EFFECT OF DIETARY β-CAROTENE, CATECHINS AND VITAMIN E SUPPLEMENTATION ON MEAT QUALITY DURING DISPLAY IN PIGS

Mitsumoto M.[1], Sasaki K.[1], Otawara K.[2], Sasaki K.[3], Sakashita K.[4], Homma N.[5], Kubo M.[6]
[1] National Institute of Livestock and Grassland Science, Tsukuba, 305-0901, Japan
[2] Iwate Animal Industry Research Institute, Takizawa, 020-0173, Japan
[3] Akita Prefectural Experiment Station of Animal Industry, Kamioka, 019-1701, Japan
[4] Kagoshima Prefectural Livestock Experiment Station, Kokubu, 899-4461, Japan.
[5] Niigata Agricultural Research Institute, Livestock Research Center, Shitada, 955-0143, Japan.
[6] National Institute of Animal Health, Tsukuba, 305-0856, Japan.

Background

Drip loss, color and lipid stability in retail meat are very important for both meat retailers and consumers. Dietary vitamin E supplementation for several weeks decreased oxidation of meat or fat in poultry, pigs and cattle (Mitsumoto, 2000). Asghar et al. (1991) reported that dietary vitamin E supplementation improved the color and lipid stability and decreased drip loss in frozen pork during storage at 4°C. Tang et al. (2000) found that dietary tea catechins at level of 300 mg per kg of feed was effective in retarding lipid oxidation in chicken meat compared to the control and dietary vitamin E (200 mg/kg feed). β-Carotene, the most extensively studied carotenoid, can act as a free radical scavenger. Wenk et al. (2000) suggested that increasing the muscle β-carotene concentration by diet modification might possibly improve antioxidant status. It is not known, however, whether dietary β-carotene and catechins supplementation to pigs are effective in maintaining meat quality as dietary vitamin E.

Objectives

The purpose of this work was to examine the effects of dietary large amounts of β-carotene, catechins and vitamin E supplementation on drip loss, meat color and lipid stability during display in raw pork steaks from LWD crossbred pigs.

Methods

Dietary β-carotene (Experiment 1; Mitsumoto et al., 2002): Four LWD crossbred pigs were fed no supplemental β-carotene, four pigs were supplemented with 20 times of daily requirement of β-carotene (15.49 mg β-carotene / day) and four pigs were supplemented with 100 times of daily requirement of β-carotene per animal daily for 4 weeks before slaughter. Steak samples of biceps femoris (BF) and longissimus thoracis (LT) muscles were used.

Dietary catechins and vitamin E (Experiment 2; Mitsumoto et al., 2001): Four LWD crossbred pigs were fed control diet, four pigs were supplemented with 2,000 mg tea catechins and four pigs were supplemented with 2,000 mg dl-α-tocopheryl acetate per animal daily for 8 weeks before slaughter. Steak samples of BF and LT muscles were used.

β-Carotene, vitamins A and E analyses: The β-carotene, retinol and α-tocopherol concentrations of plasma, liver, subcutaneous fat and muscles were determined by the HPLC method.

Drip loss analysis: Steak samples (2-cm thick x 5-cm x 5-cm: about 50g) were individually placed on absorbent paper to absorb drip fluid in a 100-mL disposable weigh boat, over-wrapped with oxygen-permeable PVC film and displayed in the dark (in Experiment 1) or under fluorescent lights (in Experiment 2) at 4°C for 10 days. Duplicate samples were weighed at sampling day (5 days postmortem) and at measurement days, and drip loss percentage was determined as weight loss relative to the sampling day.

Meat color and metmyoglobin analyses: Steak samples (1-cm thick and 5-cm diameter: 20.0g) were individually placed in a weigh boat, over-wrapped with PVC film and displayed the same as drip loss samples. CIE (Commission Internationale de l'Eclairage) L*, a* and b* values were obtained at day 1, 4, 7 and 10 using a spectrophotometer, and surface metmyoglobin percentages were determined by the method of Stewart et al. (1965) at the same measurement days.

Lipid oxidation analysis: 2-Thiobarbituric acid reactive substances (TBARS) were measured after meat color analyses by the method of Witte et al. (1970). TBARS values were expressed as mg malonaldehyde (MDA) / kg meat.

Histological analysis (only in Experiment 2): Steak samples displayed for 2, 7 and 10 days were fixed with 10% formalin, dehydrated in alcohols and embedded in paraffin. They were transversely sectioned at 3 μm and the sections were placed on glass slides. Sections were deparaffinized and stained with hematoxylin and eosin. Morphological integrity of muscle sections was observed with a light microscope.

Statistical analysis: Data were analyzed by the GLM procedure of SAS (1988).

