THE EFFECTS OF DIETARY α-TOCOPHEROL AND TUNA, SAFFLOWER, AND LINSEED OILS ON THE FLAVOR OF TURKEY

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ABSTRACT

Turkeys were fed varying levels of α-tocopherol acetate and oils containing linolenates (linseed and tuna oils). As expected, these oils caused a fishy flavor to develop in the turkey carcass, and α-tocopherol fed concomitantly, greatly retarded development of this fishy flavor, but did not affect the uptake of linolenates by the turkey carcass. These and other observations pointed to the conclusion that linolenates do not by their simple presence in turkey carcass cause fishy flavor, but that perhaps their in vivo and/or postmortem oxidation are responsible for the development of this flavor.

Several investigators have reported that fishy flavors develop in poultry carcass when diets are supplemented with oils, such as linseed oil (Klose et al., 1951) and fish oil (Neudoerffer and Lea, 1966, 1967, 1968; Miller et al., 1967a, 1967b; Miller and Robisch, 1969; Dreosti, 1970; Opstvedt, Olsen, and Urdahl, 1970; Opstvedt, Nygard, and Olsen, 1970, 1971). The latter investigators showed that this off flavor is related to the linolenate content of the oil, especially the long chain homologues. Miller and Robish (1969) showed that fishy flavors were eliminated with the withdrawal of fish oils and substitution of a more saturated fat (like tallow) in the diet. Lineweaver (1970) reported that practical experience has shown that the amount of fish oil in the diet of poultry should not exceed 0.3% if fishy flavors are to be avoided. However, it was not clear whether the specific character of the oil (ω3 fatty acid content) was a factor to be considered.

Lea et al. (1966), Dreosti (1970), and Opstvedt et al. (1971) reported that antioxidant-treated fish meal is more likely to cause fishiness than untreated meal. They reasoned that the unsaturated fatty acids of the untreated meal become oxidized and, perhaps, polymerized, thereby becoming unavailable for uptake in the tissue.

The research of Mecchi, Pool, Beham, Hamachi, and Klose (1956) showed that the stability of turkey fat closely paralleled the tocopherol content of the fat. Other work by Mecchi, Pool, Nonaka, Klose, Marsden, and Lillie (1956) whereby chickens and turkeys were fed varying levels of dietary tocopherol, further substantiated that in fact tocopherol uptake was possibly singularly important to the stability of carcass fat. These findings are corroborated in more detailed studies by Webb, Marion, and Hayse (1972) and Webb, Brunson, and Yates (1972).

Dreosti (1970) and Opstvedt et al. (1971) reported that dietary α-tocopherol acetate supplementation (above levels required to prevent nutritional disease) significantly reduced fishy flavors in poultry fed fish oils.

It is clear that dietary oils containing ω3 fatty acids do in some way contribute to fishy flavors in poultry and that α-tocopherol acetate supplementation reduces the development of this flavor. It is not clear how ω3 fatty acids, when ingested by poultry, result in fishy flavored carcasses or how α-tocopherol reduces the development of this flavor. This paper reports on the fatty acid composition of extracted lipids and on the flavor of the meat from turkeys fed fish oil and linseed oil to 6 wk and to 8 wk of age using safflower oil or beef fat to bring diets into lipid isocaloric balance. Supplemental tocopherol acetate was added to some of the diets. The flavor of adult turkeys fed tuna oil for 2 wk was also observed.

While it is not a practice to raise turkeys to only 6 and 8 wk of age or to feed fish oil midstream for only 2 wk, it was convenient and expedient for the present study. Additionally, observations can be made on the relative uptake of dietary fats and the influence of metabolic rate.

EXPERIMENTS

Oils

Linseed oil, refined safflower oil, freshly rendered beef fat, and fresh polished tuna oil (albacore) were obtained unstabilized. The oils were

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deaerated under vacuum and twice flushed with nitrogen. To part of each oil was added 0.3125% ethoxyquin (this will give 125 ppm when added to diet). The stabilized oils were again evacuated, flushed under nitrogen, and stored at −26°C until use. The rendered beef fat was stored at −26°C until used.

