INFLUENCE OF DURATION OF DIETARY VITAMIN E SUPPLEMENTATION ON SWINE GROWTH PERFORMANCE AND CARCASS QUALITY[1]

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Summary

Supplementing medium-lean genotype pigs with supranutritional concentrations of dietary vitamin E (91 IU *d*-α-tocopheryl acetate/lb of feed) for as long as 70 d during the finishing phase was not effective in improving swine performance, feeding characteristics, and 24 h loin muscle quality. However, lower carcass temperatures obtained by spray chilling pork sides at 0°C versus 4.4°C had a beneficial effect on 24 h carcass quality by improving marbling and lean firmness scores and reducing loin muscle moisture exudate. Overall, 24 h pork carcass quality was impacted more by chill rate than dietary vitamin E supplementation.

(Key Words: Pork, Vitamin E, Chill Rate.)

Introduction

Improving production efficiency and meat quality have become focal points for the pork industry as attempts are made to increase its presence in the global market and as it faces increased domestic competition with other meat species. Improvements in average daily gain and feed efficiency in swine during the early stages of growth have been reported with dietary vitamin E supplementation. Yet, the effectiveness of elevated levels of vitamin E in improving swine performance during the later stages of growth is inconsistent. Pork carcass quality can be impacted greatly by several factors including animal age, diet, preslaughter stress, storage time and temperature, and meat properties such as pH. In some instances, α-tocopherol has exhibited a protective role against lipid oxidation, color deterioration, and drip loss in pork products during subsequent chilled storage and display. Faster carcass chill rates also have been shown to improve pork quality and reduce moisture losses. Therefore, variability in cooler temperature and subsequent carcass chill rate could partially impact 24 h pork carcass quality. As a result, the objectives of this study were first to evaluate the effects of duration of dietary vitamin E supplementation the growth and slaughter characteristics of finishing pigs and second, to determine the impacts of duration of vitamin E supplementation and chill temperature on 24 h pork carcass quality.

Procedures

Growth Performance. Eighty crossbred medium-lean genotype barrows averaging 109 lb were allotted randomly on the basis of weight and ancestry to one of four dietary treatments. Treatments were based on the duration of *d*-α-tocopheryl acetate administration. The diets consisted of the following: (1) control diet (corn-soybean meal, .7% lysine, 12.0 IU added *d*-α-tocopheryl acetate/lb of feed); (2) control diet + added *d*-α-tocopheryl acetate (91 IU/lb of feed) for the last 42 d of the trial; (3) control diet + added *d*-α-tocopheryl acetate (91 IU/lb of feed) for the last 56 d of the trial; and (4) control diet + added *d*-α-tocopheryl acetate (91 IU/lb of feed) for the entire 70 d trial. Pigs were housed in an environmentally controlled finishing facility with complete slatted

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flooring. There were two pigs per pen (5 ft × 5 ft) and 10 replications per treatment. Each pen contained a single-hole self-feeder and a nipple waterer to accommodate *ab libitum* access to feed and water. Individual pig and feeder weights were taken every 2 wk to calculate average daily gain, average daily feed intake, and gain to feed ratios. Diets were mixed at the Kansas State University feed mill and stored in 50 lb bags. Duplicate feed samples were obtained from both the control and supplemented diets and stored at -20°C each time a new batch was mixed to determine α-tocopherol concentration of each diet. Upon analysis, the control and supplemented diets contained 14.9 and 72.7 IU α-tocopherol/lb of feed, respectively.

Carcass Measurements. Approximately 12 h prior to slaughter, pigs were weighed and feed was removed. Pigs were transported to the Kansas State University abattoir, and carcasses were harvested humanely using standard industry procedures. Serum samples from each pig were collected for α-tocopherol concentration analysis. At 45 min postmortem, loin muscle pH measurements were taken on each side at the anatomical center of the loin muscle through the intercostal muscle at the 9th rib using an Orion Research model 211 pH meter. One side of each pork carcass then was chilled at 0°C, while the opposite side was chilled at 4.4°C. Carcasses in both coolers were sprayed with chilled water (2°C) for 10 s every 10 min during the first 10 h postmortem. Loin and ham temperatures were collected at 1, 3, 6, 12, and 24 h postmortem to monitor differences in chilling rate. Loin temperatures were collected through the 9th rib intercostal muscle at depths of 1.27 (LM1.27) and 3.81 (LM3.81) cm. Intramuscular ham temperatures were taken 2.54 cm above the aitch bone at 2.54 (H2.54) and 7.62 (H7.62) cm deep.

