EFFECTS OF MODIFIED TALL OIL AND SUPPLEMENTAL MAGNESIUM ON GROWTH PERFORMANCE, CARCASS CHARACTERISTICS, AND MEAT QUALITY OF GROWING-FINISHING GILTS[1]

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Summary

A trial was conducted to evaluate the effects of feeding modified tall oil (MTO) and supplemental magnesium (Mg) on growth performance, carcass characteristics, and meat quality of finishing gilts. No effect of treatment was observed on ADG, ADFI, or F/G during the growth trial. Feeding MTO reduced average backfat and increased intramuscular marbling, whereas supplemental Mg reduced first rib backfat (but not average backfat) and postmortem levels of glycogen in the longissimus muscle. Additionally, Mg altered whole blood metabolic profiles in a manner that should improve meat quality, although improvements in pH, drip loss, and color were not observed in this trial.

(Key Words: Gilts, Modified Tall Oil, Magnesium, Meat Quality.)

Introduction

Modified tall oil has been shown previously to improve carcass leanness and potentially growth performance of growing-finishing pigs. Additional studies have shown that MTO positively influences display color stability, potentially by altering the way vitamin E is absorbed into the tissues. Recent work from Australia has shown that short-term administration of large doses of supplemental Mg fed to pigs about a week prior to slaughter improve fresh pork color and decrease drip loss percentage. Therefore, this trial was conducted to determine if feeding MTO and Mg together was a viable method for improving growth performance, carcass characteristics, and meat quality in crossbred growing-finishing gilts.

Procedures

Pigs used in this experiment were terminal offspring of PIC L326 or 327 boars × C22 sows (PIC, Franklin, KY). Experimental procedures were approved by the Kansas State University Institutional Animal Care and Use Committee (Protocol No. 1593).

A total of 80 crossbred gilts (initially 101 lb BW) was used in this study. Pigs were blocked on the basis of initial weight and ancestry in a randomized complete block design and randomly allotted to one of four dietary treatments arranged as a 2 × 2 factorial with 10 replicate pens per treatment. Two of the four dietary treatments were not implemented until 7 days preslaughter; thus, there were 20 pens per dietary treatment until the Mg supplementation began.

Diets were fed in meal form in two phases (101 to 168 and 168 to 260 lb BW; Table 1). The preselected pens of pigs were changed to the Mg-supplemented diets at 7 days preslaughter. At this time, pigs averaged 252 lb BW. Modified tall oil was

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substituted on an equal weight basis for soybean oil and $KMgSO_4$ was substituted on an equal weight basis (2% of the total diet) for ground corn to achieve the additional dietary treatments. The level of supplemental Mg chosen for this experiment was based on a small pilot study (data not shown) using three levels (1, 2, or 4%) of $KMgSO_4$. Feeding 2% $KMgSO_4$ elicited a 10% increase in serum Mg without reducing ADFI. Analysis of the $KMgSO_4$ indicated that it contained 17.9% K, 12.8% Mg, and 24.1% S.

Pigs were housed in an environmentally controlled finishing barn with two pigs in each 4 ft × 4 ft totally slatted-floored pen. Pigs were allowed ad libitum access to feed and water through one single-hole self-feeder and a nipple waterer, respectively. Pigs were weighed every 14 d in order to determine ADG, ADFI, and F/G. Pigs also were weighed at the beginning and end of the Mg supplementation period. Serum samples were obtained from each pig at the beginning of the Mg supplementation period and again 5 days later for the determination of initial and final Mg levels, respectively. Blood samples also were obtained on the fifth day of Mg supplementation for the determination of whole blood metabolic profiles. Feed was not withheld from pigs prior to blood sampling. Whole blood profiles were determined within 20 minutes of sampling, and serum Mg samples were stored frozen until analyzed.

One pig (closest to the average of all pigs) per pen was slaughtered after 7 days of receiving supplemental Mg (average weight of pigs at slaughter was 260 lb). Thirty minutes after exsanguation, a 1-inch core of the longissimus muscle, which corresponded to the last rib, was removed from each pig, dipped in liquid nitrogen, placed on dry ice, and ultimately stored at -70°C until analyzed for glycogen and lactic acid content. Standard carcass measurements; visual analyses of the longissimus for coloring, marbling, and firmness; drip loss; and Minolta color spectrometry (L*, a*, and b*) were obtained for each pig 24 h postmortem (drip loss = 48 h postmortem).

Data were analyzed as a randomized complete block. Pen was the experimental unit for the growth performance data and individual pig for the carcass characteristics. The GLM procedure of SAS was used for the single degree of freedom contrast between the two dietary treatments during the growth trial. All subsequent data were analyzed as a 2 × 2 factorial arrangement with main effects of MTO (0 or .50% of the diet) or supplemental Mg (0 or 7.75 g of elemental Mg/d for 7 days preslaughter). 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 analysis.

