EFFECTS OF MODIFIED TALL OIL AND VITAMIN E ON GROWTH PERFORMANCE AND CARCASS CHARACTERISTICS OF GROWING-FINISHING BARROWS[1]

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Summary

A trial was conducted to investigate the interactive effects of modified tall oil (MTO) and vitamin E on growth performance and carcass characteristics of growing-finishing barrows. Feeding MTO resulted in increased ADG and improved F/G during the growing phase; otherwise dietary treatment did not affect growth performance during the rest of the trial or overall. Feeding MTO also decreased backfat thickness and increased belly firmness. Increasing vitamin E in diets containing MTO decreased drip loss percentage of the loin. These results indicate that MTO may function as a growth promoter; reduce backfat; and in conjunction with vitamin E, improve some aspects of meat quality.

(Key Words: Modified Tall Oil, Vitamin E, Growth Performance, Carcass Characteristics.)

Introduction

Modified tall oil is an oily coproduct resulting from the kraft (sulfate) paper process and contains high levels (~70%) of conjugated linoleic acid. Prior work at Kansas State University has shown MTO to be a potent carcass modifier in terms of reducing backfat and increasing carcass lean content. One of these earlier reports showed decreases in drip loss percentage resulting from feeding MTO. Thus, we postulated that MTO could be affecting membrane stability and(or) permeability. Furthermore, feeding elevated levels of vitamin E is a common method of trying to improve fresh pork color through its antioxidant properties. Therefore, this study was conducted to determine if feeding MTO and elevated levels of vitamin E would improve growth performance and carcass characteristics, as well as drip loss percentage and fresh pork color in finishing weight barrows.

Procedures

Procedures used in this experiment were approved by the Kansas State University Institutional Animal Care and Use Committee (Protocol No. 1480). A total of 72 crossbred barrows (initially 100 lb; PIC L326 or 327 × C22, Franklin, KY) were used. Pigs were blocked on the basis of initial weight and ancestry and randomly allotted to one of six dietary treatments with six replicate pens per treatment. Previously, pigs had been fed diets containing about 40,000 IU/ton of vitamin E from weaning (21 days of age) to 50 lb and 32,000 IU/ton from 50 to 100 lb.

Diets were fed in meal form in two phases (100 to 180 and 180 to 260 lb; Table 1). Modified tall oil and vitamin E were substituted on an equal weight basis for cornstarch to achieve the experimental diets, which were arranged in a 2 × 3 factorial

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design with two levels of MTO (0 or 0.50%) and three levels of added vitamin E (0, 20,000, or 100,000 IU/ton). Dietary additions of vitamin E were made with dl-∝-tocopherol acetate. The vitamin premix typically used in diets manufactured at Kansas State University was modified so that it did not contain any vitamin E; thus, the only vitamin E present in the basal diets was that contributed by the corn and soybean meal. All diets were analyzed for vitamin E content (Table 2). This analysis showed that the corn and soybean meal used in this study contributed 12,700 to 15,000 IU of vitamin E per ton. Bioavailability of the vitamin E found in corn and soybean meal is assumed to be low. Using ADFI in Table 3, a mean vitamin E intake/day was calculated. As expected, vitamin E intakes were dramatically increased with increasing level of dietary vitamin E.

Pigs were housed in an environmentally controlled finishing barn with two pigs in each 4 ft × 4 ft totally slatted-floored pen. They were allowed ad libitum access to feed and water through one single-hole self-feeder and a nipple waterer. Pigs were weighed every 14 d in order to determine ADG, ADFI, and F/G.

Pigs were slaughtered when their average weight reached 260 lb. Standard carcass measurements; visual analyses of the longissimus muscle for coloring, marbling, and firmness; longissimus drip loss, and color spectrophotometry were determined for each pig at 28 h postmortem (drip loss = 48 h postmortem). During fabrication of the carcasses (26 h postmortem), the bellies from the right sides of all carcasses were removed and evaluated for firmness.

Data were analyzed as a randomized complete block. Pen was the experimental unit for all calculations. The GLM procedures of SAS were used for all analyses. The data were analyzed as a 2 × 3 factorial with main effects of MTO (0 or 0.50% of the total diet) and vitamin E (0, 20,000, or 100,000 IU added vitamin E/ton of feed). The statistical model included main effects and interactions of the main effects. Hot carcass weight was used as a covariate in the statistical model for carcass analyses. Belly weights and lengths were used as covariates in the statistical model for belly firmness analyses.

Results and Discussion

Growth Data. From 100 to 180 lb, pigs fed diets containing MTO grew faster (P = .03) and were more efficient (P = .09) than pigs fed diets that did not contain MTO regardless of vitamin E level (Table 3). Dietary treatment did not affect (P>.15) growth performance from 180 to 260 lb or for the overall trial.