Results and discussion

Experiment 1: Dietary 20 or 100 times of daily requirement of β-carotene supplementation for 4 weeks increased ($P<0.05$) β-carotene concentrations in liver but not in plasma, subcutaneous fat and muscles (Table 1). Either dietary β-carotene supplementation did not increase ($P>0.05$) retinol concentrations in plasma and tissues (Table 1). Dietary β-carotene had no differences ($P>0.05$) in drip loss, meat color, metmyoglobin and lipid oxidation compared to the control. King et al. (1995) reported that dietary β-carotene accumulated β-carotene in chicken meat only in low concentrations and was not effective in meat color and lipid stability as dietary vitamin E. The results indicated that pigs poorly absorbed β-carotene and/or inefficiently convert β-carotene to vitamin A (retinol), and then β-carotene and retinol were slightly incorporated into plasma lipoproteins and some of them transferred to liver but not to muscles. Therefore, dietary β-carotene could not work for retaining meat quality during display.

Experiment 2: Dietary vitamin E supplementation for 8 weeks increased ($P<0.01$) α-tocopherol concentrations in plasma, liver, subcutaneous fat and muscles. Dietary catechins and vitamin E supplementation reduced ($P<0.05$) lipid oxidation at day 10 and after day 7, respectively, compared to the control (Table 2). Dietary catechins and vitamin E reduced ($P<0.01$) muscle fiber disruption compared to the control but had no effect ($P>0.05$) on drip loss, meat color and metmyoglobin formation. The data indicated that dietary catechins and vitamin E for 8 weeks improved lipid and muscle fiber stability moderately and greatly, respectively, during display in pork steak compared to the control, but both treatments were not effective for drip loss and color stability. Therefore, we suggest that dietary catechins and vitamin E were absorbed by pigs and incorporated into cellular membranes. In this location catechins and vitamin E prevented lipid oxidation and muscle fiber disruption by scavenging free radical molecules. Hence, the stabilities of pork lipid and muscle fiber were improved.

Asghar et al. (1991) reported that dietary vitamin E supplementation increased α-tocopherol deposition in the cellular membranes and then reduced drip loss from thawed pork chops. They suggested that a higher α-tocopherol concentration in meat minimizes drip loss from frozen meat upon thawing, because α-tocopherol may preserve the fluidity of cell membranes. Mitsumoto et al. (1995) found that

dietary vitamin E stabilized cell integrity and enhanced the ability of beef steak to hold sarcoplasmic components during display. den Hertog-Meischke et al. (1997) reported that the influence of vitamin E supplementation on drip loss of muscles was not always consistent. Lanari et al. (1995) reported that dietary vitamin E improved pork color stability during display in air or modified atmosphere, although the benefit of supplementation on meat color was detectable only for illuminated storage. They suggested that dietary vitamin E was more effective in delaying lipid oxidation than meat color. The effects of dietary vitamin E supplementation on drip loss and meat color need further investigation.

Conclusions

The dietary catechins and vitamin E supplementation reduced lipid oxidation and muscle fiber disruption in pork steak displayed for 10 days. The dietary β-carotene supplementation, however, had no effects on meat quality compared to the control. Much larger supplementation of catechins and vitamin E than 2,000 mg/day in this study would be needed for maintaining meat quality of drip, color, pigment and lipid stability in fresh pork steaks during retail display.

Pertinent literature

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Table 1. **(Experiment 1)** Effect of dietary 20 or 100 times of daily requirement of β-carotene supplementation on β-carotene and retinol concentrations (mg/L or mg/kg) in plasma and tissues.

Plasma / tissue	Vitamins	Control	x 20 β-Carotene	x 100 β-Carotene	Standard error
Plasma	β-Carotene	ND	ND	ND	-
Liver		0.01 [c]	0.37 [b]	0.78 [a]	0.082
Subcutaneous fat		ND	ND	ND	-
Biceps femoris		ND	ND	ND	-
Longissimus thoracis		ND	ND	ND	-
Plasma	Retinol	0.48	0.47	0.53	0.025
Liver		98.66	104.21	109.88	3.965
Subcutaneous fat		0.43	0.60	0.71	0.082
Biceps femoris		0.08	0.08	0.09	0.044
Longissimus thoracis		0.16	0.12	0.11	0.044

x 20 β-Carotene = dietary 20 times of daily requirement of β-carotene; x 100 β-Carotene = dietary 100 times of daily requirement of β-carotene. a,b,c: within main effects, least-squares means with no common letters differ (P<0.05). ND: not detected.

Table 2. **(Experiment 2)** Effect of dietary catechins or vitamin E supplementation and days displayed on TBARS values (mg MDA/kg meat).

Days displayed	Control	Catechins	Vitamin E	Standard error
1	0.04	0.03	0.03	0.032
4	0.13	0.08	0.05	0.032
7	0.22 [a]	0.14 [ab]	0.08 [b]	0.032
10	0.53 [a]	0.43 [b]	0.16 [c]	0.032

Control = control pork; Catechins = dietary catechins-supplemented pork; Vitamin E = dietary vitamin E-supplemented pork.
a,b,c: within main effects, least-squares means with no common letters differ (P<0.05).