Feed

The following basal diet was used in the feeding of turkeys:

Ingredients	*% of diet*
Soybean oil meal (50%)	50.00
Mineral mix	2.58
Vitamin mix (in corn starch)	1.00
$CaHPO_4 \cdot 2H_20$	1.70
$CaCO_3$	1.90
Choline Cl (50%)	0.40
DL-Methionine	0.20
Ground corn	38.42

Diets contained 10 mg vitamin E (*dl*-α-tocopherol acetate) per kilogram and 0.66 ppm sodium selenite. Oils were preweighed and stored at −26°C under nitrogen before incorporation into diets. Diets were mixed with the oils every 1 or 2 wk and stored in a refrigerator and fed fresh daily.

Diets and Feeding

Experiment I

Eighty White Broad Breasted poults (unsexed) were fed chick starter (about 7% fish meal) on day 1. On days 2 and 3, they were fed one-half starter and one-half basal diet. On day 4, they were divided into eight groups of 10 turkeys each, equally distributed by weight, and fed to 6 wk of age on the following experimental diets:

Group	*Oil supplement to basal diet*[1]
1	4% SO
2	4% SO + 125 ppm EMQ
3	1% SO + 3% LO
4	1% SO + 3% LO + 125 ppm EMQ
5	3.5% SO + 0.5% TO
6	3.5% SO + 0.5% TO + 125 ppm EMQ
7	3% SO + 1% TO
8	3% SO + 1% TO + 125 ppm EMQ

[1]SO = safflower oil; EMQ = ethoxyquin, an antioxidant; LO = linseed oil; TO = tuna oil.

Experiments II and III

Eighty-one White Broad Breasted poults were obtained sexed (male only) for Experiments II and III. Starter diet containing 7% fish meal was fed day 1, and one-half starter and one-half basal diet were fed on days 2 and 3. On day 4, the poults were divided into nine groups of nine turkeys each, equally distributed by weight. Groups 1 through 8 were fed the experimental diets described below for 8 wk. These turkeys constituted Experiment II. Group 9 was fed the basal diet without oil supplementation to 14 wk of age and was then divided into three groups of three turkeys each which were designated as Groups A, B, and C. For 2 wk (until 16 wk of age), Group A was fed Diet 1 (control 4% beef fat) and Groups B and C were fed Diets 3 and 5 (3% beef fat + 1% tuna oil and 2% beef fat + 2% tuna oil), respectively. These turkeys constituted Experiment III.

Group	*Oil supplement to basal diet*[1]
1	4% BF
2	3.5% BF + 0.5% TO
3	3% BF + 1% TO
4	3% BF + 1% TO + 200 mg vitamin E/kilogram
5	2% BF + 2% TO
6	2% BF + 2% TO + 200 mg vitamin E/kilogram
7	3% SO + 1% TO
8	2% SO + 2% TO
9	No oil supplement until 14 wk of age

[1]BF = beef fat; TO = tuna oil; vitamin E = *dl*-α-tocopherol acetate; SO = safflower oil.

Sampling and Analysis

All turkeys were sacrificed at the appropriate time by cutting the jugular vein with an electrified knife and bleeding for 2 min. The turkeys were then scalded at 60°C, defeathered, eviscerated, dressed, packed in ice overnight, vacuum sealed, blast frozen, and stored at −30°C for about 4-6 wk. All birds were halved in the frozen state, with half being reserved for chemical analyses and half for baking and subsequent organoleptic analyses.

The halves for chemical analyses were thawed overnight in a 2°C cold room. Thighs and breasts were removed and minced individually after removal of skin and subcutaneous fat. Minced thighs and breasts from individual birds were

wrapped in Saran[4] film and aluminum foil, identified, and stored at −30°C until analyzed.

Oil content was determined on composites of 18-g samples of the individual thighs and breasts from each bird by the modified method of Smith, Ambrose, and Knobl (1964). Methyl esters for gas-liquid chromatography (GLC) analyses were prepared from the same oil extract by the method of Metcalfe, Schmitz, and Pelka (1966). The GLC column was 10% diethylene glycol adipate on Gas Chrom Q. GLC conditions were as follows: column, 196°C; injector, 250°C; flame ionization detector, 300°C; carrier gas flow, 24.6 cm^3/min.