Carcass Characteristics. Feeding MTO, regardless of level of vitamin E, reduced (P<.01) average backfat (Table 4); similar responses were observed for the constituent components of average backfat (first and last rib and last lumbar backfat). Three interactions of MTO and vitamin E were observed for the longissimus muscle. Adding increasing levels of vitamin E to diets containing MTO increased firmness (P=.04) and marbling (P=.07) of the longissimus muscle and decreased (P=.02) drip loss percentage compared to increasing levels of vitamin E but not MTO. Other carcass characteristics such as shrink loss, dressing percentage, longissimus muscle color, calculated lean percentage, and longissimus muscle area (LMA) were not affected (P>.10) by dietary treatment. Modified tall oil increased belly firmness, both initially (P=.01) and at 1- and 5- minute intervals (P<.05), regardless of level of vitamin E.

Similar to prior reports, feeding MTO did not seem to permanently improve or change growth performance; thus, its effects on carcass composition are not related to changes in growth rate or food intake.

Some aspects of the interpretation of data were made difficult by the quality of the pigs fed the control diet with neither MTO nor additional vitamin E. The three interactions of MTO and vitamin E observed in carcass characteristics are difficult to explain because adding vitamin E to diets not containing MTO decreased marbling and firmness and increased drip loss, whereas adding vitamin E to diets containing MTO improved these same characteristics. However, the best quality for these three traits generally occurred for the group of pigs fed neither feed additive. This may have been because of the high vitamin E content of the diets fed to the pigs before this experiment was started. Feeding elevated levels of vitamin E without MTO worsened ($P<.05$; Table 4) b* and saturation index values, whereas feeding elevated levels of vitamin E with MTO improved these same two values. The difference in saturation index values indicates a more brightly colored product from feeding the combination of MTO and vitamin E, and the improvements in b* values may indicate a delay in intramuscular marbling lipid oxidation. Results of a study with rats (pg. 143) indicate that MTO facilitates the incorporation of vitamin E into adipose tissues. This would have profound effects on meat quality in terms of increasing shelf-life and decreasing off-flavors associated with lipid oxidation. However, feeding increasing levels of vitamin E did not increase ($P>.15$) incorporation of vitamin E into longissimus tissue (Table 3). The extra vitamin E was either being excreted or deposited elsewhere in the body.

These results indicate that feeding MTO may improve growth performance and will decrease backfat and increase belly firmness in crossbred finishing barrows. Feeding a combination of high levels of vitamin E and MTO may improve some aspects of meat quality. Furthermore, feeding the combination of MTO and vitamin E also may remove some of the inconsistencies typically observed in meat quality from feeding elevated levels of vitamin E alone.

Table 1. Compositions of Basal Diets (As-Fed Basis)

Ingredient, %	Growing (180 to 180 lb)	Finishing (180 to 260 b)
Corn	68.76	78.08
Soybean meal (46.5% CP)	27.50	18.43
Limestone	1.05	.88
Cornstarch[a]	1.00	1.00
Monocalcium phosphate	.86	.78
Salt	.35	.35
Vitamin premix[b]	.20	.20
Trace mineral premix	.15	.15
Antibiotic[c]	.13	.13
Total	100.00	100.00
Calculated analysis, %		
Lysine	1.00	.75
Calcium	.65	.55
Phosphorus	.55	.50

[a]MTO and vitamin E were substituted on an equal weight basis for cornstarch to give the additional dietary treatments.
[b]The vitamin premix did not contain any vitamin E.
[c]Provided 100 g/ton tylosin.

Table 2. Analyzed Vitamin E Contents of Diets and Daily Vitamin E Intakes

	0 MTO + Vit. E, IU/ton			.50% MTO + Vit. E, IU/ton		
Item	0	20,000	100,000	0	20,000	100,000
100 to 180 lb						
Dietary E, IU/ton	12,701	40,642	89,359	13,154	36,741	81,466
E intake, mg/d	41	131	284	42	123	261
180 to 260 lb						
Dietary E, IU/ton	14,969	35,834	91,627	14,515	38,284	87,091
E intake, mg/d	59	147	370	57	159	341

Table 3. Growth Performance of Pigs Fed Increasing Levels of MTO or Vitamin E[a]

