorded as means ± SEM of 6 replicates.

2.5. Chemical composition analysis

Muscle samples were analyzed for moisture, crud protein, intramuscular fat content (IMF) and ash according to Association of Analytical Chemists methods (AOAC, 2000).

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