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EFFECTS OF MODIFIED TALL OIL ON GROWTH AND BODY COMPOSITION IN ADULT OVARIECTOMIZED RATS[1]

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Summary

A trial was conducted to evaluate the effects of modified tall oil (MTO) on growth and body composition of adult ovariectomized rats. This trial was targeted as a model for postmenopausal women; thus, only data applicable to swine production are presented herein. Feeding MTO decreased adiposity, increased concentrations of certain lipids in tissues, increased vitamin E (∝-tocopherol) levels in the adipose, and increased actual lean content. These data lend support to the carcass leanness and meat quality improvements routinely seen in swine from feeding MTO.

(Key Words: Rats, Modified Tall Oil, Vitamin E, Conjugated Linoleic Acid.)

Introduction

Modified tall oil is an oily coproduct from the kraft (sulfate) paper process and contains relatively high amounts (~70%) of conjugated linoleic acid. Work in pigs has shown that MTO is a potent carcass modifier in terms of reducing backfat and increasing lean percentage. However, all work with MTO has been conducted with young growing pigs up to market weight and slaughter at 235 to 260 lb BW. The observed reductions in backfat coupled with increases in lean content would be of tremendous interest in humans, but especially in post-menopausal women. These women are typically beset with increases in adiposity and particularly an increased susceptibility to abdominal fat gains. The potential uses of MTO would be expanded dramatically if it could be shown to reduce adiposity in a model representing postmenopausal women. Additionally, prior research has shown that MTO alters the metabolism of vitamin E. Vitamin E is taken routinely as an antioxidant and dietary supplement for people. Therefore, the current experiment was undertaken to investigate the roles of MTO in growth and body composition in a rat model used to mimic postmenopausal women.

Procedures

Procedures used in this experiment were approved by the Kansas State University Institutional Animal Care and Use Committee (Protocol No. 1531). A total of 26 adult female Sprague-Dawley rats (initially 256.8 g BW; Harlan Sprague Dawley, Indianapolis, IN) was used. Rats were blocked on the basis of initial weight and assigned to one of two dietary groups with 13 rats per group.

The basal diet was purchased from a commercial supplier and fortified with zinc carbonate to achieve a Zn level of 32 ppm. This diet was fed from the time the rats arrived until the initiation of the test. The basal diet was modified as follows to achieve the two experimental diets (Table 1). An oil

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mixture (soybean oil and fatty acids or MTO and fatty acids) was included at 1% of the total diet. The fatty acid profiles of the MTO and soybean oil were determined so that diets could be matched in fatty acid profile. This ensured that any biological responses observed in the trial were attributable only to the conjugated linoleic acid isomers present in MTO. Both oil mixtures contained 6.9 mg vitamin E (∝-tocopherol)/100 g of oil mixture.

Table 1. Composition of Basal Diet (As-Fed Basis)[a]

Ingredient	Percent
Egg white	20.00
Cornstarch	39.65
Dextrinized cornstarch	13.20
Dextrose	10.00
∝-Tocopherol-stripped soybean oil	7.00
Cellulose	5.00
Mineral mix[b]	3.50
Vitamin mix	1.00
Biotin (1 mg/g biotin sucrose mix)	.40
Choline bitartrate	.25

[a]The two experimental diets were made by adding either 1% soybean oil mixture (containing 2.98% oleic acid, 17.18% linoleic acid, and 79.84% ∝tocopherol-stripped soybean oil) or 1% MTO mixture (containing 9.0% palmitic acid, 4.5% stearic acid, 7.8% linolenic acid, and 78.70% MTO) to the purchased diet, which was fed during the adaptation and recovery periods only. The fatty acid additions were necessary to balance each diet in fatty acid profiles. Pure ∝-tocopherol was added to each oil mixture at the rate of 6.9 mg/100 g of oil mixture.
[b]As purchased, the mineral mix was Zn-free. Zinc carbonate was added to the diet to achieve a Zn level of 32 ppm.