Organoleptic analyses for the turkeys in Experiment I were performed by ranking. The panelists ranked four samples per session (of which one sample was a control). Comments about off flavors, if present, were solicited (e.g., fishy, oxidized, rancid, etc.). In Experiments II and III, organoleptic analyses were performed by scoring, using a balanced incomplete block technique. Analyses of variance and a Duncan multiple range test were calculated for Experiment II. Regression equations were calculated for breast and thigh meat and skin for Experiment III.

RESULTS AND DISCUSSION

Experiment I

All turkeys in Experiment I seemed to have grown normally and to have been in good nutritional health. The mean dressed weight was 991 g, with no significant weight differences between groups.

Table 1 gives the results of GLC analyses and lipid content (grams/100 g) of breast and thigh meat from the turkeys fed linseed and tuna oils to 6 wk of age. As expected, the thigh contained nearly twice the amount of lipid as the breast, (about 2% and 1% extracted lipid, respectively). The distribution of the methyl esters of fatty acids showed consistently higher percentages of C16:0, C18:0, C20:4, C22:5, and C22:6 in the breast, but higher C18:3 (when present in the diet), C18:2 and C18:1 in the thigh for all treatments. The lipid composition of the leg and breast reflect generally that of the dietary oils.

Results of organoleptic evaluation of the turkeys are reported in Table 2. The scoring (by rank) shows that 1% tuna oil imparts off flavor (slight) in breast and thigh meat and somewhat the same trend is indicated for odor evaluation, especially in the breast meat. But no clear trend is indicated for the skin. In general, flavor was judged as excellent. Ofttimes, there were no clear differences in a given set of comparisons. There were only a few scattered comments that described the flavor as fishy. No consistent differences were found between samples with and without ethoxyquin.

The lack of the development of positive fishy flavor in this experiment was unexpected since the oils fed to the turkeys contained high levels of linolenic acid (linseed oil, ca. 57% C18:3ω3) or one of its longer-chained homologues (tuna oil, ca. 32% C22:6ω3). Fishy flavors have been induced in poultry by other investigators using oils that contained far less linolenates than used in this exper-

[4]Reference to a company or product name does not imply approval or recommendation of the product by the U.S. Department of Agriculture or the National Marine Fisheries Service, NOAA, to the exclusion of others that may be suitable.

TABLE 1.—Methyl ester fatty acid composition[1] of linseed oil and tuna oil and lipids extracted from turkeys[2] fed to 6 wk of age diets containing varying levels of safflower, linseed, and tuna oils with and without ethoxyquin.

Fatty acid	Linseed oil	Tuna oil	1B	1T	2B	2T	3B	3T	4B	4T	5B	5T	6B	6T	7B	7T	8B	8T
C16:0 + Iso C16:0	5.3	14.2	18.4	12.1	18.2	13.6	19.0	11.5	15.7	11.1	17.5	12.5	19.0	14.0	18.5	13.0	17.5	13.1
C18:0	3.8	5.5	12.3	8.4	13.0	9.0	14.9	10.1	11.9	6.7	12.8	8.5	12.6	7.5	10.3	8.9	9.5	5.7
C18:1	18.1	15.8	10.2	13.9	9.1	16.6	11.4	15.7	14.6	18.8	10.3	14.2	9.5	14.8	9.3	13.7	11.7	17.3
C18:2	15.0	4.8	37.8	52.0	40.3	47.1	28.6	35.3	33.5	36.9	33.7	49.2	34.2	48.5	32.5	46.0	38.8	48.0
C18:3ω3	57.8	—	—	—	—	—	4.1	14.6	10.5	19.6	—	—	—	—	—	—	—	—
C20:4ω6	—	3.0	12.0	6.3	10.1	5.6	7.1	4.0	4.3	1.9	8.9	4.8	9.1	3.9	8.9	4.3	5.6	2.6
C20:5ω3	—	7.9	—	—	—	—	2.3	—	—	—	—	—	—	—	1.8	—	—	—
C22:3ω3	—	—	2.5	—	2.3	—	—	—	—	—	—	—	—	—	—	—	—	—
C22:5ω3	—	1.8	—	—	—	—	3.4	—	2.2	—	—	—	—	—	—	—	—	—
C22:6ω3	—	32.5	—	—	—	—	3.9	—	1.9	—	7.9	3.7	7.9	3.2	11.6	5.2	8.9	4.0
% lipid, g/100 g tissue	—	—	0.88	1.87	0.92	2.12	0.95	1.86	1.40	3.01	1.22	2.12	1.02	2.29	0.92	1.97	1.17	3.03