	0 MTO + Vit. E, IU/ton			.50% MTO + Vit. E, IU/ton				Probability Values (P =)		
Item	0	20,000	100,000	0	20,000	100,000	CV	MTO × E	MTO	E
100 to 180 lb										
ADG, lb	2.56	2.58	2.60	2.63	2.74	2.70	5.32	.68	.03	.51
ADFI, lb	6.41	6.47	6.35	6.41	6.67	6.41	4.20	.68	.34	.20
F/G	2.51	2.52	2.45	2.44	2.44	2.38	4.90	.98	.09	.39
180 to 260 lb										
ADG, lb	2.45	2.55	2.40	2.38	2.55	2.39	8.27	.90	.65	.16
ADFI, lb	7.92	8.20	8.07	7.87	8.30	7.82	7.39	.77	.73	.29
F/G	3.24	3.22	3.36	3.32	3.27	3.28	4.85	.45	.73	.48
100 to 260 lb										
ADG, lb	2.51	2.56	2.50	2.51	2.64	2.55	5.06	.75	.33	.18
ADFI, lb	7.17	7.33	7.20	7.14	7.48	7.12	5.37	.75	.93	.21
F/G	2.86	2.86	2.88	2.85	2.83	2.79	3.57	.60	.22	.92

[a]Values are means of two pigs per pen and six replicate pens per dietary treatment.

Table 4. Carcass Characteristics of Pigs Fed Increasing Levels of MTO or Vitamin E[a,b]

	0% MTO + Vit. E, IU/ton			.50% MTO + Vit. E, IU/ton				Probability Values (P =)		
Item	0	20,000	100,000	0	20,000	100,000	CV	MTO × E	MTO	E
Shrink loss, %	1.90	1.81	1.83	1.94	2.02	1.91	10.66	.77	.21	.71
Dressing %	74.99	75.13	75.23	75.24	75.44	74.98	1.14	.72	.93	.97
Backfat, in										
First rib	1.60	1.55	1.48	1.42	1.50	1.48	6.64	.13	.03	.57
Last rib	1.07	1.02	.98	.95	.98	.92	7.90	.61	.004	.12
Last lumbar	.92	.90	.85	.83	.86	.81	12.64	.92	.09	.43
10th rib	1.05	1.01	.98	.92	.98	.96	12.28	.52	.11	.89
Average[c]	1.19	1.16	1.10	1.07	1.12	1.07	6.13	.29	.004	.16
LMA, in^2	5.41	5.53	5.42	5.49	5.55	5.59	7.02	.65	.78	.90
Lean, %[d]	48.41	48.96	49.14	49.97	49.23	49.71	3.61	.65	.20	.90
Visual color[e]	2.54	2.25	2.08	2.29	2.29	2.46	15.85	.13	.59	.65
Firmness[e]	2.79	2.17	2.21	2.48	2.38	2.63	13.89	.04	.33	.09
Marbling[e]	2.38	2.08	2.08	2.17	2.13	2.50	14.17	.07	.43	.34
L*[f]	58.34	60.00	58.25	58.87	59.54	57.73	4.09	.83	.85	.20
a*[f]	9.47	10.21	10.87	10.55	9.98	10.28	10.77	.16	.81	.41
b*[f]	16.99	18.97	19.09	18.69	18.15	17.98	7.17	.03	.86	.33
Hue angle[f]	60.86	61.77	60.51	60.55	61.17	60.29	2.92	.96	.53	.33
Saturation index[f]	19.47	21.55	21.98	21.47	20.72	20.72	7.57	.04	.95	.38
a*/b*[f]	.56	.54	.57	.57	.55	.57	7.44	.95	.58	.32
630/580[f]	2.60	2.66	2.81	2.71	2.65	2.71	6.57	.40	.96	.26
Drip loss, %	3.05	5.12	3.93	4.71	4.37	3.46	27.87	.02	.97	.26
Belly firmness, in										
Initial	14.92	15.07	13.88	17.32	17.11	16.59	16.82	.93	.01	.59
1 min	13.53	13.32	12.38	14.63	15.42	14.65	18.10	.77	.04	.63
5 min	12.25	12.02	11.26	13.15	13.98	13.36	17.80	.73	.04	.69
Longissimus vitamin E content (µg/g)	10.92	12.33	11.25	8.42	11.17	7.83	51.00	.87	.19	.52

[a]Values are means of two pigs per pen and six replicate pens per dietary treatment. [b]Hot carcass weight was used as a covariate in the statistical model for carcass characteristics and belly weights and lengths were used as covariates in the statistical model for belly firmness. [c]Average backfat is the average of the first and last rib and last lumbar fat depths. [d]Lean percentage was derived from NPPC (1991) equations with 5% fat in the carcass. [e]Scale of 1 to 5: 2 = grayish pink, soft and watery, or traces to slight; 3 = reddish pink, slightly firm and moist, or small to modest; and 4 = purplish red, firm and moderately dry, or moderate to slightly abundant for color, firmness, and marbling, respectively. [f]Means were derived from two sample readings per loin. Measures of dark to light (L*), redness (a*), yellowness (b*), red to orange (hue angle), vividness or intensity (saturation index), and reflectance values (630/580).