Rats were placed individually in plastic cages with stainless-steel wire bottoms and given a 12-h light:dark cycle. These cages were housed in a laboratory accredited by the American Association for the Accreditation of Laboratory Animal Care. Rats were ovariectomized and given a recovery period prior to the initiation of the trial. Rats were trained to feed at certain times after the final determination of ad libitum intake. Thus, rats were pair fed twice daily for the duration of the 6-week trial at the rate of 90% of determined ad libitum intake (15 g/d; 6 g at 0900 and 9 g at 1630) and were offered free access to deionized water through a stainless-steel nipple watering system. Rats were weighed weekly to determine gain and efficiency of gain.

Six rats per group (randomly selected) were euthanized at 6 weeks for the collection of brain, heart, kidneys, liver, gastrocnemius muscle, and retroperitoneal and abdominal fat pads to determine cholesterol, phospholipids, and ∝-tocopherol levels. These data are not reported herein. Additionally, six rats per group (randomly selected) were transported to Oklahoma State University and allowed to adapt to respiration chambers. Once respiration rates stabilized, a respiration study for 44 h without food began. These data also are not reported herein. Upon termination of the respiration measurements, rats were euthanized and scanned via dual energy X-ray absorptiometry (DEXA) to determine body composition (fat, fat-free, and bone mineral contents).

Data were analyzed using paired *t*-tests. Individual rats were the experimental units for all observations.

Results and Discussion

By 3 weeks, rats fed MTO had reduced ($P<.05$) body weight; this trend continued for the duration of the 6-week trial (Figure 1). Rats were pair-fed; thus, potential differences from feed intakes were not a factor. Feed refusals were not observed in the current study, and rats quickly consumed their meals. This decrease in body weight gain from feeding MTO would be an advantage to postmenopausal women. Conjugated linoleic acid, which comprises about 70% of MTO, is known to influence growth depend-

ent upon the type of animal used. Thus, it is not surprising that MTO can be used to promote growth and carcass leanness in growing swine, but also slow body weight gain and adiposity in adult ovariectomized rats.

The rats (randomly selected) for body composition analyses were similar (P = .35) in weight (Table 2). Rats fed MTO had less fat, expressed either as total grams (P = .0001) or percentage (P = .0006). Rats fed MTO also had more fat-free mass, expressed either as total grams (P = .04) or percentage (P = .0007). On a percentage basis, rats fed MTO had about 21% less fat and about 5% more fat-free mass. Thus, the reduction in fat had the greatest impact on the improvements in leanness. This is in agreement with prior reports for pigs fed MTO. Bone mineral density and bone mineral content were not affected (P>.20) by dietary treatment, but the combined fat-free mass plus bone mineral content were higher (P = .07) for rats fed MTO.

Studies of pigs fed MTO also have shown increases in intramuscular marbling. In the current study, rats fed MTO had higher (P<.05) total cholesterol in the liver, kidneys, and fat depots and higher (P<.05) phospholipid content in the liver. Though no changes were observed in the muscle lipid content, these alterations may provide insight into the increases in intramuscular marbling routinely seen from feeding MTO to pigs.

A prior report with pigs demonstrated that feeding MTO in conjunction with elevated levels of vitamin E improved oxidation status and color and color stability of fresh pork. In the current study, rats fed MTO had enhanced (P≤.005) vitamin E (∝-tocopherol) levels in abdominal and retroperitoneal fat (134.11 vs 81.66 nmol/g and 128.51 vs 92.87 nmol/g for rats fed MTO and the control diet, respectively). This suggests that MTO preferentially shifts the deposition of vitamin E to the adipose tissues. Thus, fresh pork from pigs fed MTO should have improved display color characteristics because of the enhanced tissue incorporation of vitamin E.

In summary, feeding MTO to rats used to model postmenopausal women elicits many favorable biological responses. Chief among them are the reductions in weight gain and fat deposition and increases in fat-free mass. These results can be extended to swine production and used to help explain the improvements in carcass leanness and color improvements seen from feeding MTO to pigs.