[1]Fatty acids in amounts of 2% or less omitted. B = Breast meat; T = thigh meat.
[2]All groups of turkeys were fed a basal diet plus an oil supplement for 6 wk. Group 1 = 4% safflower oil (SO), Group 2 = (same as 1) + 125 ppm ethoxyquin (EMQ), Group 3 = 1% SO + 3% linseed oil (LO), Group 4 = (same as 3) + 125 ppm EMQ, Group 5 = 3.5% SO + 0.5% tuna oil (TO), Group 6 = (same as 5) + 125 ppm EMQ, Group 7 = 3% SO + 1% TO, Group 8 = (same as 7) + 125 ppm EMQ.

TABLE 2.—Taste panel scores (rank) on breast and thigh meat and skin of turkeys fed to 6 wk of age diets containing varying levels of safflower oil, linseed oil, and tuna fish oil with and without ethoxyquin.

Group[1]	Breast meat	Thigh meat	Skin
	Odor[2]		
	Without antioxidant		
1, 4% SO	1.9	2.4	2.9
3, 3% LO	2.4	3.0	2.6
5, 0.5% TO	2.5	1.9	2.3
7, 1% TO	3.2	2.8	2.4
	With antioxidant		
2, 4% SO	1.9	2.2	2.5
4, 3% LO	2.6	2.2	2.7
6, 0.5% TO	2.1	2.4	2.2
8, 1% TO	3.5	2.9	2.7
	Flavor[2]		
	Without antioxidant		
1, 4% SO	1.9	2.3	2.5
3, 3% LO	2.4	[3]3.2 (4F)	[3]3.0 (1F)
5, 0.5% TO	2.7	2.1	1.9
7, 1% TO	3.0	[3]2.4 (1F)	[3]2.6 (1F)
	With antioxidant		
2, 4% SO	2.3	1.9	2.6
4, 3% LO	2.3	2.3	2.9
6, 0.5% TO	2.1	2.4	2.1
8, 1% TO	[3]3.3 (2F)	[3]3.3 (1F)	2.5

[1]All groups of turkeys were fed a basal diet plus an oil supplement for 6 wk. Group 1 = 4% safflower oil (SO), Group 2 = (same as 1) + 125 ppm ethoxyquin (EMQ), Group 3 = 1% SO + 3% linseed oil (LO), Group 4 = (same as 3) + 125 ppm EMQ, Group 5 = 3.5% SO + 0.5% tuna oil (TO), Group 6 = (same as 5) + 125 ppm EMQ, Group 7 = 3% SO + 1% TO, Group 8 = (same as 7) + 125 ppm EMQ.
[2]Rank 1 = least off odor or off flavor.
[3]F = number of fishiness comments.

iment (Miller and Robish, 1969; Dreosti, 1970; Opstvedt, Nygard, and Olsen, 1970).

Some suggestions may be offered as to why no clear fishy flavors were induced, even though there was uptake of linolenates in the turkey carcass. For example, the use of safflower oil to achieve lipid isocaloric balance may have depressed the uptake of linolenates. Edwards and May (1965) observed this effect when they fed mixtures of corn and menhaden oil. Certainly the metabolism of the young birds (in this experiment 6 wk of age) must be considered. Their cell turnover is considerably higher than that of adult birds; phospholipid (an integral part of cell membranes) turnover is proportional to mitotic rate, and long-chained fatty acids are more readily found in phospholipids.