Results and Discussion

Growth Performance. Modified tall oil did not affect (P>.15) ADG, ADFI, or F/G during the growth trial, and the addition of Mg also did not affect (P>.10) these parameters. Thus, growth performance data are presented in Table 2 in a combined format.

Carcass Characteristics and Meat Quality. Feeding MTO reduced (P<.05) first and tenth rib backfat and average backfat (Table 3). Feeding supplemental Mg also reduced (P=.05) first rib backfat and resulted in an interaction (P=.03) with MTO for last lumbar backfat; Mg reduced it in diets containing MTO but increased it in diets not containing MTO. Interactions of MTO and Mg were also observed for lean percentage (P=.10) and dressing percentage (P=.05). Both were increased by Mg in diets containing MTO but reduced in diets not containing MTO. Feeding MTO increased (P=.04) intramuscular marbling, and supplemental Mg decreased (P=.04) longissimus glycogen content. Magnesium supplementation increased (P=.0001) serum Mg levels by about 7% over those of pigs fed diets without supplemental Mg. Other carcass characteristics and meat quality measures were not affected (P>.10) by dietary treatment.

Blood Gas and Metabolic Profiles. Feeding MTO increased (P=.05) glucose levels in the whole blood (Table 4). Magnesium supplementation decreased (P<.10) pH,

BUN, and base excess and increased (P<.10) K^+, ionized Mg^{++}, and lactate.

The results of this trial indicate that MTO and(or) Mg did not influence growth performance but did reduce backfat. Additionally, MTO may positively influence some measures of meat quality, such as increasing intramuscular marbling. These responses to dietary supplementation with MTO are in general agreement with prior work. Among six other reports, three noted improvements in growth performance (combinations of ADG, ADFI, and F/G) from MTO, and none reported decreases in performance. In addition, MTO also reduced backfat in three of those studies. We should note that the improvements in growth performance from feeding MTO were not necessarily coupled with the decreases in backfat. Thus, feeding MTO may improve growth performance, reduce backfat, or both. Feeding MTO increased belly firmness in all four studies in which that measurement was taken, regardless of level or source of supplemental fat present in the diets. Although improvements in color, drip loss percentage, and pH were not observed in this study, supplementing diets fed to swine with Mg may be beneficial to the overall quality of the final retail product. The postmortem reduction in longissimus glycogen content by Mg should reduce the amount of lactate produced in the muscle, thereby maintaining a higher pH and reducing drip loss percentage while maintaining color stability. More research needs to be conducted with both feed additives to determine their full value in improving overall meat quality.

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

Ingredient, %	Growing[a]	Finishing[b]	7-d Preslaughter[c]
Corn	69.24	78.58	76.58
Soybean meal (46.5% CP)	27.47	18.39	18.39
Limestone	1.06	.89	.89
Monocalcium phosphate	.85	.76	.76
Soybean oil[d]	.50	.50	.50
Salt	.35	.35	.35
Vitamin premix	.25	.25	.25
Trace mineral premix	.15	.15	.15
Antibiotic[e]	.13	.13	.13
$KMgSO_4$[f]	----	----	2.00
Total	100.00	100.00	100.00

[a]Growing diets were fed from 101 to 101 lb BW and were formulated to contain 1.00% lysine, .65% Ca, and .55% total P.
[b]Finishing diets were fed from 101 to 252 lb BW and were formulated to contain .75% lysine, .55% Ca, and .50% total P.
[c]Diets were fed for 7 days prior to slaughter (252 to 260 lb BW) and were formulated to contain .75% lysine, .55% Ca, and .50% total P.
[d]Soybean oil was substituted on an equal weight basis for MTO to give the experimental treatments.
[e]Provided 100 g/ton tylosin.
[f]$KMgSO_4$ was substituted on an equal weight basis (2% of total diet) for corn during the last 7 days of the finishing period to achieve the additional dietary treatments.

Table 2. Growth Performance of Gilts Fed MTO[a]

Item	MTO, %		CV	Contrast Probability (P =)
	0	.50		
101 to 260 lb BW				
ADG, lb	2.20	2.14	5.62	.24
ADFI, lb	6.26	6.08	6.30	.16
F/G	2.86	2.86	4.87	.63

[a]Values are means for two pigs per pen and 20 replicate pens per treatment.