Table 2. Body Composition of Rats Fed MTO[a]

Item	Dietary Group		Probability Value
	Control	MTO	(P =)
Body weight, g	293.82 ± 4.22	295.90 ± 12.37	.35
Bone mineral content (BMC), g	7.31 ± .26	7.24 ± .21	.32
Fat, g	54.02 ± 2.22	43.05 ± 3.93	.0001
Fat-free, g	232.50 ± 6.09	245.72 ± 14.50	.04
Fat-free + BMC, g	239.80 ± 6.13	252.97 ± 14.59	.07
Fat, %	18.40 ± .96	14.57 ± 1.72	.0006
Fat-free, %	79.12 ± 1.00	82.96 ± 1.75	.0007
Bone mineral density, g/cm^2	.137 ± .003	.136 ± .002	.24

[a]Values are means for 6 rats per dietary treatment group.

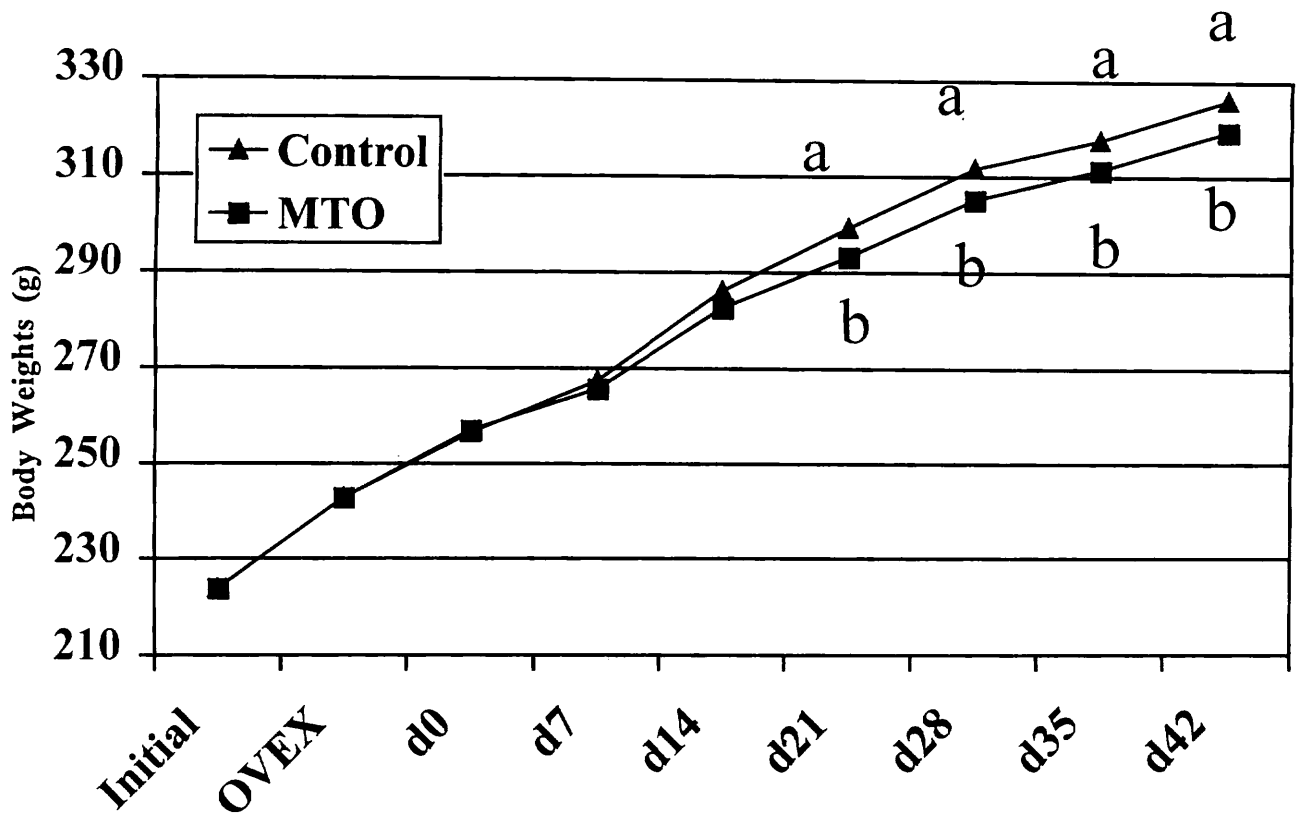

Figure 1. Weekly Body Weights (g) of Rats Fed MTO. Values are means of 13 rats/group; a and b indicate values significantly different at P≤.07.