Experiment II

As before, all turkeys appeared to be in good nutritional health. The mean dressed weight was 1,377 g for turkeys fed to 8 wk of age.

Table 3 shows the results of fatty acid (methyl esters) determination by GLC of lipids extracted from the breast of turkeys fed fish oil and safflower oil to 8 wk of age. The fatty acids C20:5ω3 and

TABLE 3.—Methyl ester fatty acid composition of tuna oil and lipids extracted from the breast of turkeys[1] fed to 8 wk of age diets containing varying levels of tuna oil and beef fat or safflower oil with and without vitamin E (*dl*-α-tocopherol acetate) supplementation.

Fatty acid	Tuna oil[2]	% distribution in extracted oil							
		Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8
C14	3.1	0.7	1.0	0.7	0.5	0.4	0.5	0.3	0.5
C14:1	—	0.2	0.2	0.1	0.1	0.1	0.1	0.0	0.1
C15	—	0.2	0.2	0.2	0.2	0.3	0.2	0.1	0.2
Iso C16	—	3.3	3.3	3.1	3.5	3.9	3.7	2.6	3.3
C16	—	14.8	14.3	14.3	13.7	14.5	14.3	15.2	14.9
C16:1	4.7	1.1	1.2	0.9	0.6	0.6	0.9	0.3	0.6
C17	—	0.5	0.6	0.5	0.6	0.8	0.7	0.7	0.7
Iso C18	—	1.7	1.4	1.4	2.1	1.3	1.6	0.7	0.9
C18	5.5	15.4	14.9	15.0	15.3	14.9	14.6	13.6	11.2
C18:1	15.8	20.8	18.9	17.4	15.7	14.7	14.9	11.1	12.8
C18:2	4.8	24.8	20.6	19.9	18.5	18.0	18.1	30.9	28.9
C18:3	—	0.8	0.7	0.5	0.3	0.5	0.5	0.5	0.7
C20:4	3.0	6.6	5.9	6.5	7.4	6.2	6.4	8.8	6.5
C20:5	7.9	0.7	2.4	3.3	3.4	4.2	4.3	1.8	3.3
C22:5	1.8	1.2	1.6	1.5	1.6	2.0	1.5	1.0	1.0
C22:6	32.5	3.3	10.3	11.9	13.4	14.9	15.5	9.2	11.8
Others	21.0	3.9	2.5	2.8	3.1	2.7	2.2	3.2	2.6
% lipid, g/100 g tissue	—	0.89	0.95	0.98	0.86	0.84	0.90	0.93	0.84

[1]All groups of turkey were fed a basal diet plus an oil supplement for 8 wk. Group 1 = 4% beef fat (BF), Group 2 = 3.5% BF + 0.5% tuna oil (TO), Group 3 = 3% BF + 1% TO, Group 4 = (same as 3) + 200 mg/kg vitamin E, Group 5 = 2% BF + 2% TO, Group 6 = (same as 5) + 200 mg/kg vitamin E, Group 7 = 3% safflower oil (SO) + 1% TO, Group 8 = 2% SO + 2% TO.

TABLE 4.—Methyl ester fatty acid composition of lipids extracted from the cooked breast of turkeys[1] fed to 8 wk of age diets containing varying levels of beef fat and tuna oil with and without vitamin E (*dl*-α-tocopherol acetate) supplementation.

Fatty acid	% distribution in extracted oil		
	Group 1	Group 5	Group 6
C14	0.8	1.1	0.9
C14:1	0.1	0.3	0.2
C15	0.2	0.3	0.3
Iso C16	2.7	2.3	1.8
C16	15.9	16.6	15.9
C16:1	0.8	2.2	1.7
C17	0.6	0.9	0.8
Iso C18	1.6	1.4	1.1
C18	17.1	14.1	14.5
C18:1	19.1	21.2	18.8
C18:2	22.5	19.3	19.7
C18:3	0.6	0.9	0.8
C20:4	5.1	3.4	4.7
C20:5	1.8	2.5	3.1
C22:5	1.0	1.1	1.1
C22:6	6.6	9.2	11.5
% lipid, g/100 g tissue	1.10	1.15	1.10

[1]All groups of turkeys were fed a basal diet plus an oil supplement for 8 wk. Group 1 = 4% beef fat (BF), Group 5 = 2% BF + 2% tuna oil, Group 6 = (same as 5) + 200 mg α-tocopherol acetate per kilogram.