At 24 h postmortem, both sides of each carcass were ribbed at the 10th rib, and data were collected to determine USDA grade and percentage lean. The lb of lean pork (containing 5% fat) was calculated from 7.231 + (.437 × hot carcass weight, lb) - (18.746 × 10th rib fat depth, in) + (3.877 × 10th rib longissimus muscle area, in^2). Percentage lean was derived by dividing kg of lean by hot carcass weight and multiplying by 100. After a 15-min bloom period, meat exudate values were obtained by placing circular 5.5 cm-diameter filter paper on the posterior cut surface of the ribbed loin muscle for approximately 1 s. The difference between dry and moist weights was recorded as the weight of moisture exudate. CIE $L^*a^*b^*$ values of the loin muscle were measured with a Minolta CR-200 Chroma Meter. Saturation index and hue angle were calculated using the equations of $(a^{*2} + b^{*2})^{½}$ and arc tangent (b^*/a^*), respectively. Visual color, lean and fat firmness/wetness, and marbling of the loin muscle at the 10th rib were scored on a scale of 1 to 5 (1 = pale pinkish-gray, very soft and very watery, and devoid to practically devoid and 5 = dark purplish-red, very firm and dry, and moderately abundant or greater, respectively). A 10 g loin muscle sample was collected from the posterior ribbed surface for ultimate pH determination. Muscle samples were placed in stomacher bags with 100 ml distilled, deionized water and stomached for approximately 30 s. Sample pH then was measured at room temperature using a Fisher model 620 Accumet® pH meter equipped with a Ross® combination electrode.

Fabrication. At 4 d postmortem, 10 carcasses within each dietary treatment were selected randomly, and both sides were fabricated to obtain the loin muscle from the 11th rib to the 4th lumbar vertebra. Six 1 in-thick boneless loin chops were collected beginning at the 12th rib and proceeding posteriorly. The final three chops collected were utilized, from anterior to posterior, to determine loin muscle Warner-Bratzler shear (WBS) force and cook loss percentage, expressible fluid values, and muscle composition, respectively.

Shear Force and Cook Loss Percentage Determination. Fresh loin chops were weighed and cooked to an internal temperature of 70°C in a Blodgett dual-air-flow oven. Chop internal temperature was monitored with thermocouples attached to a DORIC Minitrend 205 temperature monitor. After a

2 h cooling period at room temper-ature, chops were blotted and reweighed. Six 1.27 cm-diameter cores were removed with a mechanical coring device parallel to the muscle fibers and sheared once through the center with a Warner-Bratzler shear (WBS) device attached to an Instron 4201 machine. The six values were averaged to determine a WBS value for statistical analysis. Cooking loss percentage for loin chops was calculated by 100 x (fresh chop weight - cooked chop weight)/fresh chop weight.

Expressible Fluid Determination. Fresh loin muscle samples ranging from 500 to 750 mg were obtained from the interior of each chop and placed individually in the center of a circular piece of filter paper 15 cm in diameter. The filter paper and muscle samples then were placed singly between two plexiglass plates and pressed with a Carver Press for 5 min at 5,000 psi. Expressible fluid was presented as the ratio of total fluid area to meat film area. Larger values suggest lower water holding capacity.

Proximate Analysis. A boneless 1-in. loin chop obtained from each side chilled at 0°C was trimmed free of subcutaneous fat and connective tissue. Samples were analyzed for percent dry matter (DM), ether extractable lipid, crude protein (CP), and ash.

Serum α-Tocopherol Analysis. α-Tocopherol was extracted from .4 ml of plasma using 2 ml of hexane. The hexane layer was removed and dried under a gentle stream of N_2 in a water bath at 50°C. The residue was dissolved in .4 ml of ethanol, and α-tocopherol concentration was determined using high pressure liquid chromotography.

Statistical Analysis. The experiment was analyzed as a randomized complete block, using initial weight to establish blocks. Growth performance data and carcass slaughter characteristics were analyzed using the GLM procedure of SAS with pen serving as the experimental unit. Data collected on pigs randomly selected within each dietary treatment across blocks were analyzed using the Mixed procedure of SAS. Diet, chill temperature, and the interaction of diet x chill temperature were treated as fixed effects. Carcass measurements collected at 24 h were analyzed as a split-plot design with diet as the whole-plot factor and chill temperature as the subplot factor. For comparisons pertaining to measurements over time, a split-split-plot analysis was conducted to account for repeated measures. Diet served as the whole-plot factor, chill temperature as the subplot factor, and time as the sub-subplot factor. Satterthwaite adjusted degrees of freedom were used during Mixed procedure analysis to test significance among main effects and interactions. All main effect and interaction means were separated using least squares procedures when the respective F-tests were significant ($P<.05$).

Results and Discussion

Growth Performance and Carcass Traits. Supplementation of swine diets with 91 IU *d*-α-tocopheryl acetate/lb of feed for 42, 56, or 70 d prior to slaughter did not influence growth and feeding characteristics compared to control pigs fed 12 IU/.b of feed. No differences ($P>.10$) in ADG, ADFI, and F/G ratio resulted from dietary vitamin E supplementation over the duration of the trial. Carcass slaughter measurements also were similar ($P>.10$) among dietary groups (Table 1), presumably because of the lack of differences in growth rate.