Table 3. Carcass Characteristics of Gilts Fed MTO, $KMgSO_4$, or Both[a,b]

Item	0 MTO/mg		.50% MTO/mg		CV	Probability Values (P =)		
	0	7.75g/d	0	7.75 g/d		MTO×Mg	MTO	Mg
Shrink loss, %	1.30	1.16	.91	1.10	76.08	.58	.45	.94
Backfat, in								
First rib	1.54	1.50	1.46	1.35	7.89	.34	.004	.05
Tenth rib	.74	.85	.70	.67	18.00	.12	.02	.34
Last rib	.85	.86	.82	.79	13.72	.60	.18	.77
Last lumbar	.67	.75	.73	.64	16.91	.03	.52	.91
Average[c]	1.02	1.04	1.00	.92	10.00	.15	.05	.35
LMA, in^2	6.73	6.65	6.69	7.22	10.04	.20	.17	.29
Lean %[d]	54.03	52.90	54.53	55.84	4.19	.10	.02	.90
Dressing %	74.99	74.76	73.71	75.49	2.00	.05	.66	.10
Visual color[e]	2.60	2.55	2.55	2.70	21.27	.55	.82	.78
Firmness[e]	2.55	2.55	2.80	2.75	26.24	.92	.33	.91
Marbling[e]	1.95	2.25	2.45	2.45	22.04	.37	.04	.36
L*[f]	53.73	53.50	53.59	54.77	6.12	.53	.54	.64
a*[f]	12.71	14.53	12.99	12.68	18.60	.19	.31	.34
b*[f]	8.59	9.76	8.55	8.61	24.07	.41	.41	.37
Hue angle[f]	33.98	33.50	33.08	34.02	7.65	.42	.91	.76
Saturation index[f]	15.35	17.53	15.57	15.34	19.92	.24	.33	.34
a*/b*[f]	1.49	1.53	1.55	1.49	9.97	.33	.96	.78
Drip loss, %	5.64	6.20	5.79	6.34	36.36	.99	.84	.44
Carcass length, in	32.50	32.68	32.68	32.93	2.63	.95	.37	.42
Muscle metabolites								
Glycogen, mg/g	4.77	4.13	4.85	3.75	29.61	.55	.69	.04
Lactic acid, mg/g	4.12	4.00	3.90	3.74	21.69	.94	.38	.59
Serum Mg, mg/L[g]								
Initial	20.59	20.47	20.37	20.84	4.15	.28	.79	.53
Final	21.27	22.37	20.85	22.91	3.85	.53	.36	.0001

[a]Values represent one pig per pen and 10 replicate pens per treatment.
[b]Hot carcass weight was used as a covariate in the statistical analysis.
[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]Scoring system 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 for color, firmness, and marbling, respectively.
[f]Means were derived from three sample readings per loin. Measures of dark to light (L*), redness (a*), yellowness (b*), red to orange (hue angle), or vividness or intensity (saturation index).
[g]Values are means of two pigs per pen and 10 replicate pens per treatment.

Table 4. Whole Blood Profiles of Gilts Fed MTO, $KMgSO_4$, or Both[a]

	0 MTO/mg		.50% MTO/mg			Probability Values (P =)		
Item	0	7.75 g/d	0	7.75 g/d	CV	MTO×Mg	MTO	Mg
pH	7.395	7.383	7.398	7.368	.40	.36	.55	.04
PCO_2, mmHg	56.5	57.7	55.5	58.8	8.20	.50	.97	.14
PO_2, mmHg	44.5	49.3	47.0	42.8	23.25	.20	.57	.92
Oxygen saturation, %	75.6	76.1	75.6	70.9	9.60	.27	.27	.39
Hematocrit, %	41	41	41	41	6.41	.83	.70	.55
Hemoglobin, g/dL	13.6	13.4	13.7	13.5	6.34	.78	.76	.48
Na^+, mmol/L	146	147	147	147	.79	.63	.38	.18
K^+, mmol/L	5.0	5.1	4.9	5.1	5.91	.73	.63	.10
Cl^-, mmol/L	102	103	103	103	.79	.69	.35	.98
Ionized Ca^{++}, mg/dL	5.34	5.36	5.32	5.42	2.68	.37	.65	.20
Ionized Mg^{++}, mg/dL	.88	.98	.92	.97	12.85	.51	.81	.07
Glucose, mg/dL	97	92	98	98	5.58	.20	.05	.16
Lactate, mmol/L	2.5	2.9	2.7	3.9	44.30	.30	.19	.08
BUN, mg/dL	14	11	14	11	19.88	.99	.95	.01
Osmolarity, mOsm/kg	291	291	292	292	.96	.87	.37	.96
Anion gap, mmol/L	14.4	15.0	14.7	16.0	6.68	.37	.05	.008
HCO_3^-, mmol/L	34.7	34.4	34.2	33.7	3.30	.74	.13	.31
Oxygen content, mL/dL	15.1	15.2	15.1	14.2	9.72	.28	.29	.41
Total CO_2, mmol/L	36.4	36.2	35.9	35.6	3.33	.83	.15	.49
Alveolar oxygen, mmHg	76.3	74.7	77.4	73.5	7.38	.51	.98	.14
Base excess-WB, mmol/L[b]	8.4	8.0	8.2	7.1	13.99	.41	.11	.04
Base excess-ECF, mmol/L[c]	9.6	9.2	9.2	8.3	13.34	.51	.10	.08

[a]Values represent one pig per pen and 10 replicate pens per treatment.

[b]Base excess in the whole blood.

[c]Base excess in the extracellular fluid.