C22:6ω3 increase as the amount of tuna oil increases in the diet. Safflower oil added to Diets 7 and 8 seemed to reduce the uptake of these fatty acids. Tocopherol acetate supplementation did not seem to have any effect on the uptake of ω3 fatty acids. Fatty acid distribution analyses (Table 4) on lipids extracted from cooked turkey breast from Groups 1, 5, and 6 show that α-tocopherol did not have an effect on the relative stability of the long-chain fatty acids during cooking.

The results of taste panel evaluations (Table 5) show that, while α-tocopherol supplementation did not change the ω3 fatty acid distribution, it greatly reduced fishy flavor as judged by the taste panel. Opstvedt, Nyard, and Olsen (1970) also reported these findings. On the other hand, safflower oil (used to achieve isocaloric balance) reduced the uptake of ω3 fatty acids, but there were no differences in flavor when compared to the flavor of turkeys fed the same amount of tuna oil but using beef fat for isocaloric balance. There was a strong relationship between the amount of C20:5ω3 and/or C22:6ω3 and fishy flavor when no α-tocopherol or safflower oil supplementation was present in the diets. This agrees with the findings of Neudoerffer and Lea (1966, 1967), Miller et al. (1967a), Miller and Robish (1969), and Dreosti (1970). However, a comparison of the fatty acid distributions and lipid contents found by these investigators with those in this experiment and Experiment I, shows that the levels of C20:5ω3 and C22:6ω3 present when fishy flavors are detected are higher in these experiments. We should also note that the fish oils used by other investigators contained about 2-12% C22:6ω3, while the tuna oil used in these experiments contained 32% C22:6ω3.

Experiment III

These 16-wk-old turkeys had been fed diets containing 3% beef fat plus 1% tuna oil and 2% beef fat plus 2% tuna oil for the 2 wk prior to slaughter. The control diet contained 4% beef fat. All turkeys apparently enjoyed good nutritional health and the mean dressed weight was 3,585 g.

TABLE 5.—Mean[1] taste panel scores[2] and Duncan's multiple range test of mean scores on thigh and breast meat and skin of turkeys fed to 8 wk of age diets containing varying levels of tuna fish oil and beef fat or safflower oil with and without vitamin E (*dl* α-tocopherol acetate) supplementation.

Group[3]	Breast meat	Group[3]	Thigh meat	Group[3]	Skin
5, 2% TO + 2% BF	3.91	8, 2% TO + 2% SO	3.56	8, 2% TO + 2% SO	3.37
8, 2% TO + 2% SO	3.35	5, 2% TO + 2% BF	3.28	5, 2% TO + 2% BF	2.69
3, 1% TO + 3% BF	3.04	6, 2% TO + 2% BF + E	2.41	3, 1% TO + 3% BF	1.99
2, 0.5% TO + 3.5% BF	2.94	2, 0.5% TO + 3.5% BF	2.20	6, 2% TO + 2% BF + E	1.98
6, 2% TO + 2% BF + E	2.48	7, 1% TO + 3% SO	2.03	7, 1% TO + 3% SO	1.69
7, 1% TO + 3% SO	2.30	3, 1% TO + 3% BF	1.85	1, 4% BF	1.27
1, 4% BF	1.33	4, 1% TO + 3% BF + E	1.22	2, 0.5% TO + 3.5% BF	1.26
4, 1% TO + 3% BF + E	1.24	1, 4% BF	0.95	4, 1% TO + 3% BF + E	1.04
$S_{\bar{x}}$	0.228		0.211		0.252

[1]Means connected by a common line are not significantly different at the 0.05 probability level.
[2]1 = no fishy flavor, 5 = very fishy.
[3]All groups of turkeys were fed a basal diet plus an oil supplement for 8 wk. Group 1 = 4% beef fat (BF), Group 2 = 0.5% tuna oil (TO) + 3.5% BF, Group 3 = 1% TO + 3% BF, Group 4 = (same as 3) + 200 mg/kg vitamin E (E) Group 5 = 2% TO + 2% BF, Group 6 = (same as 5) + 200 mg/kg vitamin E, Group 7 = 1% TO + 3% safflower oil (SO), Group 8 = 2% TO + 2% SO.