Serum α-Tocopherol Concentration and Proximate Analysis. Plasma α-tocopherol concentration was influenced by dietary vitamin E supplementation. α-Tocopherol concentrations were higher ($P<.05$) in plasma from pigs supplemented with 91 IU *d*-α-tocopheryl acetate/lb of feed for 70 d than in plasma from control pigs (12 IU/lb of feed for 70 d). Plasma α-tocopherol concentrations for supplemented and control pigs were 6.4 ± .10 μg/ml and 4.0 ± .09 μg/ml, respectively. The plasma α-tocopherol concentration of pigs supplemented with 200 IU/kg of feed was as predicted. However, the plasma α-tocopherol concentration for pigs fed the control diet was higher than expected. This related to higher than expected α-tocopherol concen-

trations in the control diet. Diet also did not influence (P>.10) proximate analysis values of loin muscles.

Carcass Chill Rate. Sides chilled at 0°C cooled faster (P<.01) during the first 2 h in the cooler compared to those chilled at 4.4°C when monitored at LM1.27, LM3.81, and H2.54. After this time period, side chill rates were similar (P>.10). Temperatures taken at H7.62 were numerically lower at 3, 6, and 12 h postmortem for sides chilled at 0°C, although not statistically different (P>.05) from those chilled at 4.4°C. However, temperatures at all locations were lower (P<.01) for carcasses chilled at 0°C compared to 4.4°C at 24 h postmortem.

Loin Muscle Quality Traits. Visual color, marbling, lean firmness/wetness, and fat firmness values did not differ (P>.10) as a result of dietary vitamin E supplementation. Although visual color values were similar (P>.10), pork sides chilled at 0°C exhibited more (P<.01) visual marbling in a firmer, drier loin muscle. The backfat of sides chilled at 0°C also was firmer (P<.01) compared to sides chilled at 4.4°C (Table 2). No diet × chill temperature interaction was detected (P>.10). Sides chilled at 0°C also exhibited less (P<.01) loin muscle surface moisture exudate compared to those chilled at 4.4°C (Table 2). Neither a diet main effect nor a diet × chill temperature interaction was detected. The improvements in visual pork quality and loin muscle surface moisture exudate are attributable to lower (P<.01) loin muscle temperatures after 24 h of chilling at 0°C compared to 4.4°C, because ultimate carcass pH values did not differ (P>.10).

Diet and chill temperature main effect means were similar (P>.10) for CIE $L^*a^*b^*$ measures, saturation index, and hue angle at 24 h postmortem. Although neither a chill temperature main effect nor diet × chill temperature interaction was detected (P>.10) for cooking loss, dietary treatment did impact cooking loss percentages. Chops from pigs supplemented with 91 IU/lb of feed for 56 d exhibited less (P<.01) cooking loss than chops from pigs in other dietary treatment groups. This lower percentage was difficult to attribute to vitamin E supplementation, because both the 42 and 70 d supplementation treatment groups were similar (P>.10) to controls.

Table 1. Effects of Duration of α-Tocopheryl Acetate Supplementation Swine Growth Performance and Carcass Characteristics[a]

	91IU α-Tocopheryl Acetate/Lb of Feed				
Item	Control	42 d	56 d	70 d	SE[b]
ADG, lb	2.09	1.90	1.90	1.90	.09
ADFI, lb	7.05	6.83	6.39	6.83	.18
G/F	3.37	3.600	3.36	3.59	.16
Slaughter wt., lb	261.9	263.0	257.9	261.0	4.15
Hot carcass wt., lb	198.9	199.3	195.3	199.1	3.33
Dressing percentage	75.9	75.6	75.7	76.3	.24
USDA grade	2.6	2.4	2.4	2.5	.07
Percentage lean (5% fat)	44.5	44.8	45.4	44.1	.67
Loin muscle area, in^2	5.30	5.50	5.38	5.10	.16
10^{th} rib fat thickness, in	1.40	1.40	1.32	1.41	.05

[a]No treatment differences (P>.05).
[b]Standard error.

Table 2. Effects of Chill Temperature on Measurements of 24 h Pork Carcass Quality

Item	Chill Temperature 0°C	Chill Temperature 4.4°C	SE[a]
Visual appraisal[b]			
Color	2.7	2.7	.04
Marbling	2.7[d]	2.3[e]	.04
Lean firmness/wetness	3.2[d]	2.9[e]	.06
Fat firmness	3.8[d]	3.6[e]	.03
Loin muscle moisture exudate, g	.044[d]	.052[e]	.00
CIE color measurements[c]			
L*	50.5	50.0	.18
a*	8.3	8.2	.07
b*	5.4	5.3	.07
Saturation index	9.9	9.8	.11
Hue angle	33.1	32.9	.24

[a]Standard error.
[b]Scores of 1 to 5: 2 = grayish pink, traces to slight, or soft and watery; 3 = reddish pink, small to modest, or slightly firm and moist; and 4 = purplish red, moderate to slightly abundant, or firm and moderately dry.
[c]Measure of dark to light (L*), redness (a*), yellowness (b*), vividness or intensity (saturation index), or red to orange (hue angle).
[de]Means in the same row with a different superscript letter differ (P<.05).