TABLE 6.—Methyl ester fatty acid composition of lipids extracted from the thighs of turkeys[1] fed from 14 wk to 16 wk of age diets containing varying levels of beef fat and tuna oil.

Fatty acid	% distribution in extracted oil		
	Group A	Group B	Group C
C14	0.4	1.0	1.0
C14:1	0.1	0.1	0.1
C15	0.1	0.2	0.2
iso C16	1.9	2.1	1.6
C16	17.7	16.8	18.7
C16:1	5.8	1.8	1.9
C17	0.3	0.5	0.6
iso C18	0.9	0.8	0.7
C18	10.6	13.8	12.1
C18:1	21.7	20.3	20.4
C18:2	30.7	26.4	26.2
C18:3	1.6	1.3	1.5
C20:4	5.2	6.2	5.0
C20:5	0.2	0.9	1.4
C22:5	0.5	0.8	0.7
C22:6	0.5	4.5	6.1
% lipid, g/100 g tissue	2.10	2.12	2.55

[1]All turkeys were fed a basal diet without oil supplement to 14 wk of age and to 16 wk of age with oil. Group A = 4% beef fat, Group B = 3% beef fat + 1% tuna oil, Group C = 2% beef fat + 2% tuna oil.

Fatty acid distributions and percent extracted lipids from the thighs of these turkeys are shown in Table 6. (The same analyses were not possible for the breast meat because it was used in another experiment.) As before, the amount of C22:6ω3 increased as the amount of fish oil in the diet increased. It is of interest that the lipid level was only slightly higher in the 16-wk turkeys fed fish oil for 2 wk than in the 6- or 8-wk turkeys fed from day 4 to slaughter. Yet, the percent of C22:6ω3 was less than half that of the 8-wk birds, while the flavor reported in Table 7 was at least as fishy, if not more so.

In conclusion, if consideration is given to 1) the effects of α-tocopherol on (reducing) the fishy flavor, while not affecting the uptake of linolenates, and 2) the different levels of long-chain linolenates present when fishiness is detected, one has to reason that the long-chained ω3 fatty acids do not of themselves cause fishy flavor by their simple presence. It is plausible that the fishy flavors result at least in part from the oxidation (in vivo? postmortem?) of linolenates and that α-tocopherol limits the oxidation. It is further colorable that the amount of linolenate oxidation needed to produce fishy flavor may be smaller than the inherent error in fatty acid analyses and therefore, no differences would be observed in the amount of linolenates in the carcass of turkeys fed fish oils with and without α-tocopherol.

TABLE 7.—Mean taste panel scores[1] and regression equations (% tuna fish oil supplement vs. mean taste panel scores) for thigh and breast meat and skin of turkeys fed diets containing varying amounts of beef fat and tuna oil.

Group[2]	Breast meat	Thigh meat	Skin
A, control	1.44	1.11	1.06
B, 1 TO	2.06	2.50	1.89
C, 2 TO	3.28	4.11	2.94
$S_{\bar{x}}$	0.26	0.21	0.28
Regression equations:			
$y = 1.343 + 0.917X$			
$y = 1.074 + 1.500X$			
$y = 1.018 + 0.944X$			

[1] = no fishy flavor, 5 = very fishy.
[2]All groups of turkeys were fed a basal diet without oil supplementation to 14 wk of age and to 16 wk with oil. Group A = 4% beef fat, Group B = 3% beef fat + 1% tuna oil (TO), Group C = 2% beef fat + 2% TO.

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